CHALMERS
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Knowledge Management in the construction of Swedish healthcare facilities

Examining the Programme for Technical Standard

Master's thesis in the Master's Programme Design and Construction Project Management

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Master's Thesis ACEX30-19-NN
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ABSTRACT

This study examines knowledge management as conducted in the construction of healthcare facilities in Sweden, and compare it among the Scandinavian countries. To perform knowledge management in healthcare construction in Sweden, there existed several healthcare bodies up to the 1970s and 1980s when they were closed down, that then gave rise to PTS in Jönköping, first as a paper-based system that later transformed into a digital IT system. Sweden being organised in autonomous and decentralised regions, PTS acts as a tool to collect and share standardised knowledge and information on healthcare construction projects across the country, membership of which is voluntary. This is done through the IT system and social gatherings such as meetings, workshops and conferences. The study is conducted through the qualitative method based on the abductive approach, consisting of a literature review and interview study. A total of seven semi-structured interviews were conducted with professionals from across the Scandinavian region, consisting of public actors and a researcher based in the region. Findings from the study are firstly that different knowledge management systems are established in the different Scandinavian countries. Additionally, PTS has adopted a flexible approach where member regions decide on how and what to use from the system, which contradicts its goal of standardisation. Despite this, it has managed to significantly standardise, and improve the quality and clarity in healthcare construction projects across the country. Moreover, lack of direction, lack of resource and poor resource allocation have been revealed to be among the main challenges the system faces. Finally, there is great opportunity for the countries to further collaborate, learn and share knowledge among themselves, to further the advancement in healthcare construction.

Key words: Knowledge, Knowledge sharing, Knowledge Management, Knowledge Management System, Standardisation

Contents

Preface

This master thesis was conducted as the final part of the master's program Design and Construction Project Management.

First and foremost, we would like to thank Almighty God, the Most Beneficent, the Most Merciful. Thereafter, our families for their constant support throughout our studies.

We would like to extend our sincere gratitude to our supervisor Abderisak Adam and examiner Göran Lindahl for their guidance and assistance during the project. Abderisak has been of great support during our research, his feedback, insights, analysis and encouragement have been paramount to complete the study.

Finally, our thanks to the respondents who contributed to our study through their valuable practical knowledge and experience on the subject.

Gothenburg, May 2019.

Notations

AEC – Architecture, Engineering and Construction

BIM – Building Information Modelling

CAD – Computer Aided Design

CoP – Community of Practice

CVA – Centre for Healthcare Architecture

GBP – Collective Building Process

ICT – Information and Communication Technology

IT – Information Technology

KM – Knowledge Management

KMS – Knowledge Management System

NSB – Social Welfare and Healthcare Buildings Board

NUU – University Hospital Construction Board

OECD – Organisation for Economic Co-operation and Development

PTS – Programme for Technical Standard

RFP – Room Function Programme

Spri – Healthcare and Social Welfare Planning and Rationalisation Institute

1 Introduction

Public organisations have to continually adapt to changes in the needs and expectations of the society, keep up with advancements on a global level, and thus need to have proper management strategies to survive. In recent times, the public sector is under pressure to match its private counterpart in terms of productivity and service quality, hence they have established Knowledge Management (KM) efforts to bridge the gap. This necessity was echoed in the survey conducted by the Organisation for Economic Co-operation and Development (OECD) in 2003, which stated that in order to increase effective service delivery, cultural change and knowledge sharing practices should be encouraged in the sector. However, the public sector works in a different way compared to the private, due to a more strict and bureaucratic structure, and high pressure for accountability from the government and society, which creates difficulties for KM in the sector. Moreover, the public sector has been seen to have a knowledge hoarding culture, and has dampened knowledge sharing efforts and collaborative practices.

Most of the public organisations' spending is directed towards development projects such as infrastructure, healthcare facilities etc. In Great Britain for instance, the government spent around £24.5 billion in 2017 on new construction projects (ONS, 2018). Despite huge investments, the construction industry is still seen to be a handicraft profession with unique and customised products, which ultimately leads to low productivity levels and difficulty in standardising knowledge and processes in the industry. For this reason, in their paper's discussion, Aapaoja and Haapasalo (2014) argue for the use of standardised products if process standardisation is to succeed. Contrastingly, they inferred in the literature study they conducted that standardisation in the construction industry should first and foremost be about systematic approaches to perform tasks, which will then exploit the benefits of standardised products. Process standardisation can be carried out in different ways, such as detailed standard documentation and procedures, which is a form of coercive approach, stating what should or should not be done, or it could have a more strategic approach, which is proactive and a risk-aware approach, and has been seen to give better results (Aapaoja and Haapasalo, 2014).

Aapaoja and Haapasalo (2014) state that standardisation of processes helps to decrease costs, and have a positive effect on quality and design, it allows project stakeholders to have a better understanding of what is required, from whom, and when. Additionally, a number of research (Gibb & Isack, 2001; Tam *et al.*, 2007; Pasquire & Gibb 2002) showed that standardisation resulted in fewer claims, conflicts, and variations in the projects. Moreover, standardisation ensures that professional practice is based on shared knowledge (Nerland and Karseth, 2015). At the same time, Aapaoja and Haapasalo (2014) claim that without standardisation, it is difficult to measure and predict the quality, and therefore have continuous improvement measures in the organisation. However, a study conducted by Nerland and Karseth (2015) showed that standards should be set in a manner that gives room for flexibility according to local work practices.

Because of the high complexity of health care, and its rate of change (CVA, 2018), standardising the healthcare facilities construction has been perceived to be difficult. This demands the specification of requirements, documentation, communication and organisation to be correct. Project managers with experience of similar projects and time-schedules who are more flexible, are more suitable for these projects. While the construction rate remains high, the movability of personnel is increasing and the rate of

retirement of workers is also high. The second challenge is the difference between the property developer's long-term planning and the health care sector's short-term planning. This causes a greater need to predict and have an extra margin of safety for the future (CVA, 2018).

1.1 Purpose

The purpose of this master thesis is to examine the Programme for Technical Standard (PTS) in Sweden and compare it with similar systems in the Scandinavian region. The thesis will also study the opportunities for improvements and challenges with PTS.

The research questions of the study are the following:

I. What are the purported benefits of using PTS?
II. What are the possible opportunities and challenges with PTS?
III. How could PTS be further developed?
IV. How does PTS relate with similar knowledge management set-ups for healthcare construction in Scandinavia?
V. How do the Swedish regions conduct knowledge sharing outside PTS?

1.2 Research scope and limitations

This study will not compare regions applying PTS with those that do not apply it. Furthermore, the thesis shall be limited to the Scandinavian countries. In addition, this research only interviewed PTS users from the regional public facility management departments.

1.3 Case description

The study examined knowledge creation and sharing among regions in Sweden focusing on the construction of health care facilities. The mandate for the Swedish health care system is stated in the Swedish Health and Medical Services Act of 2017 and replaces the one from 1982. The purpose for the new law was to make the law clearer, easily accessible and more purposeful (SKL, 2017).

The Swedish health care system is divided according to lines of responsibility that is based on the three organisational levels for governing in Sweden: municipalities, regional councils and the state. The highest level is the state, where the Ministry of Health and Social Affairs is responsible to fulfil the above-mentioned mandate. Some of their tasks are to come up with new legislative propositions for health and social welfare, examine the state of health care and social welfare, cooperate with municipalities and regional councils on their execution of their health care plans. Additionally, the ministry is also responsible to meet objectives set by the Swedish Parliament. To help them with above-mentioned tasks, there are several agencies (Armstrong, Fischer and Parsa-Parsi, 2010).

The second level of organisation is regional councils, that were formerly known as county councils before 1st January 2019 (Sveriges Riksdag, 2017). Their main responsibility is hospital and primary care, as well as prevention and public health measures. Sweden is divided into 21 regional councils, but the health care responsibility

is divided into six regions. To access high quality specialised care, there are several regional university hospitals. In these, most of the research and teaching is also done. Beyond the responsibility of the primary and hospital care is the 290 municipalities (Armstrong, Fischer, Parsa-Parsi, 2010). According to the Swedish Association of Local Authorities and Regions, municipalities, the third level, have the main responsibility for elder care, especially home care and old age retirement homes. However, in 25 of the 290 municipalities, the regional councils still are responsible for home care (Henningsson, 2018).

Additionally, the CVA report identified three main challenges in addition to the two mentioned above, which are: the lack of knowledge sharing both between and within projects, unclear prerequisites on what the goal is, and lacking clarity on the process for starting/initiating a project (CVA, 2018).

1.3.1 Programme for Technical Standard (PTS)

To address the problem of knowledge sharing and to act as a knowledge transfer tool between regions, PTS was established in 1974. Then in 2004, it was developed into a IT-based system (PTS, 2019b). Out of 21 regions 16 have joined PTS, as shown in Figure 1 below.

Figure 1: Map of PTS member regions. PTS (2019a).

The initiator for the development of PTS as an IT-based supporting system was Jönköping region's property management, making them the legal owners of PTS (PTS Forums styrelse, 2018). The programme is a *"web-based management system for healthcare's provision of premises"* (Sundberg, 2017, p.2) meant to allow regions to cooperate in a network form with the main goal being to strengthen the regions' roles and avoiding the repetition of mistakes done in previous projects. Additionally, it assists and contributes to building health care facilities by supporting projects in early stages through designing in projects, for instance. PTS forum is a national network for member regions co-operating on standards for health care facilities. Regular meetings are arranged to exchange experiences, discuss areas of improvement, and benchmarking on different subject areas. Furthermore, to stay up-to-date in trends and to develop construction of health care facilities in Sweden, the national network co-operates with research projects (PTS Forums styrelse, 2018).

Currently the PTS has standardised room templates for hospitals and also offers a basic project management support tool (PTS Forums styrelse, 2018). However, now that it has been established in many regions, there is a need to add more functions and processes in order to give wider support throughout the project life cycle (Sundberg, 2017).

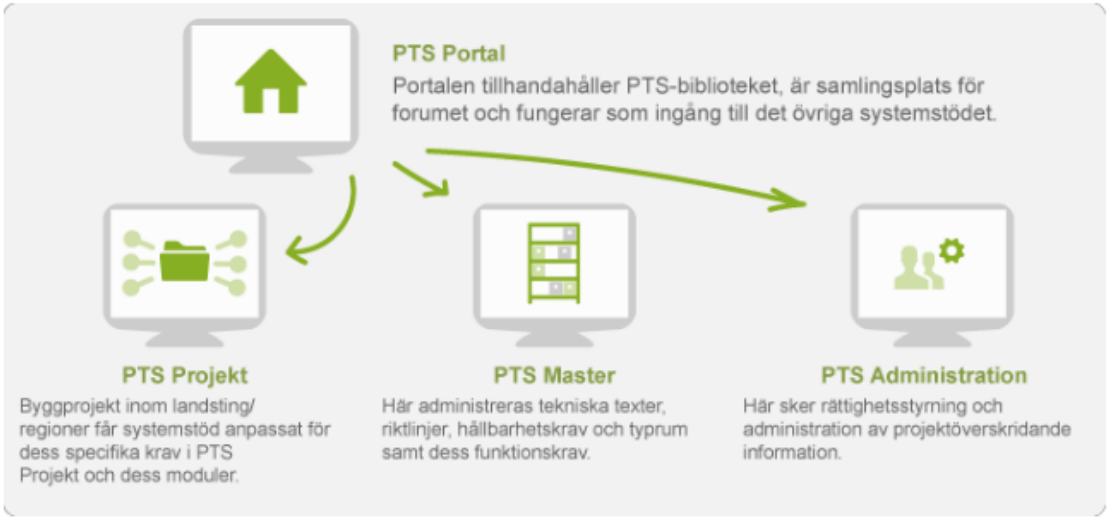

Figure 2 – PTS system configuration. PTS portal has three main parts which are explained in the section below. From PTS Forums styrelse, 2018, p. 8.

The web-based programme is designed in a way that access to different modules in the system can be restricted, which would be useful when having external consultants or designers but could also be used to restrict personnel from the property organisation. The main portal has a library and also functions as an entry to other modules. Regulatory documents such as room templates, user guides, movies with instructions and also technical requirements and guidelines, could be also be found here. Additionally, there is a link to Sunda Hus Miljödata for users who have signed a contract with them (PTS Forums styrelse, 2018). They assist users with selecting material without dangerous substances for the environment and with documenting the selection of materials (Sunda Hus, 2019).

One of the tools found in PTS portal, as shown in Figure 2 above, is PTS project which is the platform where users create projects. It has many modules with the aim of

supporting the different parts in the construction process and their activities. The different modules found are the following (PTS Forums styrelse, 2018):

- PTS process: supports members to plan, steer, follow-up on a project.
- PTS facility program: functions to help show areas which will be available in an early stage. a list of the inherent areas with its total programme area can be created. Users have the option to divide the project according to a construction sector or structure depending on the activity in the project, health clinic for instance.
- PTS Rooms functions program (RFP): users are given the opportunity to create and modify areas according to the project, based upon requirements on the function, furnishing, equipment, and surface.
- PTS Illustration: to facilitate, and to increase, the understanding of how the end product would look like this module lets users create 3D illustrations over RFP-areas or standard rooms.
- PTS Purchase planning: based upon information taken from RFP and PTS borderline users can plan purchases of furnishing and equipment.
- PTS Room categories: in this module, users can retrieve information from facility management system such as Landlord, to be able to compare the relation between the current areas with the planned areas.
- PTS Borderline: the division of responsibility between the property and the operation area is set in this module.
- PTS Sustainability: this module was set-up to allow users to follow up continuously on the environmental programme for the projects which must follow a template decided by the region.
- PTS Technical program: to assist with preparing the technical description in building projects. It also offers the opportunity to automatically create the technical description directly in the tool.
- PTS Connect: communication exchange between PTS and external system is enabled and requirements for a project could be exported.

Another tool in the PTS portal is PTS Master, which manages information stored in the database and is kept updated by administrators from every PTS-connected region. Libraries of requirements can be found for the respective region, some examples are room templates, sustainability, and functional requirements. The final tool is the PTS Administration, which mainly manages usage rights to the different modules. It is managed by the local system administrator in the respective region.

1.3.2 Sykehusbygg HF

In addition to the study of PTS, its comparable system in Norway, Sykehusbygg was examined to gain in depth understanding of the Norwegian health case construction industry and their efforts to share knowledge across projects and regions. Sykehusbygg is a development and planning organisation which shall co-ordinate a national development of a knowledge storage of construction of health care facilities and they shall also be in the process for all investments over 500 million NOK. Summarised, it could be described as an organisation which is both active in larger projects and

responsible for preparing standards, examples and guidelines on a national level (CVA, 2018).

Sykehusbygg was created 23rd of October 2014 by the existing four health care regions in Norway with the purpose of assisting the improvement of facilities for health care, modernisation, know-how advice and also offer development of competence. As of 31st December 2017, Sykehusbygg had 85 permanent employed workers, 49 in the headquarter, 25 in Oslo, three in Stavanger, four outside Molde and two in Kristiansand. Additionally, two workers are employed temporarily. The purpose of its establishment was to centralise the process of developing health care facilities in Norway. All construction projects related to health care with a cost above 500 million NOK, must go through Sykehusbygg. The head office of Sykehusbygg is situated in Trondheim and their main role is to monitor and control major expansions connected to health care. By using Sykehusbygg, clients get access to national centre of expertise at an international level for hospital planning (Sykehusbygg, 2018). Sykehusbygg's vision is *"Vi bygger för pasientens helsetjeneste"* (Sykehusbygg, 2017, p.5), which translates to *"we build for patient's health care services."*

Their mission statement is divided into two parts; the first is knowledge and the second is project. The first part contains development of standardised solutions and different concepts with a knowledge database. Furthermore, it has developed processes, methods, models and tools. Additionally, this part includes the competence in the company consisting of employees and their external partners. Important knowledge and experience from managing projects and maintenance of new and existing buildings is gained and contributes to progress in the knowledge part. The second part is comprised of supporting regional health care authorities generally and in specific projects. The support is done in two ways, one is through managing the projects and the second, is through supporting by small advisory assignments (Sykehusbygg, 2017).

During the project processes, especially in the early phase, the Sykehusbygg system takes user input and economic considerations into account as well. For example, financial sustainability analysis is done at project level to prioritise among different projects, as well as patient and employee organisations' participation in the planning phase to meet their goal. In addition, the project is evaluated to make sure it contributes to knowledge-based and future-oriented development of hospitals (Sykehusbygg, 2017).

One of the many tools developed by Sykehusbygg and used in early phase is the Framskrivningsmodell. The main purpose of the model is to prepare quantitative and qualitative documents before decisions of how future health care should be dimensioned and conducted. Furthermore, users can test consequences of different standpoints. The model is based on development of new ways of working and technology and demographic forecasts. These are introduced in dialogue with specialists in healthcare and research. Although most of the data today focuses on specialised care, the goal of the model is also to include psychiatric care. Additionally, the municipal care in Norway which is responsible for primary care and dental care, is included and exemplified in process flows. However, the model is not created to calculate the consequences of the capacity and activity within municipal care because more extensive statistics are lacking. Investigations show that data from municipal primary care will increasingly influence the activities and capacity calculations in the model, mainly because a major part in the health care of patients is the responsibility of municipalities today (CVA, 2018).

1.3.3 Danske Regioner

In 2007, the previously 14 counties were put together into five regions as part of a major structural reform in Denmark, and the interviewee explained some of the reasons behind the change being that a greater overview over the sector was achieved, longer-term plans could be made that would fit a larger geographical unit. With the restructuring, the government set up an expert panel consisting of professors from the Scandinavian countries, and representatives from hospitals and the healthcare sector. Then the newly formed regions were required to apply for grants to build new hospitals, and the expert panel had the responsibility of assessing these applications and thus making suggestions to the government. The applications also had to include plans for how they would structure their hospital sector for the upcoming years and which hospitals to shut down for instance. The amount of funding available was 41 billion DKK, and the projects funded through this method are called quality fund projects. Currently, regions are managing their own construction projects and are responsible for the economy within projects. They have a dialogue with and are closely monitored by the Ministry of Health in Denmark. Regions are not able to finance themselves through collecting taxes from citizens, they are instead financed through yearly budget agreements with the government.

Knowledge and experience about construction of hospitals in the regions are shared frequently in various ways and levels. One way is through both formal and informal forums and networks, where experience and knowledge about relevant elements in hospital construction is shared by managers and employees from building organisations across projects and regions. Another method is through the Godtsygehusbyggeri project, wherein regions coordinate and innovate with a common focus on key topics such as building management, logistics, traceability and efficiency improvements. A third way of sharing is through a more informal method where quality fund building projects match themselves with similar projects in relation to the type of construction and/or are in roughly the same construction phase. This can then result in a professional sparring between the construction project's employees, study trips and other initiatives. A final way of sharing knowledge is through construction projects learning from buildings that are further ahead in the construction phase (Godtsygehusbyggeri, 2019).

1.4 Previous bodies for health care construction projects in Sweden

Sweden did not participate in the second world war and because of that they experienced a boom for more than 25 years, this resulted in a high amount of exports of products and services globally. The government in Sweden decided to build institutions and government offices which today form the foundation of the public sector. Between the years of 1957 to 1969 the government established 82 public institutions which centralised much of the society development and many of the them play an important role in the society today. To handle construction of health care facilities the government created three bodies, which together played a crucial role until they were disbanded. In 1960, the committee for the university hospitals' construction, University Hospital Construction Board (NUU) was created with the main responsibility to inspect and approve suggestions to construction work and purchases of equipment for municipality education hospitals, in cases where they have been given grants from the state. Additionally, NUU would come with comments on the

dimensioning, placement and design. It also worked for the use of educational and research interest regarding health care requirement Ring (2017). According to Ring (2017), NUU received a strong mandate to intervene in how the educational hospitals were planned, which was later used as an argument against the committee.

Eight years after the first body was created, the committee for social care and health care facilities, Social Welfare and Healthcare Buildings Board (NSB) was created with the purpose of reviewing some of the proposed drawings from health care clients. To build a new hospital or to do major extensions or rebuilding works, both the place and the drawings had to be approved. To overrule the decision of the committee, the case would be forwarded to the government. Additionally, the committee also reviewed and approved proposals of facilities and buildings in the areas of child care and elder care. In 1979, the committee was closed down by the government, mainly because of the decentralisation work that was prevailing during that time. The main reason for closing it down was that knowledge and experience could be gathered and used in a more decentralised way by health care clients in their respective regions. The Healthcare and Social Welfare Planning and Rationalisation Institute (Spri) was also created in 1968 with the aim to support health care clients in designing health care facilities in Sweden (Ring, 2017). Ring (2017), who himself worked with system during that time, says that many could not differentiate between Spri and NSB and in many cases an application to NSB was handled by officials in Spri.

1.5 Structure of the thesis

This section provides an overview of the outline of this thesis. The upcoming chapter introduces the theoretical framework used in the thesis, including knowledge management and its challenges, the different knowledge management systems in literature and practice, their success and failure factors, and communities of practice.

The methodology is presented in the third chapter, explaining the research strategy and approach adopted, the data collection methods, their analysis, and ethical issues faced during the research.

In chapter four, empirical findings are presented.

Chapter five provides a discussion of the empirical findings based on the theoretical framework presented earlier.

Finally, the sixth chapter presents the concluding remarks as well as suggestions for future research.

2 Theoretical framework

This section examines knowledge and knowledge management in the construction industry, looking at its history, its increased popularity in recent years, and different social and IT related tools that are used in the industry.

2.1 Knowledge management

Knowledge could be defined as "the product of learning which is personal to an individual", while information is seen as "the expression of knowledge, which is capable of being stored, accessed and communicated" (Kamara et al. 2002, p. 54). Nevertheless, there are other descriptions of knowledge, i.e. an invaluable economic resource which could be seen as a source of upcoming revenue or as an element in systems which performs tasks. If the knowledge element is absent during an extended time, it suggests that the system is rendered useless (ibid, 2002). According to Nonaka and Takeuchi (2000), knowledge can be defined as tacit or explicit. Explicit knowledge is the type which could be stated as formal and organised. This knowledge could be communicated and distributed through, for instance, specific formulas, manuals or details. Tacit knowledge, however, is personal and could be regarded as non-visible, almost never expressed, communicated, realised or measured (Leal, Cunha and Couto, 2017). In literature, there are different approaches to the understanding of tacit and explicit knowledge, the objectivist perspective and the epistemology of practice. As explained by Hislop (2013), the objectivist perspective believes that tacit knowledge sharing is known to be difficult, time-consuming and complex, while explicit knowledge sharing is simple. The perspective further supposes that tacit knowledge can be converted into explicit, through collecting and codifying relevant/important tacit knowledge that employees possess, into bodies of knowledge. He further goes on to state that the quality of organising the newly obtained explicit knowledge is equally important for its diffusion. That is to say, if the knowledge is merely stored as large piles of information or disorganised digital files, the knowledge would not be actively used or referred to in the organisation's work practices. In stark contrast to the objectivist principle, the epistemology of practice suggests tacit and explicit knowledge cannot be separated and that all knowledge constitutes both tacit and explicit components (Hislop, 2002).

Managing of knowledge is getting more and more relevant for companies to focus on (Carrillo et al., 2000; Xu et al., 2011). Knowledge management (KM) in the construction, architecture and engineering sector, could be described as a discipline which tackles the necessity for innovation and enhanced business performance, as defined by Kamara et al. (2002, p. 54) "KM deals with the organisational optimisation of knowledge to achieve enhanced performance, increased value, competitive advantage, and return on investment, through the use of various tools, processes, methods and techniques". According to the objectivist perspective introduced above, the steps involved in knowledge management include converting tacit to explicit knowledge, collecting the knowledge in a central repository, structuring the knowledge into categories or sub-sections, and the utilisation of information and communication technologies (ICT) to facilitate all these steps (Hislop, 2013).

When an organisation does not store and convey knowledge in projects with temporary virtual systems, there is an increased probability of repeating the same mistake as others have done, as well as the inefficient use of time and impaired execution in projects (Kamara et al., 2002). Opposing definitions of KM and the many different approaches

that are advocated for in research have hampered the attempts of the construction industry to reap the benefits of KM (Carrillo and Chinowsky, 2006). This claim is also echoed by Kanapeckiene et al. (2010), who said that the diversity in the definitions and understanding of KM has misguided efforts and failed to serve its desired purpose, especially in the construction industry. They therefore advice organisations to adopt one view on KM, then apply and modify it specifically to their business situation.

2.1.1 Knowledge management strategy

According to Hislop (2013), the knowledge management strategy adopted by the organisation should stem from the business strategy of the organisation, because of the role of knowledge resources in the successful achievement of the business strategy. He suggests that the business strategy, characteristics of the organisation with regards to its employee base, geographical spread, and cultural composition are some factors that influence knowledge management practices and their extent. He further lists the market environment in which the organisation is operating in as another factor influencing the type of KM strategy and practices of the firms. He makes a point about the level of standardisation of the products developed by the organisation, a relevant factor with respect to the construction industry, to have an influence on the KM practices of the organisations, elaborating that for firms working with routine projects across different sites and teams, knowledge codification and sharing is particularly important. On the other hand, if the firm works with unique projects every time, knowledge creation processes should be given emphasis. Likewise, from the case studies conducted by Zou (2012), he showed the importance of aligning KM with business strategy, and stated that, if this alignment was achieved, sustainable competitive advantage and benefit for both the company's business and the employees could be achieved.

Further in his discussion, Zou (2012) elaborates on how different knowledge assets require different processes and KM strategies to capture, store and share knowledge, by differentiating between two different methods that were used by the companies, one focusing on capturing knowledge from individuals, which is tacit knowledge, while the other focusing on capturing knowledge from individuals as well as technological infrastructures, attempting to capture both tacit and explicit knowledge. This observation is also supported by Carrillo and Chinowsky (2006) who also indicate that tacit and explicit knowledge require different approaches to be managed, as one form of knowledge is held by individuals and the other is in documented form.

2.1.2 Challenges with knowledge management

Hislop (2013) says that a key challenge found in KM is the willingness of employees to participate in knowledge management processes in the organisation. However, research is divided on this topic. Some research suggests knowledge workers to be ideal employees, and that motivating them to work with KM processes is not difficult because knowledge workers find their work intrinsically interesting and fulfilling (Alvesson, 1995; Alvesson, 2000; Deetz, 1998; Robertson and Swan, 2003). Conversely, Hislop (2013) explains that the major inhibiting reason for the workers was the potential for conflict between workers and higher management, and intra-organisational conflicts. He illustrates his point by reflecting on a case research where employees from two companies that had merged, were reluctant to share their knowledge with their new colleagues. For that reason, Zou (2012) explains that an

effective motivational system should be in place to encourage employees to make use of a knowledge management system (KMS).

It has also been noted that organisational culture affects KM through issues such as the willingness of people to share their knowledge, vertical silos in organisations where employees are not aware of what others are doing in the organisation, or if there exists a culture of internal competition that hinders knowledge sharing between 'competing' departments. Carrillo and Chinowsky (2006) discuss that if individuals would realise the benefits of KM processes to their work personally, they would be more motivated to use it. They further advice the use of human resource management strategies and methods to foster a knowledge sharing culture, by supporting teamwork or having a shared vision. Zou (2012) also commented on research carried out by Rezgui (2001), which indicated the important role IT is going to play for managing knowledge in the construction industry, and noted that it was important to reshape the business process and work to alleviate cultural barriers.

Carrillo *et al*. (2004) claimed that the major challenges for implementation of KM in construction companies are: not enough time, organisational culture, lack of standard work processes, and insufficient funding. On the other hand, according to the case study research conducted by Zou (2012), the most significant issue the companies faced was the cultural issue, particularly human behaviour, attitudes, thoughts and relationships. He recognises that with the introduction of KMS, individuals comfortable with their routines and methods would need to try something that can expose their weaknesses, leading them to develop resistance to the new methods.

2.2 Knowledge Management Systems

Kahlil Gibran, a poet from the early 20th-century once famously quoted *"A little knowledge that acts is worth infinitely more than much knowledge that is idle"* (Pasupathy, 2006, p.18). This is still appropriate to use today when discussing knowledge management systems despite the fact that it was said before the computer era. Moreover, Pasupathy, (2006) argues that knowledge management systems could deliver the part of Gibran quote which says *"A little knowledge that acts…"* (Pasupathy, 2006, p.18). A KMS can be described as a set of libraries, collections, databases and systems which solely focus is on using intellectual assets effectively. The system may include a wide range of information and could be presented as illustrative or written information for instance (Zhmaylo, 2018). According to Fibusch and Van Way, 2011, p.34) "*A KMS allows an organization to systematically manage knowledge in order for its workforce to acquire, create and use knowledge to innovate and compete in the marketplace".* A KMS helps create value for the organisation through the use of existing knowledge (Zhang *et al.,* 2009).

There are several other examples of frequently known definitions of knowledge management systems, such as that it is an IT-system with the purpose to support those in need through categorising, gathering, classifying and spreading information throughout an organisation. Another example is that KMS organises and makes know-how accessible anywhere and when needed; an additional example is that knowledge management integrates classification, intelligent searching and accessing of data from different databases, files and e-mails; or that it assists organisations to arrange data which may be stored in several sources and only provides relevant information through merging searching, indexing and push technology; finally, that it analyses information

and organises it in the databases of an organisation and in this way facilitating access to knowledge in all departments. Somehow in one way or another all of these descriptions reinforce the quote from Gibran which says that people with knowledge can use it more beneficially than while idle (Pasupathy, 2006).

Centobelli, Cerchione and Esposito (2017) define KMS consisting of two parts, as shown in figure 3 below, KM practice, that include methods and techniques supporting knowledge processes of creating, sharing and storing in the organisation; and KM tools, that are IT based systems that support KM practices.

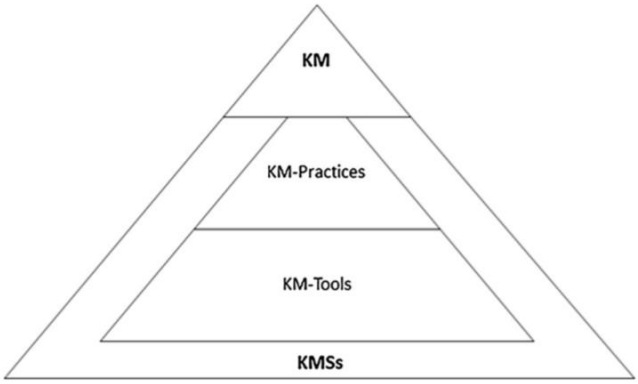

Figure 3: KMS by Centobelli, Cerchione and Esposito (2017, p. 295).

The vast majority of organisations have some kind of system to manage their knowledge. Some organisations use it more while others use it less. Below in figure 4, an example of KMS can be seen. The model was created by senior leaders in the Saint Luke's Health System of Kansas City in 2008 and altered by the authors for usage in their report. The reason for depicting the KMS as a house is because knowledge management is internal at all times. The model is reliant on the type of data that is put into the system, which could be external such as technical and economic data, it could also be internal such as human resource and information technology. To create a route from knowledge in the enterprise to a flow of information, the Saint Luke's Health System uses six process steps which is to collect, analyse, create, store, share and use. The tacit knowledge is made up by mentoring, internal and external education of the workforce, teams and committees, a culture of a non-stop learning and by human experiences. Furthermore, the explicit knowledge is made up of research data, best practices, e-portals, tools for collaboration, information systems etc. The main goals of this KMS is to grow, sustain and innovate. To reach these goals would not be possible with a leadership lacking a visionary approach which stresses the importance of persistent use of data to create knowledge. Additionally, KMS can be perceived to be the instrument of leaders to achieve the goals mentioned above. According to Fibuch and Van Way (2011), a KMS is a requirement for a truly effective management of knowledge.

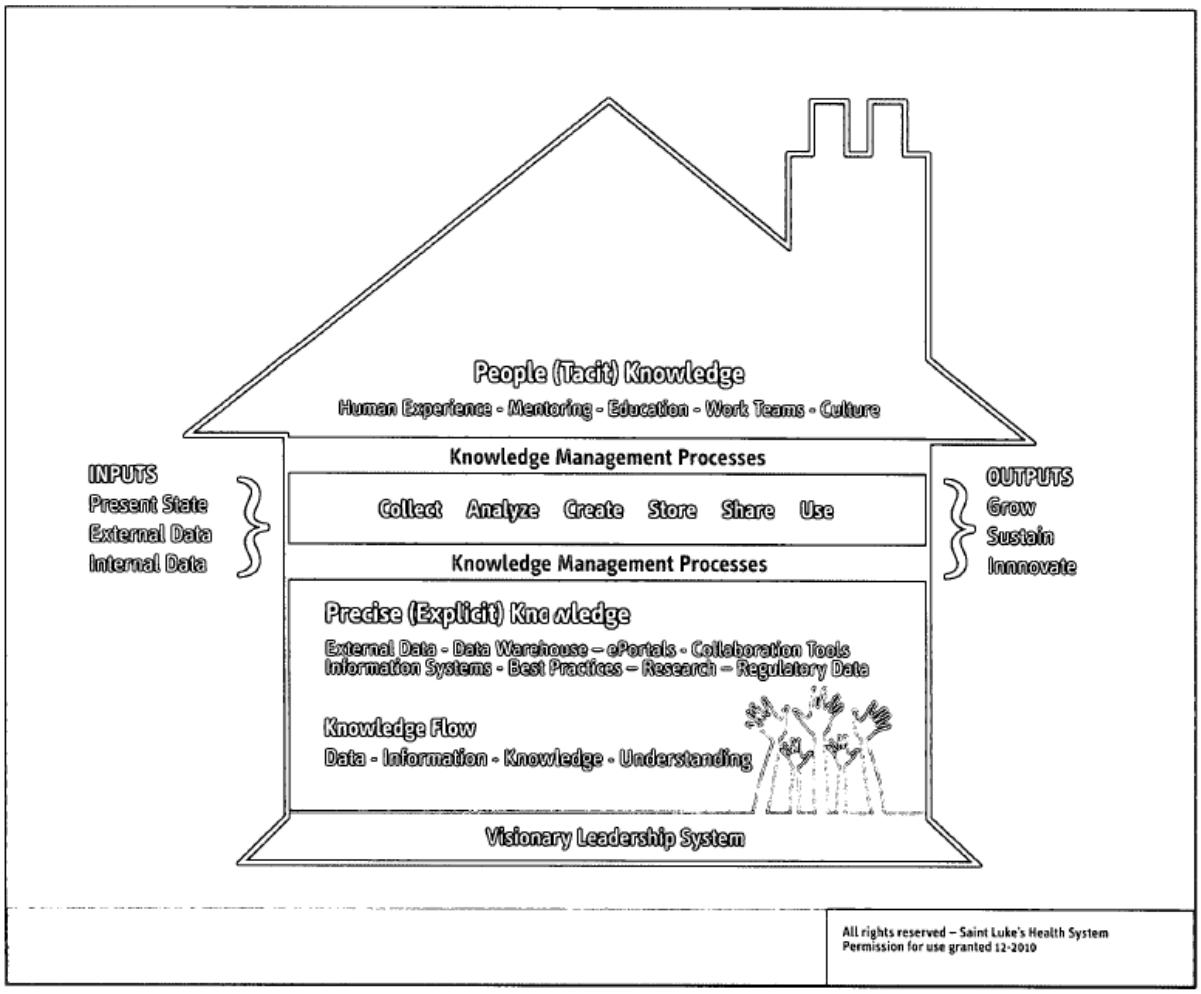

Figure 4. Example of a KMS. From Fibuch and Van Way (2011, p. 35).

According to Milovanović (2011), KMS projects usually have one or more of the following aims:

1. Creating knowledge warehouses - Storing documents for easy retrieval in the future.
2. Improving access to knowledge - Having a repository of knowledge alone will not be sufficient unless access to knowledge through its effective searching and transfer is established.
3. Enhancing the knowledge sharing environment - The aim is primarily to foster an environment facilitating knowledge processes for creating, sharing and using knowledge.
4. Managing knowledge as an asset for the organisation - Knowledge is treated like any other asset for the organisation, and it is also accounted for in the company's balance sheet.

KMS have been divided into two generations to indicate the organisation's KM maturity as described by Dave and Koskela (2009). The first generation KMS is based around people sharing knowledge and ideas. These systems include emails, document management systems, content management systems, intranet, information portals etc. The second generation of KMS is used to aid employees in creating knowledge and thereby promote innovation in the organisation. This group of KMS consists of wikis, forums, blogs etc. Because of the temporal nature of the construction industry, KMS

are required to retrieve vital knowledge and information from team members before they move on to other projects or companies (Zhang *et al.*, 2009).

2.2.1 KMS in practice

From their study, Carrillo and Chinowsky (2006) found that half of the organisations studied had ad-hoc processes to retrieve lessons learned from projects, and around half do not employ communities of practice (CoP) to exchange ideas and discuss problems. They further found that a significant percentage of the organisations do not make use of IT tools for KM, and around two thirds of the organisations are slow to react to potential improvements in KM processes. In addition, they believe that a 'lessons-learned' session and a project extranet are not supposed to be considered KMS. The former has many shortcomings as they are not conducted in a systematic manner, some stakeholders may be missing, and records may not be kept. While the latter is only an information system and not a KMS. Dave and Koskela (2009) discuss some of the tools used by organisations as KMS such as intranets and extranets, which are web-based platforms that contain contact lists, standard forms, and company information. Furthermore, Zhmaylo (2018) stresses that through these systems you are able to accomplish the three crucial requirements of users, which are to provide users with a sense of belongingness in a group, access to multimedia, and the demand for search result to be correct despite a not clearly defined information request. Dave and Koskela (2009) however, point out that these systems mainly work with explicit knowledge and not tacit. Further, they list social networking applications such as forums and wikis that focus more on sharing tacit knowledge. There are also other ways to provide people access such as through integrated decision-support systems.

According to Milovanović (2011), some of the most important IT tools used as KMS include:

- Systems for document management - Storage of the company's documents and contain tools to create and manage complex documents.
- Data warehouses and data mining - Platforms that support extraction and the analysis of information for decision making purposes.
- Enterprise information portal - A web application providing personalised information to both external and internal users.
- Groupware - Assist tacit knowledge exchange between employees.
- Workflow - Knowledge transfer processes are formulated, and flow of information is managed according to the flow of work processes.
- Knowledge mapping - Similar to yellow pages for connecting knowledge searchers and possessors.
- Training systems and simulation software - Employees acquire knowledge, and aids conversion of explicit knowledge to tacit.

Milovanović (2011) further argues that the above-mentioned IT tools need to be operated with social components in mind, where together they constitute a KMS. These social components include:

- Tacit knowledge
- Organisational structure - a flexible organisational structure is suitable from a KM perspective, these are project and team-oriented structures that gives members the authority to make decisions on the project.

- Organisational culture - Having a culture that encompasses both business issues and human resources would help KM efforts.
- Individual and organisational learning - includes among other initiatives, employee training, communities of practice, and knowledge sharing group.

2.2.2 Failure factors of KMS

According to a study done by International Data Corporation on the knowledge management market, the market value has increased significantly and reached a value approximately 5 billion USD. In spite of the spread of applying KMS, reaching its goals is still a demanding task. Another surprising fact mentioned by Matayong and Mahmood (2012) is that 50-70 % of KMS projects do not obtain the desired benefits.

Malhotra (2004) stated one reason for the failure of KMSs to be the lack of inclusion of variables such as attention, motivation, commitment, creativity, and innovation on KMS inputs like data, information technology etc. He further stresses that KMS should be developed to adapt with the changing business environment, and the advancement in IT to avoid obsolescence of the systems. Akhavan *et al.* (2005) on the other hand, indicated through analysis of their case study, that the lack of top management commitment was one of the reasons for the failed implementation of the KMS. They also highlighted the lack of qualifications of the employees who were responsible for running the KMS as another important reason behind its failure. From another perspective, it is important for the KMS to be as simple to use as possible for non-experts as well. They further noted the lack of cooperation between organisation employees and the KM team, and the organisational culture as factors that led to the failure of the KMS (ibid, 2005). Milovanović (2011) wrote that research has shown that a lack of knowledge sharing, and collaboration culture are among the main hindrances to IT implementation in an organisation, and thus suggested that organisations should recognise their culture profile before embarking on implementing a KMS.

In their study, Ballal and Elhag (2006) noted that there was a difference in the perception of the obstacles to KMS between companies that used and did not use them. The main obstacles to KMS according to companies making use of the systems included: the unwillingness to share knowledge, corporate culture, and time pressures; while the companies not using KMS said the main obstacles were: time pressure, scarce project resources, and unawareness of KMS benefits. In another study conducted by Lin *et al.* (2006), although the respondents who participated in the case study said that the map-based knowledge management system was perceived to be helpful for KM, they did comment that: it was still difficult to acquire and manage experience and knowledge using the knowledge database content; most people were not willing to share their knowledge and experience without having a reward system; and it was difficult for the engineers to manually input the information.

2.2.3 KMS success factors

From the case study research conducted by Akhavan *et al.* (2006), a framework for the successful implementation of a KMS, as depicted by Figure 5 was formulated, which consisted of 13 factors that were divided into three layers. The first inner layer consists of knowledge architecture, knowledge strategy, knowledge sharing, knowledge storage, and knowledge identification. The second middle layer is made from factors such as

business process re-engineering, pilot, organisational structure, and training programmes. These factors can be seen to support and guarantee the success of the KMS. The final outer layer consists of more general aspects existing in the organisation such as organisational culture, transparency, CEO support, and trust. On the other hand, Milovanović (2011) identified the following factors that according to him are critical for a KMS: support of top management and leadership, having organisational and social structure supporting learning, and building a culture to support knowledge sharing. He further elaborated that the support from top management and the leadership is supposed to stem from their strategic planning for the company, planning the effective use of resources, facilitating the creation of a culture of sharing and learning. They should also set up a motivational and stimulative mechanism for risk taking, learning and knowledge sharing.

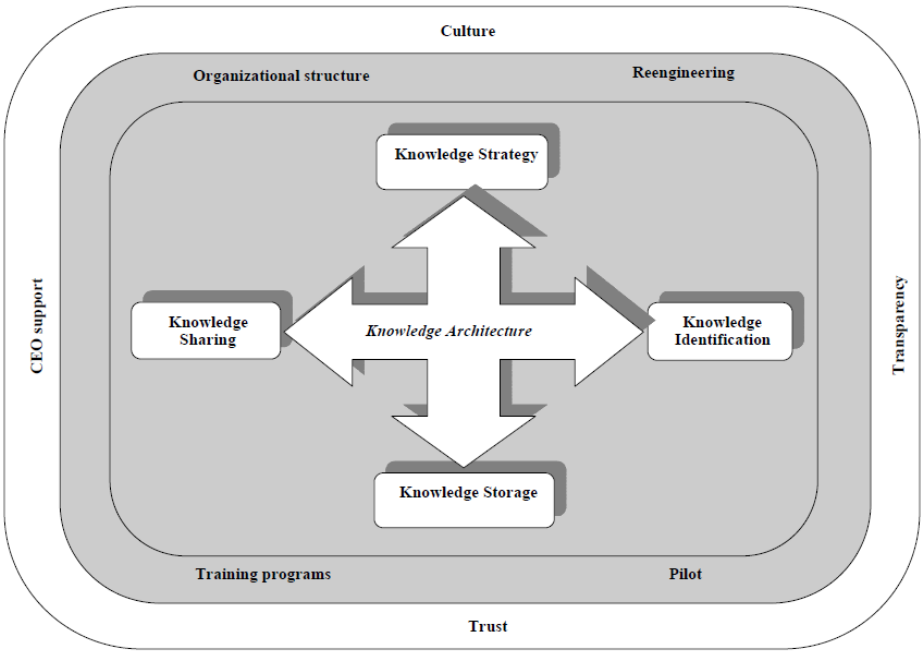

Figure 5: Conceptual framework of a KMS (Akhavan et al., 2006, p. 111).

2.2.4 Benefits of KMS

Through KMS people are able to share experience and knowledge which is tacit, by using IT-systems and knowledge maps. If people then make use of the tacit knowledge in KMS, the people's own knowledge could increase. A real-life example where KMS were applied is the company British Petroleum that has managed to save millions of dollars in costs for travelling and downtime each year by using videoconferencing to come up with solutions for critical operational problems (Xu & Quaddus, 2005). Ballal and Elhag's (2006) study noted that there was a difference in the perception of the benefits of KMS between companies that used and did not use them. According to companies that used KMS the main benefits included: increased profits, improved processes, and risk reduction; while companies that did not use KMS identified the benefits to be: increased competitiveness, improved teamwork, and enhanced project success. Moreover, from the respondents in his case study, Lin (2012) found out two benefits in using the BIM based KMS. The first being that it made automatic corrections and notifications when changes were made to the project knowledge base, and the other

that it was easy for the members to obtain knowledge and experience related to the project.

2.2.5 Knowledge mapping

One type of KMS as listed by Milovanović (2011) is knowledge mapping. Lin *et al.* (2006) define a knowledge map to be *"a diagrammatic and graphic representation of knowledge illustrating how knowledge and knowledge attributes are related"* (ibid, p. 696). Its main purpose is to assist users in finding knowledge easily. The advantages of using knowledge maps are that they are visual methods that are easy to use and interact with, and that they facilitate the identification of critical and easily available knowledge areas of a project.

According to Anumba, Egbu and Carrillo (2005), developing a knowledge map that locates tacit knowledge is one of the first steps to structure knowledge in a construction project. The different type of elements or items could be depicted as drawings/graphics or as texts, documents, symbols, etc. Having a map would facilitate locating the right person for a specific task. One top consultant organisation created a type of knowledge mapping by having available skills listed in yellow pages, this facilitated the process of finding the right person. Additionally, Lin *et al.* (2006) claimed that knowledge mapping provides a blueprint for KMS implementation, as it helps identify the organisation's intellectual capital, socialise its members, and improve its learning. The major risk associated with knowledge maps is not keeping them up-to-date.

2.3 Knowledge in projects

According to Zou (2012), in the construction industry, there are three categories of knowledge, these are: domain knowledge, organisational knowledge, and project knowledge. Table 1 below gives a few examples on these knowledge types as described by Zou (2012, p. 19).

Table 1: Examples of knowledge types in construction projects.

Type of knowledge	Examples
Domain knowledge	Administrative information, standards, technical rules, product databases etc.
Organisational knowledge	Firm's intellectual capital – Personal skills, employees' project experiences, inter-firm and stakeholder relationships.
Project knowledge	Project records, process memory, problems and solutions.

To facilitate live capture of knowledge, Kamara *et al.* (2003) propose using both soft and hard tools. They list learning histories as a 'soft' method for live knowledge capture. Learning history is described as *"a process for capturing usable knowledge from an extended experience of a team and transferring that knowledge to another team that may operate in a different context"* (ibid, p. 4). They explain that this process can

be used by another project team when they face difficulties in a different situation. The hard tools they propose consist of ICT applications such as extranets, workflow management tools and other groupware applications for collaborative working.

To allow for knowledge transfer across projects and organisations, Bresnan *et al*. (2004) argue that knowledge is required to be context-independent. However, knowledge is context-specific, and each individual or organisation 'translates' the knowledge to their understanding. In addition to this, Lin *et al.* (2006) mention a survey that found face-to-face meetings, e-mail messages and technical business gatherings as fundamental knowledge transfer mechanisms. However, these types of mechanisms do not come without issues such as mis-interpretation depending on the situation and context. Also, according to Bresnan *et al*. (2004), tacit understanding within social contexts developed through shared experience facilitates explicit knowledge sharing.

Research has shown that project-based organisations face difficulty in capturing, sharing and diffusing knowledge and learning across projects, citing the contradictory nature of short-term project objectives and long-term development required for organisational learning as the reason behind these difficulties (Bresnan *et al*., 2004).

According to Kamara *et al.* (2003), at the time of their research that aimed at developing a tool for the live capture of project knowledge, KM in the construction industry was largely informal and based on people. They further noted that there was a trend at that time towards more 'recognised' KM strategies. They list some of the early KM techniques to be codes of practice, standard operating procedures, and best practice guides. They go on to give a thorough picture on another knowledge capture method that was used in the form of post-project evaluation, and thereafter discuss its disadvantages. In their study, they conclude that the issue of knowledge management should be handled by employing both IT systems as well as developing a focus on organisational and people-related issues; implementing one part without the other would not lead to a desired outcome. Likewise, Kanapeckiene *et al.* (2010) suggested conducting KM in the construction industry through both IT and human interaction (socialisation). Milovanović (2011) agrees that organisations should establish the correct IT platform according to the organisational and social context of the company, and also establish a structure and culture that supports knowledge practices.

The case of project organisations in the construction industry is somewhat different to that in other industries. The organisations are the result of projects, and not the other way around. This indicates that the organisation itself is not static/stable, as it must adapt to the projects it is involved in. In some cases, this also leads to weak bonds between the project and the organisation. The organisation thus requires use of unique ways for knowledge diffusion and working practices that would consider the constantly changing project conditions and the dynamic organisation (Bresnan *et al*., 2004).

According to a study carried out by Bresnan *et al*. (2004) in which they examined project-based organisations in the UK construction industry, they determined that it was important to understand project characteristics such as decentralisation, short term emphasis on performance, and distributed work practices to develop the organisation's ability to learn and share knowledge.

2.4 Knowledge sharing

In the construction sector, there are numerous facilitators of knowledge sharing. Some examples are social factors, extrinsic incentives, intrinsic motivations, conformity and reciprocity. Despite all the facilitators, there are many hindrances that restrict the sharing of tacit knowledge such as the lack of trust between contributors and receivers, and knowledge providers not willing to share information with possible competitors. To achieve knowledge sharing in construction projects, it is important to gather information from start to end and then apply it in the following projects. In Table 2 below, facilitators and inhibitors found in the literature are shown (Leal, Cunha and Couto, 2017).

Table 2: Facilitators and inhibitors of Knowledge Sharing (Leal, Cunha and Couto, 2017, p. 1000).

Inhibiting factors	**Facilitating factors**
Resources – Mainly time	Financial/Social motivations
Mainly a male sector	Conformity to corporate culture
High turnover	Reciprocity
Low level of training, intellectual capital	Perceived value and uniqueness of knowledge
Culture	Peer recognition
	Mimicking the behaviour of leaders
	Culture

These factors could be divided as shown in Figure 6, whether they are individual or organisational factors. Remarkably, all the inhibitors of knowledge sharing in construction sector are organisational factors according to Leal, Cunha and Couto (2017).

	Individual factors	**Organisational factors**
Facilitators	Conformity to corporate culture Reciprocity Perceived value and uniqueness of knowledge Peer recognition Honouring KS commitments Mimicking the behaviour of leaders	Financial/social motivations Culture
Inhibitors		Resources – Mainly time Mainly male sector High turnover Low level of training/ intellectual capital Culture

Figure 6: Individual and organisational inhibiting and facilitating factors (Leal, Cunha and Couto, 2017, p.1001).

To avoid losing knowledge acquired in construction projects it is of utmost importance to have an effective knowledge sharing process. Some of the main approaches identified by Leal, Cunha and Couto (2017) for managing knowledge in construction are, to develop best practices and to share critical tacit knowledge. Table 3 and Table 4 below present the different type of facilitators and inhibitors shown above in Table 2. However according to Zou (2012), architecture, engineering and construction (AEC) companies should make use of KM in order to reinforce management roles, increase competitive advantage, and improve innovation capability. He further suggests the use of IT, integration of business processes, motivation of employees, and positive culture to improve the chances of success for KM.

Table 3: Facilitators framework (Leal, Cunha and Couto, 2017, p.1001).

Financial/social motivations	To achieve goodwill knowledge sharing and overcoming barriers, it is important to develop a structure of rewards and incentives.
Conformity to corporate culture	To be able to maintain a knowledge management system it is of vital importance to keep a culture which is both coherent and supportive.
Honouring KS commitments	By committing to knowledge sharing openly, people have a need to show that they are reliable to others and honourable to commitments made.
Peer recognition	To be regarded as an expert, is in the interest of people because this could in the end be seen as a source of power.
Perceived value and uniqueness of knowledge	People see knowledge more important, the less available it becomes. This results in some workers seen as more fascinating.
Reciprocity	When sharing knowledge people generally expect something in return, i.e. relevant knowledge.
Mimicking the behaviour of leaders	By having leaders that set an example in knowledge management activities, the likelihood of others following the lead increases.
Culture	This factor is regarded by many as one of the most vital in achieving a successful implementation of knowledge management in a project. The norms and rules for conducting yourself in an organisation is based on a culture.

Table 4: Inhibitors framework (Leal, Cunha and Couto, 2017, p.1001).

Resources – Mainly time	One of main reason to not share knowledge, people say is the shortage of time.
Low level of training/intellectual capital	Due to inability for knowledge, there is a loss of intellectual capital. Carrillo stresses that due to the low training of the employees there is a deficiency in standardised work processes.
High turnover	Another vital inhibitor is the lack of staff who have worked in the organisation for an extended time and having a small number of workers who defect.
Mainly a male sector	Women understand individual specific information better than men.
Culture	As the norms and rules in an organisation are based on a culture, it could also act as an inhibitor for managing knowledge.

2.4.1 Resistance to new knowledge and how to avoid it

In their case study, Bresnan *et al*. (2004) observed that the 'good' managers were the most reluctant to implement a KM tool because they already had processes in place that were working exceptionally well for them. Because the project managers possessed vital tacit knowledge, making them important to the company, they could resist the introduction of new tools/knowledge. They therefore inferred from the study, that for knowledge to be widely accepted, it should be established in the existing working practices and shared understandings, norms and values, and that one should also consider the influence of power relations and control within the organisation for the success or failure of knowledge diffusion. Interestingly, they also concluded that some project management practices can have a passive influence on organisational change and learning (Bresnan *et al*., 2004).

On the other hand, in his research, Zou (2012) narrows down the success of KM to the existence of a climate of trust, without which knowledge stored in databases and IT tools would be useless and static. From another study conducted by Leal, Cunha and Couto (2017), some of the main reasons for resisting the use of information technology tools on knowledge sharing is not taking into consideration people's capability, motivation and opportunity to share knowledge and the established nature of knowledge sharing. Bresnan *et al*. (2004) in their study state that the KM tool being studied was perceived to be rigid and static because it did not support the teams close to deadlines when their working methods changed to meet the deadlines which suggested that it did not have dynamic project performance capacity. They also found that it was easier to use the tool and hence easier to implement new knowledge when the regions were conducting similar, more predictable projects, rather than when they had variable and unpredictable projects. Bresnan *et al*. (2004) say that this is because the criteria for success are clearly known when working with similar, predictable projects.

Bresnan *et al*. (2004) further identified the influence of existing structural conditions and working practices in projects within the same organisation, on the success and/or failure of the implementation of a new project management tool. Because the company in the case had a decentralised structure which was divided into autonomous geographic regions, it was met with resistance when the company tried to introduce changes in their work practices.

2.4.2 The project organisations' configuration

The construction industry works through non-routine production processes and has complex inter-professional and interorganisational relationships that govern the interactions between the parties. In addition, project teams often constitute individuals with different professional and organisational backgrounds. This complicates the possibility of knowledge captured/gained in one project to diffuse and be used in another one. The complication can be further severed because of the influence of close working relationships within the project team that were developed during one project, against the fresh, weak bonds in a new project (Bresnan *et al*., 2004). Interestingly, Hislop (2013) elaborated on another aspect of knowledge work practices, stating that knowledge workers are faced with an identity conflict, where they feel connection to both the parent organisation and the client organisation. Research looking into this issue found that knowledge workers were reluctant to contribute to their parent organisation's knowledge management processes (Grimshaw and Miozzo, 2009; Ravishankar and Pan, 2008).

In addition, the type of organisational structure can either encourage or hinder knowledge transfer. For instance, according to Van Wijk *et al.* (2008), the number of relations and the organisation's position in the network are significant factors for inter-organisational knowledge transfer. On the other hand, Mason and Leek (2008) spoke of 'soft' mechanisms that allow actors working together on a project to learn from each other, similar to communities of practice. They further go on to state that a hierarchical structure would affect the initial setting up of inter-organisational routines and would impact on where knowledge codification and articulation takes place.

Transferring knowledge between organisations takes on different forms, such as training members in the recipient organisation, socialising activities, transferring experienced personnel, or by providing documents, blueprints or hardware. Organisations are usually reluctant to share knowledge with other organisations, thus limiting their capabilities when they engage with each other. This is true particularly when the capabilities are highly tacit and core to their business, when the receiving organisation shows strong interest in learning, and when the organisations are very similar resource wise (Easterby-smith *et al.*, 2008).

2.5 Communities of practice

Communities of practice is a network of professionals created through the process of working together by coming to an agreement through discussions. Additionally, there are two parts to the meaning, involvement, and making things concrete. For instance, by involving people through social interactions, the CoP stays together and forms a strong bond. The other part of making things more concrete has the purpose to create meaning through manifestation of a wide range of cognitive activities. To have a shared

practice is required to be able to share knowledge between people because it facilitates the flow of knowledge within a group. Furthermore, a shared system of meaning enables an effective and possible communication of knowledge within a CoP. Another benefit with CoP is that it could be used in a way where it acts as a facilitator for integrating functional areas such as marketing and design for instance. According to a study made by Carillo *et al*. (2002), they concluded that the most extensively used knowledge sharing technique is CoP. The ones who gain the most and have the greatest demand from CoP, are major international construction firms with an extensive range of specialist competences (Anumba, Egbu and Carrillo, 2005).

An interesting observation that Carrillo and Chinowsky (2006) made was that a proactive feedback mechanism was established in the case study companies, where views of the front-line employees were used to improve the KMS. This had a psychological impact on the employees seeing that the organisation valued their opinions. Moreover, because one of the companies was employee owned, there was no need to have a reward system to motivate the employees to use the KMS.

There is more to KMS than only computer technology according to Xu & Quaddus (2005). They then continue saying that more focus should be on topics such as infrastructure, culture and the content. According to Ford and Murphy (2008), IT systems in knowledge management are less effective in storing tacit knowledge compared to explicit knowledge. Furthermore, they also mention that using IT based strategies for knowledge management has been criticised for overstressing knowledge which is explicit at the cost for knowledge which is tacit. Interestingly, Dave and Koskela (2009) claim that IT based KMS such as intranet, extranet and document management systems can be difficult to implement and could actually have negative effects on the organisation's KM capabilities, because these systems are often linked to information overload as a result of unorganised and ad-hoc information exchange.

While early literature stressed the importance of gathering and storing knowledge in IT systems, more recent literature has focused on issues around the people who will use it, because the sharing and learning of knowledge does not start automatically when installing an IT-system. An important factor for knowledge sharing and learning is removing barriers between functional departments. In many cases in the public sector there is a predominance of bureaucratic structures which does not favour sharing of knowledge. Sveiby and Simons (2002) say that the private sector commonly has a more superior collaborative climate than public sector organisations. They continue suggesting that a reason for this may be the difficulty of integrating public services when hindered by secret and open problems of territory and control. Other reasons that may delay and undermine the implementation and use of technical systems may be aspects related to the economy, politics and society. Reid, Bardzki and McNamee (2004) point to the rooted culture as the reason for the unwillingness of sharing information and knowledge which is accredited to the inexistence of trust.

3 Method

This section shall shed some light on the methods employed in the study with regards to the research strategy and design, and the data collection and analysis. Towards the end of the section, ethical issues faced have also been reflected upon.

3.1 Research strategy and design

This study adopted a qualitative method, with an abductive approach, which is meant to create an understanding of the social world through the lens of its participants (Bryman, 2012), conducting a literature study, a case study from literature, interviews in Norway and Sweden with actors working on healthcare projects, Sykehusbygg, and PTS, and observations, where possible, of PTS.

It is however known that qualitative research has its fair share of criticism. Bryman (2012) states that qualitative research is very subjective, where the researcher gets to decide on the areas to focus on based on their views. Moreover, because of its unstructured format and the fact that no real standard procedures are followed, it is hard to truly replicate. In addition, generalisation of the population based on the sample group of individuals, events, etc. can end up giving wrong interpretations of the population. Finally, it can be difficult to actually know what the researcher has done and how he/she has arrived at the conclusions.

3.1.1 Literature review

The aim of the literature study was to form a solid base of the subject and explore the opinions and recommendations from prior research in the field of knowledge creation, sharing and management, the PTS system in Sweden, and Sykehusbygg in Norway. The literature study was based on academic articles, journals, conference proceedings, and master theses that were searched through Google Scholar, Chalmers Library and Scopus. Some of the keywords used were ‘knowledge’, ‘standardisation in construction’, ‘knowledge management in construction’, ‘knowledge management systems’, ‘healthcare construction’, ‘IT knowledge systems’ etc.

3.2 Data collection method

Interviews were conducted to obtain information on the handling of healthcare construction based on Spri, PTS and Sykehusbygg, on the knowledge management platforms established in their organisations, and the current practice in the industry. The interviews were semi-structured for in-depth understanding of the responses. Two interviews were conducted in a face-to-face setting, two other interviews were conducted over Skype, and due to technical issues, three interviews were conducted over the telephone. The interviews lasted between 40 and 70 minutes each, as shown in Table 5 below. The type of questions asked in the interviews can be broadly divided into three themes: Interviewee’s background, main part, and conclusions. The interviewees were chosen based on their experience with PTS, Sykehusbygg and healthcare construction projects in the Scandinavian region. It was realised after the first interview, that conducting the interviews in English for respondents who had Swedish as a native language affected the quality of the information obtained, hence it was decided that the subsequent interviews with Regions A, B and C shall be conducted in Swedish, and thereafter translated to English.

Table 5: List of Interviews conducted.

Organisation	Role	Type	Time	Language
PTS	Representatives from PTS system	Face to face	60 min	English
Sykehusbygg	Manager	Telephone	40 min	English
CVA	Senior Lecturer	Face to face	45 min	English
Danske Regioner	Consultant	Telephone	50 min	English
Region A	Section Manager	Skype	50 min	Swedish
Region B	Function Planner	Skype	70 min	Swedish
Region C	Manager	Telephone	45 min	Swedish

3.2.1 Transcribing interviews

The interviews were audio-recorded and thereafter transcribed, in order to be able to perform a complete analysis of what the interviewees said. One of the many benefits with transcribing is that the natural limitation of the memory of interviewers and the interpretation on what people have said in interviews will be corrected. Another benefit is that it allows interviewers to study the interview more in-depth by for instance repeating the recording (Bryman, 2012). Because some of the interviews were conducted in Swedish, it was a challenge to capture what was said in Swedish in the English translation of the interviews, a challenge that is encountered in every translation task. In some cases, a close translation that captured the point or claim of the respondent was cautiously used.

3.3 Data analysis

Qualitative data usually leads to collection of huge amounts of data which is seen as one of its disadvantages (Bryman, 2012). Moreover, analysis of qualitative data is perceived to be difficult, requiring filtering, sorting and other processes to create meaning, compared to quantitative data (Fellows and Liu, 2015). Therefore, after the interviews were transcribed, NVivo was used to analyse the results. NVivo is a computer aided qualitative data analysis software that simplifies data analysis and finding relationships between the interview responses. Transcribing interviews was considered the first step of analysis (Bryman, 2012), thereafter, coding was used to categorise the compiled data into specific themes, in the form of words and short phrases. In addition, during the interviews, one could focus on the non-verbal behaviour of the respondents to identify aggression or nervousness (Fellows and Liu, 2015). The purpose of data analysis is primarily to provide information and relationship between variables, but also to provide evidence of relationships and support decision making (Fellows and Liu, 2015).

3.4 Research reliability and validity

When social research is conducted, as in this case, reliability and validity of the data are two important criteria to consider (Bryman, 2012). Reliability of the research requires that the same results are obtained in constant circumstances at any given time (Bell, 2010). On the other hand, validity is a more complex phenomenon. It is concerned about the conclusions' integrity in the research (Bryman, 2012). There can take on different forms such as measurement validity, internal validity, external validity, and ecological validity (Bryman, 2012). Important to note for an interview study is that opinion-oriented questions can get different answers due to various reasons, then if an item is unreliable, it also lacks validity. At the same time, it is not necessary that a reliable item is also valid. Similar responses can be obtained on every occasion despite the fact that it is measuring the wrong variables (Bell, 2006).

3.5 Ethical Issues

Kvale (2007) recommends interviewers to inform interviewees on the overall purpose and procedure of the interview, which could include data on confidentiality and who will have access to the interview. Additionally, information regarding the right to publish the interview fully or partially, and the interviewee's possible access to the analysis and transcription, may be included but in many cases, this is not something required. Further on, he suggests interviewers to keep a written agreement to protect both parts. Another recommendation is that preventive measures need to be taken for interviews done privately which possibly could be published in public reports. However, interviewees may in some cases want their name published due to the amount of time and effort spent and Parker (2004) reasoned that this may expose the researcher because the information about the study cannot be controlled and would be disseminated. Parker (2004) continues saying that the option whether to publish the names of those who take part should be discussed openly with them.

In our study, the interviewees were made aware of the purpose of the study, and their participation in the study was voluntary. Furthermore, data was stored securely offline, and after the study, destroyed. In the thesis, the different regions are identified as A, B…E for the purpose of anonymity.

4 Empirical findings

This chapter shall present the empirical findings from the interviews and observations conducted. The findings are arranged by presenting each organisation or region individually.

4.1 PTS

PTS is a flexible system according to the interviewees. The regions have the freedom to choose what guidelines, designs and modules they would want to use in PTS for each particular project. Additionally, PTS can be used for any project type, not limited only to healthcare projects, as was done during the Spira project in Jönköping, where they used PTS to design the unique rooms for the cultural building.

> *"Every user can submit their own suggestions to make the system better, because the system is not a static system, this is what you get, it is more like what the users say what the system is going to be so if their suggestion is good we could develop it and implement their suggestion so that it fits their needs."*

For new regions, the PTS team, made up of the National System Administrator and the Development Manager, arranges visits to help them familiarise with the system. They also assist through Skype when requested. To improve the assistance, PTS are currently developing video tutorials for the regions as a simple, time-saving and quick alternative to the visits and Skype meetings. Furthermore, the regions can decide by themselves on their PTS implementation strategy. Two regions that chose two different ways of transition were brought up in the interview, where one chose a slow process of implementing PTS, while the other region chose a fast track implementation of the system.

Improvements in PTS are done based on the demands of the users. The PTS board allocates some amount of money for each module through their budget, which would determine their focus and improvement strategy for PTS. Then, throughout the year, the users in the forum discuss and decide on the functions, modules or information that need to be updated or added, which is then taken up by the National System Administrator, who then has the responsibility of making the improvements. The interviewees said that they try to implement suggestions on modules or functions that would benefit many member regions in several projects, and not functions that would be required for only a single project.

> *"The system is like a living being that is developing all the time."*

It was also mentioned that not all PTS modules are used equally. Likewise, different member regions do not use PTS equally, reasons for this were claimed to be the amount and size of projects but also the PTS implementation stage of the region. An example was given of a region that was regularly using PTS when they had large projects compared to now when they have relatively smaller projects. The most used modules in the system are Room Function Program (RFP), Facility planner, and the forum. One of the key functionalities missing from PTS stressed by the interviewees, is that you cannot view rooms in CAD-viewer or 3D. Because of this, PTS users have to switch to

another system like dRofus, to be able to view rooms in 3D. Furthermore, the fact that five regions are still not members, affects PTS negatively, as they themselves say they cannot yet be considered as a nationwide organisation, which is their interest. Thus, the interviewees stressed that it was up to the board to decide on the strategy for expanding their member base.

According to the interviewees from PTS, the main reason other regions have not joined PTS yet is due to the costs of becoming members but explains that the cost goes into preparing and setting up the system at the region's premises, and that the system is worth more than the cost they would pay.

4.2 Region A

In the different regions, the amount of times PTS is used and the specific modules that are used in their projects are left to themselves to decide upon, according to their specific requirements locally. In some cases, the modules may require to be modified to suit the use in that particular region. PTS has been of immense benefit for region A, especially when they have had detailed RFPs in the early stages of the project. This has led to clearer understanding for the consultants who then develop improved drawings and specifications for the project, eventually leading to smooth project progress. PTS has also helped the region to standardise healthcare facility design, that is based on laws and regulations that have been agreed upon by a group of professionals, hence it is something concrete to design upon. It has supported designs that allow for the creation of a good working environment for the healthcare professionals taking care of sick patients.

In PTS, all the users have their own specific groups or what they call councils, where they meet and communicate digitally around the year, discussing on ways to improve the system or prioritisation of suggestions for improvements (then forwarded to the PTS team or National System Administrator). Moreover, they have the PTS forum days which are popular and highly anticipated among the PTS member regions, organised every 18 months.

> *"PTS forum is the network you could say, we have a page in the program where you show some things and then a day is arranged every 18th month, there will be lectures on things that influences the facility planning and the health care, and we also talk about the system, how can we develop, how can we improve etc."*

Outside PTS, function planners in Sweden have a mailing list of their colleagues from other regions, whom they contact when they need help. The interviewee describes the atmosphere as generous, where they help each other by posing questions on any issues they may be facing, and one can get several responses from their colleagues that can help solve the issue. In addition, they plan study visits across the regions which also promotes knowledge sharing amongst them.

There are different phases that every project goes through, such as early phase, design, construction and commissioning. The phase of a project influences the use of the system. During the early phase, depending on the size of the project, the region extensively uses the facility program module in PTS to develop the project design, if

the project is significantly large. In the design stage, RFP, which is the biggest tool in PTS, is used. The consultants are only involved in projects after the RFP design is complete.

In the construction phase, PTS is used to a limited extent, however with the PTS Process module that they shall be implementing soon, they expect to use it instead of project plans, where all the activities to be carried out can be listed and cross-checked for, clarifying the requirements during that stage. Likewise, during the commissioning phase, PTS is not used as much unless if there is something useful that has been discussed in surveys or evaluation dialogues. In that case, the newly discovered knowledge is then used to modify the type rooms in PTS.

> *"...Now we've finished this project and we've seen that, this component, the toilet brush holder doesn't work, then we can go in the Master level and change in our type rooms or if there's new rooms on that way we use it…"*

At the same time the contract type also has an influence on the involvement of the contractors in PTS. When the design-bid-build contract is used, the contractor does not make use of PTS, however, when the design-build contract is used with partnering, the contractor uses PTS in the same way as the consultants. Additionally, the interviewee explained that the design-build contract in itself is not beneficial without the aspect of partnering, because they as clients do not manage to get the desired quality and products that they need.

> *"...there are so many special requirements regarding hygiene and other things, both from a quality aspect and especially hygiene. So, it is difficult to believe that a totalentreprenad [design-build] can cover all that, then you are governed by the economy, lowest possible price."*

In region A, they mostly use the RFP and facility program, but also the purchase planning module, and are in the process of familiarising with PTS Process as well. Further on, the interviewee explained that some of the modules developed had had complications when they were first developed, that hindered their use in the projects. It was explained that one module, PTS Illustration initially was developed only to function on an iPhone, and hence one needed to have a tablet on site, and with a large group it gave poor viewing on a tablet. The module is not used by region A and they do not think further investment should be made to develop it since there are readily available software in the market such as Revit but the original idea to develop the module was good although it has not been a success. Likewise, when the platform is changed, there are technical issues that the regions face.

> *"...we are now approaching a change of platform, which is very good, the biggest disadvantage with it is that you get thrown out all the time because it is too heavy. But that will happen during the summer, so we have big hopes for it."*

Another challenge that PTS would likely face is that of managing all the regions together, with the risk of being too steering possible when more regions join the system because of their different working practices. At the same time, challenges with regards to logistics and moving around were brought up.

> *"...that it has worked very well, it is governed by Jönköping and you have it from there. If all regions in Sweden joins PTS, then maybe you need to evaluate it. But the structure is good, but then the emphasis maybe shouldn't be based in Jönköping, I don't really know, it should maybe, be more spread out in the country, at the same time we don't want to have it top-down like Spri."*

Although the interviewee was very satisfied with the support the region gets from the PTS team, she did indicate that with the increase of the PTS member base, more resources may be required, especially personnel.

> *"...I think that they need to expand this system administrator role [...] maybe it's not enough with one person, it is a bit vulnerable. If we become so many, then his work time or that person's work time would not be enough. Then I believe that you also maybe from the board in PTS to set-up more requirements that those people engaged on a regional level, also get dedicated time for that work, because that is not how it is today..."*

It was mentioned that in the beginning they were supposed to work with a specific type of room 'type1 room', but in the process, they realised it was not working and thus removed the restriction. Later restrictions were put up again and modified later in the process. Last year, experts and representatives from member regions got together and unanimously agreed upon a collection of type rooms that are now used by all regions as a base for their room designs. If someone wants to have their own design that is different from the type rooms, they'll need to motivate their decision.

> *"...you start with a room which you know everyone has gone through, then you have to do those improvements or changes you like to do in your own region, and then it is clarification, but it is actually about small changes…"*

4.3 Region B

In region B, many of those who previously worked with PTS as function planners had an engineering background, however currently, all of them have a background in healthcare. If seen as a network, PTS has influenced their construction practices when ideas are exchanged, a standard is decided upon, trends can be observed, and what did and did not work well can be learned. Additionally, the interviewee stressed that it is more user-friendly than compared to similar systems in the industry. The technical support which in the beginning was slow to respond has improved over recent years, so issues are solved more promptly. However, the technical support team's understanding of the issues reported could still improve as sometimes Region B do not get their

questions answered. Furthermore, the collaboration PTS has with CVA, and the Swedish Health Care Facilities Network (Forum Vårdbyggnad) is seen as a strength.

The use of PTS varies according to the stage of the project. Region B only uses PTS during the preliminary design phase, and not during the detailed design, construction, or end phases. However, in the interview it was stated that the region was in the process of improving PTS use across all the project phases. When using PTS, users can get feedback on their type rooms from other regions through comments on the type room files, which helps them during their planning phase.

> *"So the thing we are working with now is that I will meet the project managers, to make them understand how much information you could get from the PTS, and check if we can start use PTS on how it is planned it should be used through the whole process, so that we have a RFP in the end that is updated for real, if I could express it like that. But this is more about us not caught up with."*

From within a project team in region B, the consultants and the architect make use of PTS, however the contractor does not. The interviewee is at the moment trying to expose the project managers to the borderline module in PTS, which would be beneficial for their work. Because of the absence of PTS use during the subsequent stages, the furnishing team that comes in at the end of the project has to re-work with the drawings, trying to update them with the changes that were made during the different project phases.

> *"They'll go in, as for example the electrical designer does. The electrical designer enters the room, reads what kind of room, what kind of furnishing and what kind of equipment in the room, and then you calculate the electrical outlets depending on the equipment needing it, you calculate computer connections, and then you write this in the PTS. The heating, ventilation and air conditioning designers do the same thing regarding sewage and installations. Check so that all installations are there and then they use it as basis for their documents. So, in the PTS you should find, for instance if you have a lab, then you'll need many electrical outlets and then you need to calculate it. So that everything will be correct and follow the electrical standard but also according to [your] equipment. Go through the different levels of electrical classification, when you go to the next stage."*

The most used modules by the region are the facility program and the RFP modules. In addition, they also use the furnishing module and the borderline module. There is a lack of time to evaluate and use the many tools available for PTS users. There are also function groups for each profession in the PTS Forum, that meet on a national level at least twice a year and communicate through the phone as well. During these meetings, in addition to general workgroup discussions, questions coming from the PTS board or questions that are to be directed towards the board are discussed. Additionally, there is an event organised once every two years where members of PTS and the different function groups gather and attend lectures.

The PTS Illustration module has been considered by the users as redundant to their requirements. However, the interviewee realised that this particular module was still being developed by the PTS team, and no clear explanation was given over the subject.

> *"And when you later ask, 'but we decided that we would not pursue this development', I get the reply that we do not pursue it, but who is pursuing it then? And why do we function planners have an expert user if we have decided that we will not pursue the development. Then there are others pursuing this and there are other elements in movement, and I'm not saying that this decision is right or wrong, but it is this that makes it ambiguous in the governance of PTS."*

The main challenge according to the interviewee is the identity PTS wants to forge for itself, explaining that PTS needs to identify what it really wants to do, it needs to identify its users and their needs, adding that there are many good ideas from the different PTS users and thus it requires a limitation method/process.

> *"Obviously, they had some documents on what PTS was and what they were doing but there has been a very bad coordination, it has improved, and they have developed more but... I have lacked a general plan for what PTS actually should include and not include. They have developed it [in] many different ways and they have said that it is the regions who owns it and it is we (PTS) who shall develop it. But it doesn't help if we are all running towards different directions, the end result would not be a lot."*

Related to this issue, the interviewee gave the example of two modules that had the same function in PTS, the 'borderline' module and the 'furnishing' module. PTS are now checking if they could merge the two, but this could have been realised by someone with insight in the computer program. Furthermore, some of the modules in PTS are not fully developed, usually due to financial reasons. Another challenge mentioned in knowledge sharing through PTS is the reluctance of individuals to admit their mistakes, sometimes trying to shift the blame to other individuals, this behaviour rooted in the industry culture. The interviewee suggests that to avoid this challenge, only fact-based discussions on what went wrong, and its results should be discussed.

The resources available to PTS are limited, and that causes difficulties for the implementation of the system. If PTS does become a truly national system, the idea of it being owned by one region, and their capabilities to maintain it with regards to personnel resources can be seen as a challenge.

> *"Yes, and this is somehow their baby, there are some who always are in all groups, always involved when something is to be decided for better or worse as everything else. You have a history but also a thought which is cemented since many years. And also, that they could drop [the idea] that Jönköping region are the ones who have been the most propulsive, yes maybe they were that in the seventies but maybe they have to realise that they now are one player among many and that another type of structure is needed but I'm not the one who decided on this."*

Another challenge mentioned was the use of the suggestion box within the PTS platform, where suggestions from most of the regions are sent to PTS, that are then voted upon. In the interview it was clarified that in some cases, suggestions that are provided by a region or which do not get enough votes may not get further developed since it is only that one region that would benefit from the suggested feature or function.

The interviewee being a functional planner stated that, they have their own networks and mailing lists across the nation, that also includes the regions not yet members of PTS, through which they try to communicate with each other when an interesting project is going on, they send out questions within their group, look for experience from previous projects. Another initiative within the region is project meetings once every two weeks, where they work the whole afternoon either in different constellations or everyone at the same time, where they try to talk about things which have happened or if there are any experiences to share. They also have within their work description, three study visits per year, both within and outside the region.

In region B, they have a feedback mechanism that helps improve the information in PTS and ultimately the design process, but the interviewee does concede that this is difficult with knowledge sharing and the search for experience, since there are so many things to be done.

> *"We have coordinators helping to move that could give feedback and you could see that many times you get it wrong, then we try to go back to the type rooms."*

4.4 Region C

The most used module in the region is the RFP, but they also use the technical requirements in PTS. The use of PTS in the different phases varies, in the early phase, PTS is used as a standard to ensure the correct areas are added to the preliminary design, to identify the activities required for the project, and to check which rooms are required. In the design stage, PTS technical requirements are consulted while preparing the tendering documents before they are sent out to the contractors. During the implementation phase, when any changes are made to the original plans, they have to be updated in PTS as well. Thereafter, the hospital is handed over to the facility management team that will have to follow up on the deviations between the actual facility and the PTS information.

The use of PTS among different professionals also varies. The facility planners use PTS all the time, preparing new facilities for new construction. When the consultant is being recruited, they get access to PTS to obtain information on the project. The project managers use PTS as well. However, contractors do not get access to PTS unless it is a design-build contract, because in that case the contractor shall also be responsible for the design stage.

In the construction sector, organisations usually face the same problems that are looked at from different perspectives. When PTS users discuss the problems usually through the user groups in PTS, it may lead to solutions and common guidelines that help future project steering.

PTS has worked as a common standard across the regions providing technical requirements and experience, that has made the hospitals robust and allowing the performance of the correct things from the beginning eventually leading to the project

being constructed as ordered by the facility management team. The interviewee believes that this also leads to 4-5% lower investment. This is hard to prove through clear evidence, however the costs are lower presumably because of not repeating the same mistakes. Through PTS, clients can also generate clearer project requirements to be provided to the project team. An example of requirements is the Miljöbyggnad (environment certification) requirements that have also been incorporated into the PTS requirements.

> *" So you could say that the requirements not covered in laws, you put a limit saying that this is an acceptable standard we want our facilities to have, to be able to manage them in a good way and so that we are economical with our funds, and also the health care, there's a lot of work together with them, how does the facilities work, when you build these room function programs. Then we'll know that these works good from a health care perspective also, you will not repeat the same mistakes you've done before."*

According to the interviewee, one of the challenges with PTS is that it takes a significant amount of time to make changes to things within PTS, mainly because it works as a common standard and thus requires all the member regions to vote on the changes before a decision is made. Another challenge is the different versions of PTS that get released and updated throughout the project lifetime leading to more requirements and costs in the project.

4.5 Sykehusbygg

Within Sykehusbygg many employees have health care backgrounds, some having experience working as nurses and others as engineers. According to the interviewee this incentivises the use of Sykehusbygg services for projects that are below the NOK 500 million threshold. Additionally, the close connection between the owners of the hospital and Sykehusbygg was stressed. Activities conducted by Sykehusbygg include meetings and evaluation sessions, where project team members discuss the project in detail. The interview revealed that the IT system is currently under development, and knowledge is stored temporarily on the computers at their offices in the meantime.

> *"It is just here on our computers, we have it locally here now. We have a lot of knowledge or information on our website about the project. We have in our system in Sykehusbygg."*

Sykehusbygg's main strategy to obtain knowledge from projects is through detailed pre- and post-evaluation sessions, from which information and knowledge is then taken into their computers (or database systems when available).

The organisation also works with other projects on the side, called development projects that are aimed at advancing construction practice, such as BIM strategies, guidelines and guidance on the planning and building phases. In order to accommodate the increasing number of hospital projects referred to them, the interviewee also says that they need to recruit more professionals.

Sykehusbygg collaborate with other organisations, to share knowledge between each other, and to develop concept programmes, through workshops, communication, and through the European Health Property Network (EHPN). The collaboration with EHPN is explained and described by the interviewee in the following quote.

> *"We have different kind of topics, it can be energy, environment, architecture, the discussion in the last 3-4 years have been on the hospital structure and development of health care, and we have workshops once a year, and we have members from those countries, and we have board meetings of course, and that is a really good working network for us."*

Additionally, they also collaborate with research organisations, trying to develop healthcare construction in their respective countries. One of the universities which they collaborate significantly with, is the Norwegian University of Science and Technology (NTNU) in Trondheim. They closely work with PhD students from NTNU, through meetings for instance. They also collaborate with universities in England, like Loughborough University and University College London (UCL) in England. Additionally, Sykehusbygg collaborate with Netherlands Organisation for Applied Scientific Research (TNO).

One suggestion of a possible improvement mentioned by the interviewee is to add visualising functions to their systems. Additionally, facilities management has also been an area that many of their owners have requested for, and which they are considering developing. When asked generally on KM in public construction projects, the interviewee responded that the reasons for failing with KM are because of several reasons, especially in the early phase where there is less sharing of information and knowledge among team members. In addition, there is pressure from external stakeholders such as the market and politicians. Furthermore, change management for the users of the hospital facilities was mentioned as another area that construction projects currently lack.

4.6 CVA

The closing down of Spri was not only a result of internal affairs in Sweden, but rather an international trend at the time, where healthcare systems' management was being moved away from a centralised system to move decisions as far out in the organisation as possible. Another reason for the close down was the rapid technological developments during the time, it was becoming more and more difficult for the central body Spri to grasp the changes.

> *"innovation is much quicker than the central body has possibilities to grasp, and they were also conservative and cost driving…"*

Furthermore, during the 1970s Sweden had a strong legislation for the influence of the employees. There were laws that required people who worked in workplaces to be part of the building process and approve drawings for instance. This resulted in a mismatch between the requirements of the users and those from Spri. However, the advantage

with decentralisation was that the local regions already had knowledge and understanding of what was required.

> *"...and when you need the knowledge you had it out in the organisation, because there were people who had been working with this previously in the architects' office or in the engineering offices or in the facility organisations."*

Then during the late 2000s because of an investment push into healthcare that coincided with the retirement of many experienced professionals who were previously involved in these sorts of projects, PTS had to come in to ensure continuity of vital knowledge. The decentralised management structure still remains in parallel to the KMS of PTS, the two systems working together for the betterment of the healthcare sector. Furthermore, the interviewee exclaimed that:

> *"...I think it's a good opportunity for the county councils [regions], they actually build for themselves, for a long-term management, so they are very aware of quality for materials or construction solutions of course, because they will take care of everything themselves."*

In the interview, differences between PTS and Spri were brought up. The interviewee emphasised that Spri had a central commission in Stockholm that searched for good examples and then they compiled these and sent them out as advices, and during that time you also had to get an approval from Stockholm to make an investment. Spri was described as a typical example of a centralised system. PTS was described more as an extremely decentralised network where every region has their own platform in that network. All member regions produce knowledge locally and then discuss this and other topics, in regular meetings. Additionally, similarities between the system used in Norway and PTS was talked about. The Norwegian system was described as much more centralised, they are also more leaning on design tools like tools for dimensions for instance, while Sweden lean more on dialogue. Additionally, they have different methods and approach compared to Sweden which could depend on tradition. According to the interviewee, many people in Sweden envy the Norwegian system, as they have more resources to use, because they are given money from the state. To further improve the PTS system, the interviewee explained that more money needs to be invested into PTS, to meet the knowledge needs from the investment that is being done.

As more and more organisations are trying to standardise their work to improve the overarching quality, adaptability, and sustainability, there is a dilemma that can affect the projects negatively, that is that it will not adapt to specific needs of a clinic and the opportunity for users to be involved in the planning will be limited. Users are not interested in standardisation, instead they are more interested in tailoring unique solutions that would fit their needs.

During the interview, it was expressed that PTS focus on research by collaborating with CVA and Chalmers has been a wise move and has also led to increased interest from other regions in Sweden. In addition, the collaboration makes up for the lack of research and innovation in the construction industry, when it tries to work together with the

highly sophisticated and professional medical sector. When planning hospitals, function planners make use of concept programmes that are developed in collaboration with CVA- Chalmers. To be able to have meetings and discuss things with an academic institution in a neutral position not involved in any project, is described as a significant advantage.

> *"...the building industry isn't, I'm sure you are aware of, not that knowledge intense, it has a problem with too low grade of innovation, too little research, all this. On the contrary, the medical profession, they are the most research oriented and very highly qualified organisations. So, you have a meeting between, I would say this is simplifying of course, but you have a meeting between a very qualified organisation and not that qualified organisation. So, […] the point that PTS can make by joining together with academic to get legitimacy, seeing from that, here we have at least some research we have done, basic knowledge survey which is sometimes lacking in standard building projects…"*

The different knowledge used to base decisions were explained in the interview to be evidence-based, best examples, experience-based, and anecdotic, as shown in Figure 7 and Figure 8 below. Most of the knowledge used for decision making is evidence-based, while the best examples are the evidence-based knowledge that have been discussed, analysed, reflected upon, and agreed upon. CVA's intention with the concept programmes are to add the knowledge as evidence from research done. At the same time, they work to increase the portion of best examples by taking it in, discussing and reflecting on it, to eventually illustrate it as a best example. The third type of knowledge used to base decisions is the anecdotic knowledge, which is based on personal experiences and preferences.

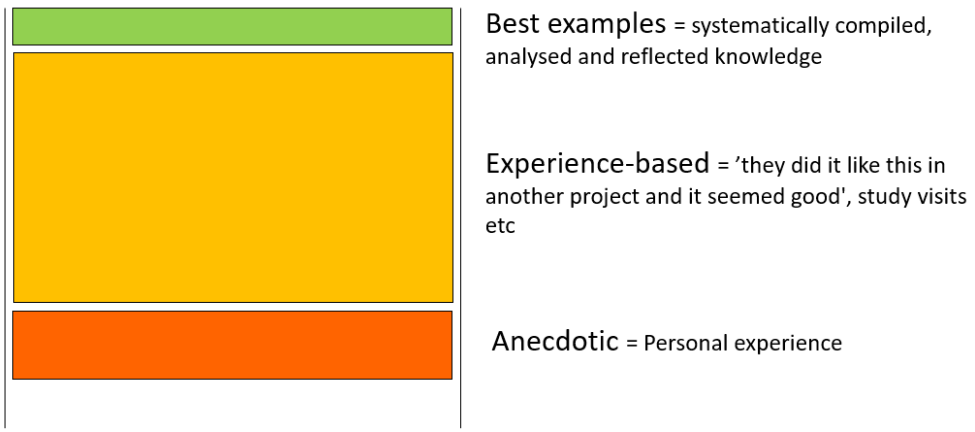

Figure 7: Knowledge base protions without concept programmes. Adopted from Fröst, P.

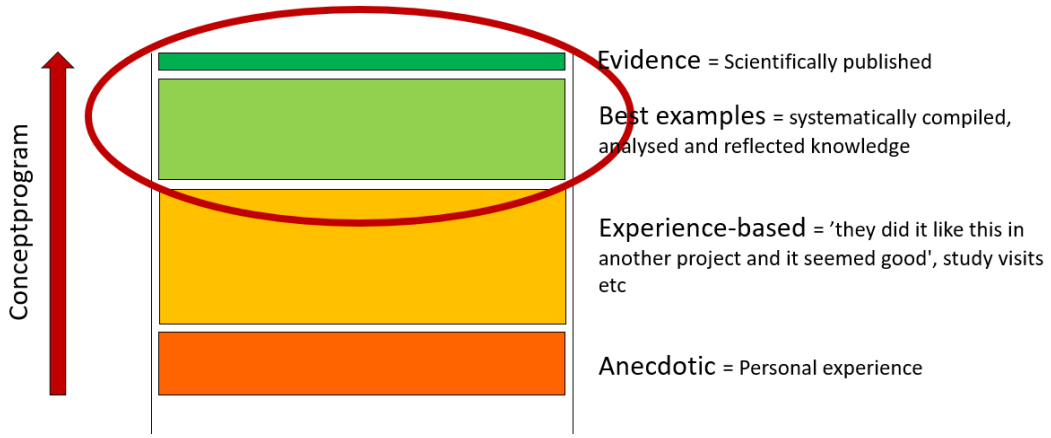

Figure 8: Knowledge base portions with CVA concept programmes. Adopted from Fröst, P.

4.7 Danske Regioner

Currently, regions are managing their own construction projects and are responsible for the economy within projects. They have a dialogue with and are closely monitored by the Ministry of Health in Denmark. Regions are not able to finance themselves through collecting taxes from citizens, they are instead financed through yearly budget agreements with the government. This makes regions highly dependent on the negotiations they have with the government every year. When there are issues that involve all the five regions, Danske Regioner steps in to support the regions in their efforts to find solutions.

> *"... if there are subjects that are on a broader scale that involves all the five regions, then we would step in as Danske Regioner and have a role in this part. We meet here in Danske Regioner, with the representatives from the five regions from their construction organisations every two months, we actually had a meeting yesterday, with all the construction managers from the regions, so we would have a meeting that usually takes an entire day. And they would say 'we have these issues right now with our construction process', and that's the sort of broad knowledge sharing that we do with the management part of the regions."*

In the beginning, Godtsygehusbyggeri had set up ten benchmarks and eight focus areas when it was established with the purpose of directing the regions to focus on these areas when they started their projects. Now that the projects are well underway, many of the benchmarks and focus areas are not as important and thus Danske Regioner have set up and support network groups that are created based on specific themes such as communication, financial management, and moving process (logistics) among others. Through these network groups, employees from different regions get the opportunity to share their knowledge between each other. Some network groups are created when the regions are facing common challenges, to create a collective effort solving the issue. However, they do not make use of any IT or database system to communicate or store the knowledge and information obtained from these network groups.

> *"... I mean if you have the problem in one region, for example we were discussing insurance yesterday, and how they work with insurance within the construction project, and one of the regions would bring it up that 'we have these issues with it', and the other regions had some of the same issues, so we set up a group and said we would have a meeting in May or June, where we can discuss these issues and see what the right approach would be to this."*

Every year in September, Danske Regioner arranges an annual conference where around 300 employees from all the five regions come together and have presentations on the different projects in their regions. This was described by the interviewee as a good way to get people together to share knowledge, because many times people are focusing on working on their own project to such an extent that they do not find time to do this. Other conferences on specific topics are also organised whenever it is perceived that there is something relevant that all the regions can gain from. One example of a conference they are currently working on is the moving process, the actual moving in when hospital construction projects are finished, which was described as a big issue for many projects right now. Besides the network groups and conferences, Danske Regioner prepares an annual report gathering knowledge from all the different projects, collecting some best practice examples, and sending the report to all the regions in addition to making it available on their website. Professionals in the construction industry such as architects, engineers and contractors are also actively sharing knowledge through other networks and groups such as The Construction Society (translated to English), where they discuss all construction projects and not only within the healthcare sector.

According to the interviewee, Godtsygehusbyggeri has managed to make sure that the regions share knowledge between them, on their healthcare projects. Additionally, having great focus on communication and awareness, they have managed to inform the public within Denmark and around the world about the hospital construction projects and their impact on the healthcare sector. They do this through open house days that they organise and through their website.

The organisation has an overall focus throughout all the different stages of the project from pre-study to commissioning phase, and ensure that knowledge sharing also persists throughout all the phases with the development of the project.

> *"And this is something that will be relevant for all the construction projects, I mean when you have to, for example think about 'how do we make sure that when we move the patients from the old hospital to the new hospital, how do we make sure that we get all the equipment that we need to the new hospital that we get the entire process to run smoothly', 'how do we make sure that the employees are comfortable in the new environment that they will have to be working in in the future', these are some of the processes that will be similar to all the projects, and something that we can of course share a lot of knowledge on."*

This implies that Godtsygehusbyggeri maintains interest and focus on the projects throughout all its phases. They have at the moment planned to carry out this phase through engaging the medical staff, discussing "lessons-learned" from previous

projects and getting their views in order to achieve a smooth transition for the medical staff.

> *"...as I mentioned the employees, how do you get them used to the new environment, the new buildings that they now have to have their daily working life, so this is what we're getting into now and we will be focusing on also to have a dialogue with the clinical staff, the doctors, the nurses at the hospitals in order to make sure this transition period as smoothly as possible, and together the experience and the knowledge from the project that have already done that, and see what kind of advice they would have for the other projects in the coming years."*

The interviewee considers that the challenge they are facing currently is to collect as much knowledge from projects that are about to be completed before the teams are dismissed and the employees move to other projects. For this task, they have planned to introduce evaluation project (sessions) to get all the relevant information from them.

Godtsygehusbyggeri do not intend to achieve standardisation of the hospitals explaining that the main reason for this, is that the regions have different needs with different patients being treated at different hospitals. It was clarified that this does not mean all projects are unique, there shall still be some points that will come across all the projects, some similarities among the projects, which is why knowledge sharing is established to learn from each other on the issues that affect all the projects. The interviewee recognised the importance of having knowledge management at different levels which is not currently done.

> *"...it's very important that you have it on different levels so to speak, it's also very important to get the employees on other levels involved in the process and make sure they share the more practical detail, I think, and get it more down to earth so to speak. So, it's not just the overview problems but that you actually get into a little bit more detail..."*

5 Discussion

In this chapter, the findings from the interviews have been analysed through the lens of the theoretical framework presented in Chapter 2. The discussion is arranged according to themes identified from the findings, trying to answer the research questions.

5.1 PTS

If seen through the KMS framework developed by Centobelli, Cerchione and Esposito (2017), PTS works in two parts, the social (practice) part and the IT system (tools). The social part takes place through the forum and annual meetings, while the IT system is the extensive database, tools and functions that every region tailors to their requirements, where all the project design is done. This is also in line with the suggestions of Kanapeckiene *et al.* (2010), that KM should be conducted with both IT systems and human interaction. As indicated by Zou (2012), and Carrilllo and Chinowsky (2006), PTS uses the two parts of its KMS to capture the different types of knowledge. The IT system is used to capture explicit knowledge from the projects such as the project designs and room layouts, while the social events such as the meetings, conferences and workshops are intended to capture tacit knowledge from the project team members. It has been observed that PTS focuses on knowledge codification and sharing, more than knowledge creation, which agrees with the literature that organisations working with routine projects tend to focus more on those aspects of KM (Hislop, 2013).

Akhavan *et al.* (2005) as referred to in the theoretical framework section, have noted that KMSs need to be easy to use even for non-experts, as well as have a good cooperation between the KMS team and other employees, to avoid KMS failure. In a similar perspective, the interviews indicate that PTS is a comparatively simple system to use than similar systems in the industry, and the support provided by the PTS team to the regions has been described as good. Additionally, the video tutorials that are available and under development from PTS would most likely increase the interest and use of PTS for current and potential member regions, as it will ease usability or support for the system. These observations suggest that PTS is moving in the right direction.

Having focus on workplace environment for healthcare professionals is seen as a major benefit and advantage of using PTS. This ensures that designs lead to patient care of the highest standard, and are tailor made for the requirements based on the function of the facility. From PTS, the regions get standards and guidelines for their projects, that are agreed upon by a group of professionals, thus having the guarantee of quality and conformity. In addition, they have at their disposal a network of professionals with whom they can discuss and evaluate possible solutions to challenges before implementing them, as a form of risk avoidance or reduction. These are some of the realised benefits of PTS as mentioned also by Ballal and Elhag (2006), who said that improved processes and risk reduction are some of the benefits of KMS. An additional benefit is the slight reduction in the investment cost in the projects due to the avoidance of repetitive actions and tasks. Furthermore, having everything gathered in one place such as in PTS, and access to view room designs prepared by others was something mentioned in the interviews as a benefit. This is something also mentioned by Xu & Quaddus (2005) as a benefit. In addition, it was argued by some of the interviewees that if PTS would not have been there they would have been forced to use another knowledge repository and probably would not have been better.

Research conducted by Lin *et al.* (2006) showed that most of the people were not willing to share knowledge without a reward system, however it was observed that PTS still managed to get its users to share knowledge without such setups, and therefore do not need to consider the suggestion put forward by Milovanović, (2011) of setting up such a system. This is also true about the different regions in Sweden, who also share knowledge outside the PTS setup through the professional group network without any formal reward mechanism.

5.1.1 Use

PTS is used extensively mostly by smaller regions, while larger regions such as Västra Götaland region and region Stockholm are working more independently. This could be because the larger regions have many projects of their own that allow them to learn within their own region, and thus not require a large network system such as PTS to help them learn and improve. This and the fact that five regions are still not members, affects PTS negatively, as they themselves say they cannot yet be considered as a nationwide organisation, which is their interest. Additionally, PTS use seems to be influenced by the size and number of projects under development in the regions, hence in some periods, PTS could be used extensively while in others, it is not used at all. The different regions are motivated to use PTS when they have large projects, where knowledge from other regions would be beneficial to have, to reduce loss of time and money reinventing the same solutions that other regions developed in similar previous projects. PTS use also varies depending on the phase of the project. It seems that PTS is or can be widely used during the early and design phase, where the project is planned, however it may be hard to use, or may not be originally designed to be used during the construction phase. Focus on the early stages is also evident when the interviewee describes that they try to involve as many project team members in the early phases by introducing new roles. Because it has type room designs, it may be useful during the facility management phase. As an improvement to the system, live capture and storage of knowledge and information from ongoing projects is important. An important observation from one interview was that the more detailed the RFP documents were in the early stages, the better the consultants' understanding of the tasks. This implies that the RFP module plays an important role of communication between the client and the consultants. Secondly, it is vital to have a clear picture of what is required when preparing the RFP documents, to ensure smooth progress in the project.

5.1.2 Flexibility

PTS has attributes of a flexible system, where the regions decide on the strategy for implementation of PTS when they join the network, some regions deciding on gradual implementation while others go for immediate implementation. In addition, the different regions are free to choose their own version or style of PTS, making it tailored to the regions' requirements, however at the same time, PTS's goal is to standardise healthcare construction. These are two contrasting ways of managing a system. At one point, PTS would need to choose one of the two. Furthermore, one example showing the flexibility of the system was the Spira project undertaken in Jönköping. It successfully used PTS in its design phase, and the representatives from the PTS system suggested that it can be used for any type of project. However, it could be argued that doing so would diminish the specialised knowledge in healthcare construction that exists in PTS, and would turn the focus of the system towards a more general approach

to KM in the construction industry. On the other hand, more projects shall benefit from the standardised work processes, guidelines and tools available in PTS.

5.1.3 Time

As already described in the theoretical framework chapter, a lack of time has also been stated to be a challenge for the effective use of PTS in the regions. Regular changes or updates made to the platform and the addition of new modules that are sometimes incomplete, hinder the ability of the users to effectively use them and PTS in general (Leal, Cunha and Couto, 2017; Ballal and Elhag, 2006). On the other hand, time constraint has also been considered a challenge for the regions when trying to bring about changes and modifications to PTS, because all changes have to be agreed upon by the member regions. Then again, continuous improvements made to the PTS platform allows it to adapt to the requirements and standards of the rapidly changing IT and construction industry, which is also the view of Malhotra (2004) if KMS want to avoid obsolescence. The changes that are made to PTS are those that are put forward by the user forum groups through discussion of the suggestions from the different regions. This aspect is an example of ways that motivate the users and show that they are valued by the organisation, which in turn would have a positive effect on knowledge sharing in the network (Carrillo and Chinowsky, 2006).

5.1.4 KM tools

Interviews with two of the three regions confirmed that at least one of the professional groups working under PTS has their own network and mailing list across all regions of Sweden, which has been established outside PTS. In there, they may send out questions looking for people with experience from previous projects, thus sharing knowledge between each other in a network. These networks are a form of CoP as described by Carillo *et al.* (2002), to be a network that facilitates an effective and possible communication of knowledge within a network of professionals. Furthermore, the authors argue that this helps forming a strong bond between people with a shared practice. Additionally, Carillo *et al.* (2002) concluded that the most extensively used knowledge sharing technique is CoP. Other forms of CoP within PTS are the different types of conferences they arrange and the function groups for each profession that meet at a national level twice a year. Moreover, the study visits between the regions allows the sharing of knowledge among the professionals, the discussion of best practices, and for inspiration.

Another KM tool identified was the knowledge map, which was described in the literature to have the purpose of assisting users to find knowledge easily (Milovanović, 2011). A form of a knowledge map was identified in an interview where one of the regions described a list that they have set up, that contains information of the different professionals working in the region on what they are good at, and the experience from projects they have worked on. This facilitates finding the right person who has the experience that is required to help solve the issues.

5.1.5 Identity

The interviews showed that PTS are facing a challenge regarding forging their identity, as asked in the interview there is a need to clarifying both short term and long-term goals and coordinate them with the needs of their users. The lack of direction in the

organisation is causing confusion for their users and could affect knowledge sharing and their capacity to perform tasks. Furthermore, in the interview with representatives from the PTS system, they stressed both the desire to be flexible while at the same time, the desire to standardise. These are two contradicting desires which are difficult to reconcile. In the long run, PTS may need choose to either to standardise or to make their system flexible. In the literature it is mentioned that knowledge workers are faced with an identity conflict feeling connection to both the parent organisation and the client organisation (Grimshaw and Miozzo, 2009; Ravishankar and Pan, 2008). Based on the interviews it can be added that the identity conflict for those involved could also occur due to the lack of direction in an organisation. In addition, the representative from the Danske Regioner stressed the cost of achieving standardisation when a system does not take into consideration different needs for a wide range of patients being treated in hospitals in different regions.

5.1.6 Project managers resistance to knowledge

In one of the interviews, it was expressed that they are trying to convince project managers to use PTS and to make them realise the benefits of using it. Previously project managers have not been interested in listening to the interviewee describing the benefits. This shows that there may be a resistance to new knowledge among the project managers, as mentioned in the literature part, it could be that they believe that they do not have a need for new knowledge because they already possess vital tacit knowledge. Additionally, Bresnan *et al.* (2004) inferred that 'good' managers were the ones most reluctant to implement a KM tool, such as PTS in this case, because the processes in place that were working exceptionally well for them.

5.1.7 Structure and its influence

In one interview, the autonomy and decentralisation of the regions in Sweden was discussed to have an influence on collaboration among them. It can therefore be believed to be a hindrance to establishing a centralised knowledge database or system, or been seen as a resistance towards the use of PTS. This is similar to what has been explained by Bresnan et al. (2004) in the literature section and a similar challenge can also be seen in Denmark. Furthermore, one interviewee described that the PTS system is somehow region 'Jönköping's baby'. The owners are involved in all groups and also all times where decisions are to be made. This structure could hinder knowledge transfer from regions who could feel that the owners have an unproportionate say in PTS. This is also stressed in the literature part, where Van Wijk *et al.* (2008) mentions that the type of structure in the organisation can either encourage or hinder knowledge transfer. As more and more regions are joining PTS, interviewees warned that the current structure where one region is the owner could be seen as a challenge and may need changes. It may also act as a hindrance for regions within PTS to use the system more and as a hindrance for regions outside PTS to join. It was realised that large PTS member regions use the system limitedly, for instance one large region responded saying that they have a limited use of PTS when asked for an interview. Furthermore, large regions could have their own knowledge management systems because of the many projects and personnel they have.

5.2 Comparison between countries in Scandinavia

PTS, Sykehusbygg and Godtsygehusbyggeri are forms of KMS and can be used throughout the whole project phase from pre-study to use-phase, however they each have different strategies for KM. Sykehusbygg has chosen to gather all knowledge/experience in one building, as an organisation, and has to be involved in the project if it wants to gain access to the knowledge Sykehusbygg possesses, while PTS is trying to gather/sharing knowledge with as many regions as possible through an IT system locally accessible in the regions. On the other hand, Godtsygehusbyggeri that is developed by Danske Regioner focuses on the social interactions to gather and share knowledge between the professionals and across the projects. As stated from Kanapeckiene *et al.* (2010) in the theoretical framework, these three organisations have adopted their own understanding of KM and thereafter set up three different types of systems based on that.

Both PTS and Sykehusbygg have two KMS parts, the social part (KM practices) and the IT system part (KM tools). However, they implement the social part in different ways. Sykehusbygg conduct meetings and evaluation sessions, which allow for the transfer of tacit knowledge among the participants, and reflecting on completed projects, while PTS has the forum and annual meetings. Godtsygehusbyggeri on the other hand only has the social part of KMS such as network groups, workshops and conferences. One of the social components constituting a KMS is individual and organisational learning, which includes employee training, CoP, or knowledge sharing group (Milovanović, 2011). Both PTS and Sykehusbygg have been seen to collaborate with each other, and with research organisations, trying to develop healthcare construction in their respective countries. PTS seems to be more developed as it has a database while Sykehusbygg is still working on creating a database and their information is currently stored locally on their computers. Based on the interviews, it can be assumed that Sykehusbygg is used more and is also more of a nation-wide organisation compared to PTS, where five regions are not members and many regions do not use it as frequent as desired. A possible reason for this could be that regions in Norway are required to use Sykehusbygg for projects with a budget above NOK 500 million. Godtsygehusbyggeri is also a nationwide system, where all five of the Danish regions are working together. Furthermore, the different organisations in Scandinavia are financed through different methods. Godtsygehusbyggeri and Sykehusbygg are similar in the sense that they are financed by the state, Godtsygehusbyggeri is financed by the regions which are financed by the state and Sykehusbygg is financed directly by the state. On the other hand, PTS is financed by the yearly fee paid by the member regions. In the interviews with both representatives from PTS and its member regions, it was stated that PTS lacks financial resources to develop further which was not mentioned by Sykehusbygg or Godtsygehusbyggeri.

Sykehusbygg seems to be more rigid compared to PTS because it is more centralised, and all projects go through Trondheim and Sykehusbygg. They have gathered vital knowledge on managing projects and experience in one place/office, thus they manage projects and/or offer advisory support. So, if the regions would want to use this knowledge they have to contact Sykehusbygg which then acts as the project manager for some projects, which is contrastingly different to the PTS system. This seems to suggest that Sykehusbygg is first a management organisation, then a knowledge hub. As project managers, they take control of projects and utilise the stored/acquired knowledge to successfully deliver them. Contrastingly, PTS can be perceived to be a flexible system that allows for the different regions to adopt their own form of PTS and

project designs by gaining insight from the other regions' information and knowledge stored in PTS. An aspect unique to Godtsygehusbyggeri is that during its establishment, it set up ten benchmarks and eight focus areas to ensure the projects had a focus on those key challenges and discussed them to bring up best practice to overcome them. When all three systems are compared, PTS can be understood to be a stand-alone KMS organisation, while the other two are KM projects within larger organisations.

6 Recommendations

This chapter shall present recommendations for PTS drawn from the study.

Contractor involvement

Contractors should be given more access to PTS, as they are the ones who implement the project and possess important knowledge that can improve project execution. This can be possible by having partnering type of contracts, where the contractor is also involved in the early phases of the project.

Visualisation function

Additionally, the visualisation function would be a good addition/improvement to PTS, however its implementation would need the PTS board members' consent, which is difficult to get as this function would require a large amount of investment. PTS does not have a 3D-function but instead make their files accessible for other systems such as dRofus. Taking this one step further, PTS could add BIM function where information is automatically updated in the database, when changes are made along the project.

PTS use in construction phase

To increase the use of PTS during the construction phase, a formalised, standard feedback mechanism should be established, to capture knowledge from the project team that would develop and improve the knowledge database within PTS for future projects. This could take the form of regular, periodical evaluation meetings, project surveys, or simply capturing knowledge from the project meetings. The important aspect is to discuss, record, and publish it in writing on PTS for other members to benefit from.

Review of the financial model

From the study, the issue of a lack of resources at the disposal of PTS was observed, and therefore a review of their financial model can be recommended, to re-think the sources of funding for PTS. At the same time, the spending of the limited funding should be given attention to, where currently funds are used for module projects that cannot be completed or are not necessary. Having short term and long-term plans for development would support their decision making on fund allocation. Additionally, this will reduce if not solve the problem of a lack of direction with regards the areas of development within PTS.

Standardisation vs flexibility

Having aspects of both standardisation and flexibility, PTS have two contrasting paths of development, which they eventually need to decide upon. It is recommended to study how Collective Building Process (GBP) has tackled the same issue previously. GBP is a work process that is used by the City of Gothenburg to steer construction projects throughout all its stages.

7 Concluding remarks

The study intended to examine the Programme for Technical Standard (PTS) in Sweden and compare it with similar systems in the Scandinavian region, and study the opportunities for improvements and challenges with PTS.

PTS has 16 member regions currently, who use it in different capacities, and have uniquely modified systems for their regions. Through PTS use, the regions have managed to somehow standardise their healthcare facility designs, while at the same time increase quality and reduce risks pertained to it. PTS collaboration with CVA and Chalmers is viewed positively among the member regions, and is a source of increasing the credibility for the system, especially when working with the healthcare sector that is state of the art and highly sophisticated. The flexibility of PTS has been a recurring subject throughout the study, but contradicts the PTS goal for standardisation. Both strategies (standardisation vs. flexibility) have their pros and cons, eventually PTS will have to decide on one of them. The system has improved significantly in recent years, but there remain some issues that can be further improved such as modules development within PTS, where suggestions from member regions are sometimes overlooked or do not get developed after being voted down. Moreover, expanding the use of PTS along all project phases, especially the construction phase and the use phase, where PTS can be used more actively when changes are made to designs and requirements, or to refer back to during the use phase. Involvement of more professionals from the project team during the design phase shall ensure a collective design that considers all aspects of the project, and shall bring clarity on the project requirements for the project team. Additionally, a feedback mechanism is needed from the project team that would continually improve the quality and accuracy of information in PTS. The PTS organisation structure may need modification with its expansion and perhaps responsibilities distributed among the members. The issue of a lack of resources and at times poor resource allocation can also be improved for better value for money from the system.

It can be concluded that the three Scandinavian countries have their own unique KMS namely, PTS, Sykehusbygg and Godtsygehusbyggeri. All the three systems are different from each other with regards to source of financing, KM focus and strategy, organisational structure etc. PTS is a stand-alone KMS organisation, while Sykehusbygg and Godtsygehusbyggeri are KM projects within larger organisations. PTS and Sykehusbygg collaborate with each other to enhance learning, and also collaborate with research organisations to improve the healthcare sector. There are aspects from each system that can be used as improvements for the others, such as Sykehusbygg can get inspiration for their IT system under-development from PTS, while PTS can learn about standardisation from Sykehusbygg. Aspects such as transparency of knowledge and information for the public, issue prioritisation through setting up benchmarks and focus areas, and network groups for specific subjects/issues can be learnt from Godtsygehusbyggeri.

Finally, further research could look into the technical challenges with PTS and how they affect project delivery, the possibilities of further collaboration between the Scandinavian countries with regards to KM, or examine KM through the EHPN.

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