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A Knowledge Management Methodology to enhance knowledge transfer between concomitant projects under construction

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A research report is submitted to the Faculty of Engineering and the Built Environment, University of the Witwatersrand, in partial fulfilment of the requirements for the degree of Master of Science in Engineering.

Date: 29 October 2019

PLAGIARISM DECLARATION

I Lerato Elsie Lekhema (Student number: 0416577Y) am a student registered for the degree of Master of Science in Engineering in the academic year 2018/19.

I hereby declare the following:

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- I confirm that the work submitted for assessment for the above degree is my own unaided work except where I have explicitly indicated otherwise.
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ABSTRACT

The aim of this research work is to develop a knowledge management methodology that will enhance knowledge transfer between concomitant projects under construction in the North West Operating Unit (NWOU), a Distribution division of South Africa's power utility, Eskom Holdings SOC Ltd. A qualitative study was done to determine the current status of knowledge management in the NWOU. The Construction Activity Based Knowledge Management (ConABKM) framework was applied as a benchmark to assess the state of knowledge transfer in the NWOU. The data indicated a lack of knowledge management implementation in the NWOU's construction projects; this ranges from utilisation of knowledge management techniques and technologies, implementation of knowledge management processes/activities and management failure. A knowledge management methodology for NWOU was then developed to address these challenges and enhance knowledge transfer between concomitant projects under construction.

Keywords: Knowledge, knowledge management, knowledge transfer, concomitant projects under construction, knowledge management framework, knowledge management methodology

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LIST OF ABBREVIATIONS

CAPRIKON – Capture and Re-use of Project Knowledge in Construction

CLEVER – Cross-sectoral Learning in the Virtual Enterprise

ConABKM – Construction Activity-Based Knowledge Management

CoP – Community of Practice

CRA – Concept Release Approval

DPA – Development Phase Approval

DRA – Definition Release Approval

DTC – Design to Cost

ERA – Execution Release Approval

Eskom – Eskom Holdings SOC Ltd

FRA – Finalisation Release Approval

GDP – Gross Domestic Products

HV – High Voltage

IDEF – Integrated DEFinition

IMPaKT – Improving Management Performance through Knowledge Transformation

IT – Information Technology

KM – Knowledge Management

KMC – Knowledge Management Cycle

LV – Low Voltage

MV – Medium Voltage

NWOU – North West Operating Unit

PCM – Process Control Manual

PLCM – Project Life Cycle Model

PMBOK – Project Management Body of Knowledge

PMI – Project Management Institute

PPM – Portfolio and Project Management

PWC – PricewaterhouseCoopers

SECI – Socialization, Externalization, Combination, Internalization

SeLEKT – Searching and Locating Effective Knowledge Tools

SWOT – Strengths, Weaknesses, Opportunities and Threats

CHAPTER 1: INTRODUCTION

1.1. Introduction

The aim of the research presented in this report is to develop a methodology to enhance knowledge transfer between concomitant projects that are under construction in the North West Distribution division of South Africa's power utility, Eskom Holding SOC Ltd (Eskom). The knowledge management practices in the construction environment at the North West Operating Unit (NWOU) will be studied to determine the current status of knowledge management, particularly the transfer of knowledge between concomitant projects that are under construction. After which recommendations, presented as a methodology, will be made to further enhance knowledge transfer with the intention of improving projects performance.

1.2. Research Background

Knowledge management is a discipline that has been evolving in the past three decades; its importance and impact have grown over the years and organisations have realised the benefits that could be realised through this process. Knowledge management is multidisciplinary and has roots in cognitive sciences, philosophy, social sciences, anthropology and ethnography, management sciences and many other disciplines [1]. This is mainly because knowledge management applies across different industries and disciplines. Due to its multidisciplinary nature, many definitions of knowledge management have been developed without a widely accepted definition.

However, in general, knowledge management is the process through which an organisation manages its knowledge, existing and new, to enhance organisational performance. The benefit of applying knowledge management in organisations lies in the ability of the organisation to leverage on its knowledge base. Thus, if the organisation is conscious about the knowledge that exists it will be able to use/leverage on that knowledge to improve its competitiveness. Also, the organisation becomes aware of the knowledge that is needed but does not exist in the organisation and in this way new knowledge can be created through different learning processes which will improve the organisation's performance against its objectives.

Knowledge management provides a vehicle to enable and intentionally manage the process of learning; it is "the process through which organisations generate value from their intellectual and knowledge-based assets" [2, p13]. "In an economy where the one source of lasting competitive advantage is knowledge and with the drastic changes in the economy and markets, successful companies are those that consistently create new knowledge, disseminate it widely through the organisation, and quickly embody it in new technologies and products" [3, p162]. This adaptation is particularly important in highly competitive industries where knowledge, created and shared, can differentiate an organisation from the rest. Such a competitive industry is the construction industry, where there is increased pressure to deliver projects faster, within the budget constraints while meeting the quality requirements and project objectives.

Construction projects are in a "knowledge intensive environment" where most of the knowledge is tacit, based on an individual's experiences and perceptions [4]. Transfer of tacit knowledge is important to "making knowledge actionable and operational in the construction industry" [5]. Project managers and the project team get to experience the construction of an asset and gain experiential knowledge which is mostly converted to tacit knowledge throughout the project [5]. Thus it follows that knowledge management can be utilised to improve project performance and the organisation's competitive advantage. The main benefit of applying knowledge management systems in the construction of assets is to enable organisations to perform better on the so-called triangle of project execution: time, cost and quality [4].

The construction industry is an integral part of economic development as construction projects are initiated to fulfil specific objectives and provide value-added-benefit to the organisations and the economy. The construction industry in South Africa contributed R108 million to Gross Domestic Products (GDP) in the first quarter of 2018 [6]. However, in the past five years, there has been a decline in the industry's contribution to GDP with the 2017 financial year experiencing negative growth [6], decreases for the first quarter of 2018 included a decrease in construction work [6].

Eskom Holding SOC Ltd referred to as Eskom in the report is the state-owned power utility that supplies electricity to the Republic of South Africa and is one of the major public sector contributors to construction works [7]. The PricewaterhouseCoopers (PwC)'s report on construction trends indicates that Eskom's capital expenditure in the construction industry decreased by 19% in 2016 [7]. In the 2018 integrated report, Eskom reported liquidity challenges and a loss of R2.3 billion [8]. Many challenges face the state-owned electricity company including governance, reputational damage, escalating new build costs, municipal debt and the funding gap amongst others [9].

Eskom's corporate plan for the 2018/19 to 2022/23 financial years details a few strategies to improve the current financial challenges; one of these is the Design to Cost (DTC) strategy to stabilise and improve the current financial situation [9]. One of the intended outcomes of DTC is cost containment and efficiencies, and one of the focus areas is capital optimisation [9]. As a result, Eskom's capital expenditure is reduced to R45 billion rand per year for the next three years [8]. Consequently, different business divisions are limited in terms of capital expenditure due to these challenges. In terms of the Eskom structure, there are three main divisions which are Generation, Transmission and Distribution.

The structure of the Distribution division is comprised of 9 operating units that are assigned to the provinces of the Republic of South Africa. The research study will be conducted in the Distribution division's North West Operating Unit (NWOU). The NWOUs mandate, in line with the vision and mission of Eskom, is to provide and ensure reliable electricity to customers by building, operating and maintaining distribution assets while enhancing stakeholder relations [10].

The majority of the capital expenditure to achieve this mandate is apportioned between building new and refurbishing old distribution assets. The NWOUs construction works, with reference to asset creation, include refurbishment of existing distribution substations, High Voltage (HV), Medium Voltage (MV), and Low Voltage (LV) distribution lines as well as expansion of the North West network through the construction of new distribution substations, HV, MV and LV distribution lines. The most significant assets in terms of capital expenditure and performance impact on the distribution network are the substations and the HV lines. Due to the liquidity challenges, the expansion and refurbishment needs of the NWOU network exceed the capital expenditure budget that is allocated for the province. This requires that the NWOU optimise the limited capital expenditure through prioritisation of projects, designing-to-cost and efficiencies in project management and subsequently disciplined project execution/construction.

Eskom and the NWOU utilise the general Project Life Cycle Model (PLCM) for projects as shown in Figure 1-1[11]. The Development Phase Approval (DPA) and the Concept Release Approval (CRA) are stages of concept development and concept approval respectively. The Definition Release Approval (DRA) is the detailed design stage. After which, the project then advances to the Execution Release Approval (ERA) stage where the project is constructed and then finally closed off in the Finalisation Release Approval (FRA) stage.



Figure 1-1: Project Life Cycle Model used in Eskom NWOU [11]

This research will focus on the ERA stage of the PLCM since the study will be on knowledge management in the construction of projects and its application in construction project management. It is critical that each PLCM stage is completed with due diligence to ensure the success of projects as all the work done in the different stages culminates to the construction of the project. Projects can fail due to a number of reasons, one of which is the inefficiencies in the project construction stage.

The Project Management Institute's (PMI) Project Management Body of Knowledge (PMBOK) guide provides a guideline on the best practices of the discipline of project management [12]. The PMBOK guide states that project success is determined by completion of projects within specified scope, time, cost, quality, resources and risk [12]. However, a Global Construction Survey in 2015 indicated that 71% of projects in the energy and natural resources and 90% of projects in the public sector fail respectively [13]. It could be argued, as has been in project management research, that the different scope of works of projects make it difficult for project teams to improve project performance. Further to that, project complexities increase with customer demands, and the project teams move on as soon as the project is completed, hindering the process of reflection on the lessons learnt on projects.

However, this is not the case in the NWOU projects environment, firstly the type of projects constructed do not differ much in scope, and most of the technical specifications are standardised through the Distribution Technology department. The type of construction projects, substations and lines, will vary only on issues such as topographical layouts, construction sites and line routes. Secondly, project teams, except for contractors, are within the Eskom environment and depending on their specialisation and geographical location they will be allocated certain types of work in certain areas. Logically, in this context, there should be knowledge gained over the years and through the projects executed. Therefore, this should result in better project performance since lessons learnt and best practices can be applied to upcoming projects or concomitant projects under construction.

In The State of Project Management 2017 survey, lessons learned was recorded as the second most difficult process to embed in project management [14], contributing to the non-improvement of project performance. Ahmad & An [4, p133] explain that construction projects are in a "knowledge intensive environment where most of the knowledge is tacit, that is, based on an individual's experiences and perceptions" and that the main benefit of managing knowledge in this environment is to enable organisations to perform better on time, cost and quality measures in construction projects. To enable knowledge management, it is imperative to have a formalised system to embed in project construction management.

In Eskom, a procedure for the development of knowledge management and a knowledge management strategy was drafted specifically for implementation on Capital Projects, and not for the organisation as a whole with Process Control Manuals (PCMs) developed for 1) Conceptualizing 2) Establishing 3) Implementing and 4) Evaluating knowledge management [15]. However, these PCMs are only implemented at an organisational level and have not been adopted on the operational level; this is mainly due to the different operational activities across Eskom's divisions. These PCMs can, therefore, be used as a guide to developing knowledge management frameworks/models for different operational activities across Eskom divisions and be applied to suit specific operational needs.

1.3. Problem Statement

The preliminary investigation in knowledge management in the NWOU has revealed an apparent gap in the knowledge management initiatives of the organisation and the application of knowledge management initiatives in the NWOU. The Integrated Knowledge Management Framework was proposed and adapted for Eskom in 2008 [16]. The framework is not implemented in the NWOU across the project life cycle and further to this the framework adopted by the organisation is a broad overview and does not address knowledge management application for projects that are under construction. The NWOU does not have a formalised knowledge management system, framework or model that is used to address the knowledge management needs. The unintended consequence of this is that there is no learning from the mistakes and best practices of previously completed projects or related projects that are still under construction.

This leads to the application of the same processes, the same structures and the same methods that contributed to failed projects. Errors during the construction phase of the project, as opposed to the DPA, CRA and DRA stages, are the most expensive since these require modifications on site, extended construction hours, additional material, resources and so forth. Thus, results in budget and cost overruns as well as the compromised quality of assets.

The evaluation of construction projects over the past few years in the NWOU has mirrored the general trend of construction projects in the industry. Projects ranging from 2014 to 2018, some of which are still under construction are over budget (based on the contract value with the contractor) and are past the project completion date as per the original schedule. Only 20% of projects with the earliest planned construction start date of September 2014 and the latest original completion date of June 2018 were within their allocated construction budget. The average percentage increase between the original construction budget and the revised construction budget is 37%; with the original construction budget escalating by 21% on the total construction cost. NWOU has seen the below construction budget increases year on year:

- 2014 – average percentage increase of 48%
- 2015 – average percentage increase of 34%
- 2016 – average percentage increase of 47%
- 2017 – average percentage increase of 31%

It is also important to note that 38% of the projects are still under construction; these are projects with construction start dates of 2016 and 2017, implying that the average percentage variation of the construction cost will increase for the projects under those years. On average, only 22% of projects are within 10% variation of the original construction cost and considering the current challenging financial situation of the organisation these figures are not acceptable and have to be improved.

Construction project failure, as seen in the case of these projects statistics, can be due to a number of factors however the project teams are generally constructing the same type of assets with the same project team, but the construction project performance is not improving. Under these circumstances, there should be improved project performance over the years based on the experiential knowledge that the project team gains. In addition, there is no system to learn or transfer the knowledge from arising issues and solutions that are occurring every day on construction sites that can be used positively to influence decisions on other construction sites. There is no mechanism to transfer, share and gain knowledge, such that the problems occurring on site can be easily resolved or avoided saving time and money. The knowledge management initiatives developed in Eskom at this stage are not implemented in the NWOU environment and may require scrutiny to ensure that they can meet the requirements of knowledge transfer in construction projects.

1.4. Research Question

The research work focuses on answering the following question:

- How does the NWOU enhance knowledge transfer between concomitant projects under construction?

To enhance knowledge transfer is to ensure that there is an improvement in knowledge management practices in the NWOU.

1.5. Research Objectives

To adequately answer the research question, the main objectives of this research are to:

1. Identify an applicable construction based knowledge management framework to use as a benchmark for knowledge management application in construction projects in NWOU
2. Identify existing knowledge management practices in the NWOU
3. Develop a methodology to improve continuous knowledge transfer in construction projects

1.6. Summary of Research Methods

The research methodology will be based on the most applicable methods to answer the research question and fulfil the research objectives. The research study will start with an extensive literature review with two goals. The first goal will be to gain an understanding of the important concepts of knowledge management and in so doing develop a conceptual framework to highlight the key themes and relationships in this field of study. The second goal of the literature review is to determine an applicable, existing knowledge management framework for construction projects that can be used as a benchmark for the NWOU.

The second part of the study will be the data collection process. The study collects both primary and secondary data. The secondary data will be collected from the organisation's database. This will cover Eskom's knowledge management policies, strategies and frameworks, with the aim of analysing the organisation's knowledge management initiatives, developments and existing practices. This is followed by primary data collection which will be conducted through a qualitative study using semi-structured interviews. A purposive sampling technique will be used to determine the appropriate participants for the study.

The study results will then be analysed, and the findings will be validated using appropriate data validation criteria. After which, a gap analysis will be conducted between the organisation's current knowledge management practices and the desired knowledge management practices using the benchmark framework and knowledge management principles. Finally, a knowledge management methodology will be developed as a recommendation to move the NWOU towards the desired knowledge management and projects performance status, and as a result, enhancing knowledge transfer between concomitant projects under construction.

1.7. Limitations

The research is limited to the North West Operating Unit, a distribution division of Eskom Holding SOC Ltd (Eskom) and may not be applicable or generalizable to other distribution operating units and other Eskom divisions. The study is also not generalizable to other power utilities, organisations or sectors as the knowledge management practices and the data gathered is specific for the North West Operating Unit.

1.8. Outline of Chapters

Chapter 1 provides the details on the background and context of the research study and further defines the problem statement that the research aims to resolve. The research question, objectives and a summary of the research methods used to resolve the research problem is also outlined in the chapter. This is then closed off by briefly stating the limitations of the research study.

Chapter 2 presents the literature review, focusing on knowledge management definitions, knowledge management approaches, knowledge management cycles and knowledge management tools, classified as techniques and technologies. The application of knowledge management in construction projects is also highlighted, with the benefits, enablers and barriers identified. This chapter is then concluded with a conceptual framework that describes the important themes of knowledge management and shows the interactions and relationships between these themes. The purpose of the conceptual framework is to guide the research study, data collection and analysis process. The conceptual framework should not be confused with the construction-based framework that will be used as a tool for benchmarking.

Chapter 3 reviews five construction-based knowledge management frameworks with the aim of determining a benchmark framework to be used for the NWOU. The ConABKM, CAPRIKON, CLEVER, IMPaKT and SeLeKT frameworks will be reviewed with an analysis provided on each framework. The framework that best fits the criteria which is set out by the themes from the conceptual framework and other additional advantages for implementing an effective knowledge management system will be chosen.

Chapter 4 details the research design and research methodology of the study and will also include details of the research strategy indicating the sampling technique and instrumentation that the study will utilise. The data collection and analysis procedure will also be shared. The reliability and validity aspects of the study and ethical considerations will conclude this chapter.

Chapter 5 will present the data analysis and results of the study. The data analysis and results will be in two parts; the first part is the secondary data analysis and results from Eskom's knowledge management documents and the second part will be the primary data analysis and results from the semi-structured interviews. The data analysis and results will be presented structurally using the themes identified in Chapter 2's conceptual framework.

Chapter 6 discusses the finding of the study and the desired knowledge management practices for effective knowledge transfer. The chapter also embarks on a gap analysis between the existing and desired knowledge management practices. This is then followed by Chapter 7 which presents the knowledge management methodology to enhance knowledge transfer between concomitant projects under construction in NWOU. It is noted that there may be confusion between the terms research methodology, in the context of research, and the knowledge management methodology that the study aims to develop. The knowledge management methodology developed in this chapter is an implementation methodology for the NWOU to go through the steps presented in the methodology to enhance knowledge transfer.

The conclusion, recommendations for future work and the limitations of the study will be summarised in Chapter 8.

1.9. Chapter 1 Conclusion

The research proposes an investigation into knowledge management at a division of a power utility with the aim of improving projects performance. The research question and objectives, aligned to the problem statement, were presented and the research methodology to achieve the objectives was summarised. The purpose of this qualitative, interpretivist, exploratory case study is to develop a knowledge management methodology that will enhance knowledge transfer between concomitant projects under construction within the NWOU.

CHAPTER 2: LITERATURE REVIEW

2.1. Introduction

A critical review of the existing literature in the field of knowledge management is presented in this chapter. The review will firstly clarify the definitions of knowledge and its management to distinguish knowledge management as a separate field of study. Thereafter, knowledge management concepts, tools, models and its application in the construction environment will be reviewed. The chapter will be concluded by developing a conceptual framework, from the literature theory reviewed, through which the study can be directed.

2.2. Knowledge Management

Defining Knowledge

The Oxford dictionary defines knowledge as "facts, information, and skills acquired through experience or education; the theoretical or practical understanding of a subject" [17]. It also defines knowledge from a philosophical point of view as true, justified belief [17]; Plato, an ancient Greek philosopher, originally introduced this definition [18]. This definition is widely accepted and used throughout the years despite counter-arguments including that of Gettier [19]. Gettier made cases that there will be times where justified belief is not necessarily true but is perceived to be true by the subject and therefore cannot be called knowledge. However, many philosophers still regard Plato's definition sufficient for the concept of knowledge and provided alternative interpretations and counter-examples to Gettier's cases [20].

Data, Information and Knowledge

There is much debate in the literature regarding the difference between information and knowledge; with some using the two terms interchangeably, and due to this debate, knowledge management has been argued to be another term for information management. So this has somewhat resulted in organisations implementing information management systems thinking that knowledge management will be an inherent benefit. As a result, literature has sought to identify and define the differences between these terms: data, information and knowledge, to validate knowledge management as a discipline and differentiate it from information management.

Data is defined as "raw and without context" [21, p2] and therefore because it is out of context does not provide any useful meaning [2]. Whereas information is "data given meaning by way of context" [21, p3], and so the collection of data or different types of data can be related to each other and in this way provide some context [1; 2]. Groff and Jones [21] differentiate between data, information and knowledge using a Venn diagram as illustrated in figure 2-1 [21]. Information is needed for knowledge to be created, however, for this to occur there must be a capability to understand and interpret that information; and this interpretation stems from being able to refer to experiences.

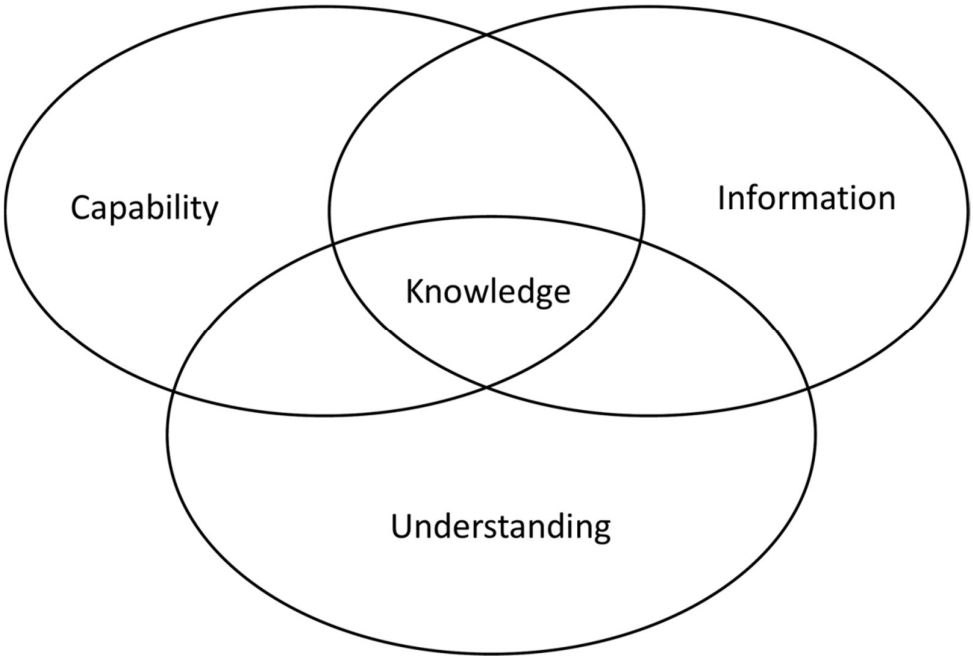

Figure 2-1: Venn diagram showing the relationship between information and knowledge [21].

Types of Knowledge

Table A-1 in Appendix A shows the different types of knowledge taxonomies sourced from a review of the knowledge management literature study by Kakabadse et al. [22]. Different types of knowledge must be considered as it may be ineffective to manage different types of knowledge in the same way. Knowledge can be classified and characterised in different ways; Polanyi [23] differentiated between two types of knowledge, tacit knowledge and explicit knowledge. Wiig distinguishes between knowledge forms and types; where knowledge forms are public, shared or personal [1; 24]; and the types are factual, conceptual, expectational and methodological knowledge [1; 24]. These different types and forms of knowledge each have tacit and explicit dimensions to them.

The field of knowledge management focuses on tacit and explicit knowledge. Wiig [1, p10] describes tacit knowledge as "consisting of complex, diffuse, and mostly unrefined knowledge accumulated as know-how and understanding in the minds of knowledgeable people". Tacit knowledge is in the heads of people, accumulated through experiences, developed through interactions with people and grows through continued experiences [2]. It is often hard to manage tacit knowledge since it stems from years of experience and intuition, and it is embedded within individuals; it is also hard to formalise it, as this intuitive knowledge, know-how and know-why, is difficult to communicate and articulate [2; 25].

Nonaka [3] identifies explicit knowledge as formal and systematic and therefore can easily be communicated and shared. Wiig [1, p10] defines it as "highly refined knowledge, consisting of a description of facts, concepts, judgements and relations". This explicit knowledge is usually stored in documents and databases

[2] and, is easily accessible and is a representation of the accumulated knowledge of the organisation's experience [2]. Properties of tacit and explicit knowledge are shown in table 2-1 [25]. From the definitions, tacit and explicit knowledge can be thought of as two types of knowledge on opposite far ends of the knowledge spectrum, but this is not accurate.

Table 2-1: Comparison of tacit versus explicit knowledge [25]

Properties of tacit knowledge	**Properties of explicit knowledge**
Ability to adapt, to deal with new and exceptional situations	Ability to disseminate, to reproduce, to access and re-apply throughout the organisation
Expertise, know-how, know-why, and care-why	Ability to teach, train, to train
Ability to collaborate, to share a vision, to transmit a culture	Ability to organise, to systematise, to translate a vision into a mission statement, into operational guidelines
Coaching and mentoring to transfer experiential knowledge on a one-to-one, face-to-face basis	Transfer knowledge via products, services, and documented processes

Explicit knowledge and tacit knowledge are mutually complementary [2]. Explicit knowledge is created from the tacit knowledge that the individuals or the organisation possess; it would be difficult to codify knowledge that does not exist in the mind. To further clarify this Dalkir [25] explains that explicit knowledge is a final product whereas tacit knowledge is all the processes that were required to produce this final product. Also, without tacit knowledge, it would be challenging to understand codified or explicit knowledge [2]; there must be some knowledge foundation in the mind to comprehend what is codified.

Both explicit and tacit knowledge types are essential in knowledge management, however, tacit knowledge has been regarded as most important in construction projects because the know-how is crucial in this environment [26]. Tacit knowledge, gained from experience of different construction projects, improves the quality and timing of decisions, which has a direct impact on the cost, quality and schedule of a project. The challenge, however, is that much of the construction knowledge that resides in the minds of individuals and the rationale behind decisions is often not shared or recorded [26].

What is Knowledge Management?

Knowledge management is multidisciplinary and has roots in different disciplines [1], and as a result, there is not a generally accepted definition of knowledge management. Shankar et al. [27] consolidated different definitions of knowledge management illustrated in table A-2 in Appendix A. Some define knowledge management using the need for knowledge management, and others define it based on what it requires in terms of implementation [27]. Some authors focus on the holistic nature of knowledge management; these definitions incorporate processes, activities, requirements, benefits and tools to make knowledge manageable.

Dalkir [25, p3] presents a definition of knowledge management that is more holistic and relevant for this study:

"Knowledge management is the deliberate and systematic coordination of an organisation's people, technology, processes, and organisational structure in order to add value through reuse and innovation. This coordination is achieved through creating, sharing, and applying knowledge as well as through feeding the valuable lessons learned and best practices into corporate memory in order to foster continued organisational learning".

Knowledge management in an organisation requires different areas to be coordinated, increased knowledge activities will result in increased knowledge assets, which will increase the capability of individuals in using the knowledge and will have a direct impact on the organisation's goals and objectives [1]. If the organisation goals and strategies are not aligned to knowledge management practices, there will be reduced knowledge activities, knowledge assets and capability [1; 28]. And thus it follows that organisations need to be intentional in the implementation of knowledge management.

Benefits and Enablers of Knowledge Management

Jarrar [28] in a survey of 40 case studies found that the main benefits of knowledge management were:

- contributes to increased competitiveness,
- improved decision making and avoidance of wasted time "reinventing the wheel",
- increased responsiveness to customers,
- encourages employees who are not natural networkers to engage in knowledge sharing and discourages information hoarding,
- improves support among colleagues because they value the knowledge and help they receive,
- improved efficiency of people and operations and better products and services and
- greater innovation.

Jung Yeh et al. [29] consolidated four categories of knowledge management enablers from different knowledge management theories. Firstly, the knowledge management strategy must be aligned to organisational strategy, and it is vital that senior leadership provide the necessary support to ensure successful implementation of knowledge management in the organisation [29]. The second enabler is the corporate culture; if the organisation does not create a culture of sharing or learning, then the implementation of knowledge management will not be effective [29; 30]. The third enabler is the people; the individuals in the organisations are the ones who have the knowledge and therefore it is essential to ensure that they share knowledge [29]. Lastly, information technology, this can be the database where information is stored and accessed [29]. These are considered important for effective knowledge management.

2.3. Knowledge Management Approaches

There are two distinct approaches in literature for knowledge management implementation; these are human-oriented and technology-oriented approaches [31]. The human-oriented approach focuses on tacit knowledge whilst the technology-oriented approach focuses on explicit knowledge. Table A-3, in Appendix A, from Maier and Remus [31] shows a comparison between technology- and human-oriented approaches. The authors suggest that if an organisation focuses on one of the approaches and neglects the other, then knowledge management implementation will fail as both are required for an effective knowledge management system [31]. Hansen, Nohria and Tiernay's study on the two approaches recommended that organisations need to choose one approach that aligns with its strategy and that organisations that choose both risk failing at both [32].

Jasimuddin [33], reviewed literature on these approaches and cited Scarbrough (1999), McAdam and McCreedy (2000), Desouza and Evaristo (2003), Swan and Scarborough (2001) and Pan and Scarbrough (1999) who argued that knowledge transfer requires both people and technology. The process-oriented approach to knowledge management identifies the knowledge processes that are required and then integrate the human- and technology-oriented knowledge management systems and in this way bridges the gap between these approaches [31]. To enhance knowledge transfer both tacit and explicit knowledge must be managed.

Knowledge management needs to focus on process, people and technology to be effective. If the approach focuses on processes and people, it will not have the technological infrastructure to support the knowledge management initiatives; and if it focuses on processes and technology, it risks leaving out the most vital aspect of knowledge management, the employees, which will be disastrous. This provides a more holistic approach to knowledge management making its implementation more effective, this is also inherent in the definition of knowledge management cited from Dalkir [25, p3].

2.4. Knowledge Management Cycles (KMC)

For knowledge management to be effective and to add value to organisations, it must be incorporated systematically in the operations of the organisation. Wiig [1] also warns that for knowledge management to be value-adding "it must be implemented with care to ensure it does not become a burden rather than a vital benefit" [1, p10]. There have been numerous life cycle models created for the management of knowledge; these models are a representation of the activities of knowledge management. This section reviews different knowledge management cycles.

Wiig's Knowledge Management Cycle

Wiig [1] presented a cycle that can be used for "building and using" knowledge in an organisation. The cycle has four stages, see figure 2-2. These stages do not have to occur sequentially and are not necessarily dependent on each other; there can be iterations and going back and forth between the stages. The build stage is concerned with obtaining and analysing knowledge, and the hold stage is concerned with retaining the knowledge through codifying and storing, the pool stage is concerned with gathering knowledge through different interventions and the apply stage is for utilising the knowledge in different scenarios [1].

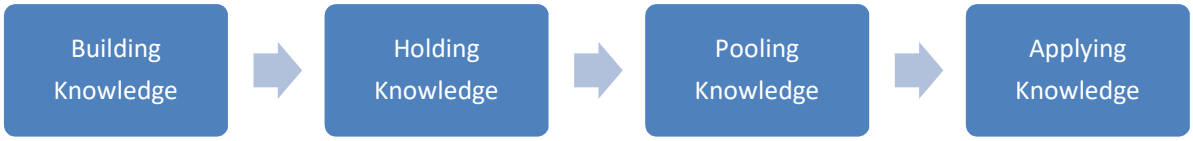

Figure 2-2: Wiig's knowledge management cycle [1]

Building knowledge has five primary functions, which are: obtain knowledge, analyse knowledge, reconstruct/synthesise knowledge, codify and model knowledge and lastly organise knowledge [1]. According to Wiig, obtaining knowledge focuses on the acquisition of new knowledge by initiatives such as research and development, market research, innovation and getting insights from subject matter experts; these different activities improve the organisation's knowledge assets and enhances the function of obtaining knowledge.

The analysing knowledge function's activities according to Wiig include checking the knowledge that has been obtained, assessing and then extracting it. The reconstruct knowledge function is concerned with reviewing the analysed knowledge and creating hypotheses to validate the new knowledge, compare it with the old knowledge and then discard outdated or false knowledge. The next activities will then be to codify the knowledge in books, procedures and mental nodes. The last function of the build knowledge stage is to organise the knowledge accordingly.

The holding knowledge stage also has primary functions that are made up of different activities; the functions include remember knowledge, cumulate knowledge in repositories, embed knowledge in repositories and archive knowledge [1]. The author states that knowledge is held in the individual's mind, books and repositories in the organisation. Activities for remembering knowledge includes activities of retaining individual and organisational knowledge by internalising such knowledge. To cumulate knowledge in repositories by creating databases for the knowledge is the next phase. Then embed knowledge in repositories by ensuring that the knowledge that has been obtained is embedded in procedures and processes. The last function in this stage is to archive knowledge by creating a library for knowledge and also retiring old knowledge.

Wiig indicates that the pooling knowledge stage is concerned with accessing knowledge through different interactions. These functions include collaborative work, creating subject matter experts, and getting knowledge from focus groups. The activities associated with the applying knowledge stage is centred around using the knowledge to perform tasks and to identify issues, solutions to the issues and ensure that the knowledge is applied to provide the organisation with the competitive advantage that knowledge brings with it to the organisation.

The advantage of the Wiig KMC according to Dalkir [25] is that it details and is clear about how the organisation uses knowledge to generate value for individuals and the organisation [25]. The Wiig KMC also explicitly distinguishes and includes both tacit and explicit knowledge and also recognises both human- and technology-oriented approaches thereby supporting a holistic knowledge management perspective. Another advantage is that Wiig through the KMC also details how the knowledge in the organisation can be used for better decision making [25]. One disadvantage of the Wiig KMC is that it only focuses on functions and activities conducted by knowledge workers and exclude other uses of knowledge [1]. And is not explicit on how knowledge is validated and how knowledge that expires is divested from the organisation.

McElroy's Knowledge Management Cycle

The concept of double-loop knowledge management places emphasis on organisations to learn and not just the individual [34]. McElroy [34] refers to and distinguishes between first generation knowledge management schemes which are there to improve the knowledge of the worker on his day to day operations and second generation knowledge management schemes that are concerned with creating knowledge at the organisational level [34]. First generation knowledge management focuses on technology application for knowledge management, while the second generation focuses on process-based organisational learning [34].

The second generation knowledge management is based on "knowledge production processes" [34, p5]. In this process, the individuals and the organisation interact and new knowledge is created; McElroy [34] argues that it is simply not enough to manage existing knowledge as this does not create new knowledge or learning. The consequence is that the organisation will apply existing knowledge to its day to day operations, but there will not be any strategic impact on the organisation since there is no new knowledge that can take the organisation to the next level.

The knowledge cycle, shown in figure 2-3, consists of knowledge production and knowledge integration processes [35]. According to the author the knowledge production process starts in the minds of individuals, as the individuals learn, there is either agreement or disagreement of the new learnings with the individual's experience, based on that knowledge is either re-affirmed or questioned [35]. The process also includes group learning where the "new" knowledge is discussed. These knowledge claims are then tested, scrutinised and refined through a knowledge validation process [35].

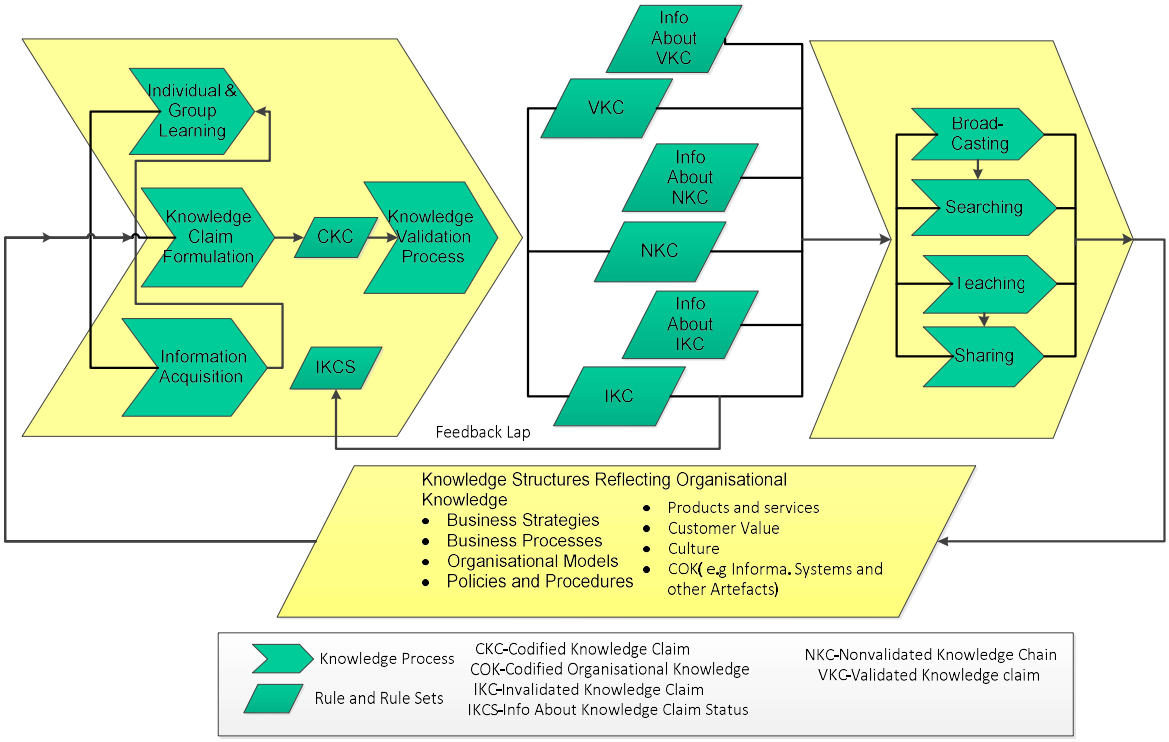

Figure 2-3: McElroy's knowledge management cycle [35]

The knowledge integration stage follows after knowledge claims have been validated and are being integrated into the organisation; this can be through broadcasting, teaching or sharing [35]. As the new knowledge is integrated into the organisation, the author indicates that it will be visible in the organisational practices and will be diffused into the business strategies and processes [35]. Lastly, McElroy indicates that knowledge is then fed back to the knowledge worker, and new learning can occur which starts the process of knowledge production all over again [35], and this is how organisations can continuously learn and create new knowledge.

The advantage of the McElroy knowledge management cycle is that it provides a clear account of how new knowledge is evaluated and how a decision is consciously made to either integrate the new knowledge in the organisation or not [25]. The disadvantage with the McElroy KMC is that it does not account for divesting old, outdated knowledge from the organisation. It also does not explicitly address the application of knowledge within the organisation.

Bukowitz & Williams' Knowledge Management Cycle

Bukowitz and Williams also created a cycle for knowledge management in organisations, to outline how organisations can generate, maintain and deploy strategically the correct stock of knowledge to create value [36]. The cycle is shown in figure 2-4 below; the life cycle stages are *Get, Use, Learn, Contribute, Assess, Build/Sustain or Divest* [36]. The get stage consists of getting the relevant information from different sources; it also encompasses analysing the information to see if there is value that it adds to the organisation. Bukowitz and Williams also distinguish between getting explicit knowledge and getting tacit knowledge [36]; that in getting tacit knowledge, the users must be connected to people, where the tacit knowledge resides [25].

The next stage is in the life cycle is the use stage; this refers to the use of knowledge by the individuals and organisation to create innovation [25]. The learn stage is mostly concerned with learning from experiences and then taking those learning and applying them to perform better [36]; the contribute stage refers to individuals sharing their knowledge with the organisation, and this knowledge will mostly be from experience including best practices [25]. The assess stage is at an organisational level and requires the organisation to assess existing knowledge, define critical knowledge and perform knowledge mapping for the organisation [25].

The build and sustain stage is to ensure that the organisation can remain competitive with the knowledge that it has; knowledge must grow and be sustained [25]. The last stage is the divest stage; this requires the organisation to determine knowledge assets that are no longer creating value and should, therefore, be divested from the knowledge base of the company. The advantage of this knowledge cycle is that it explicitly forces the review of knowledge that exists and a decision on whether or not to divest needs to be made; this ensures that only relevant, up to date information is kept in the repositories, and not unnecessarily taking up space. This KMC also includes the characteristics and benefits of the Wiig and McElroy knowledge management cycles.

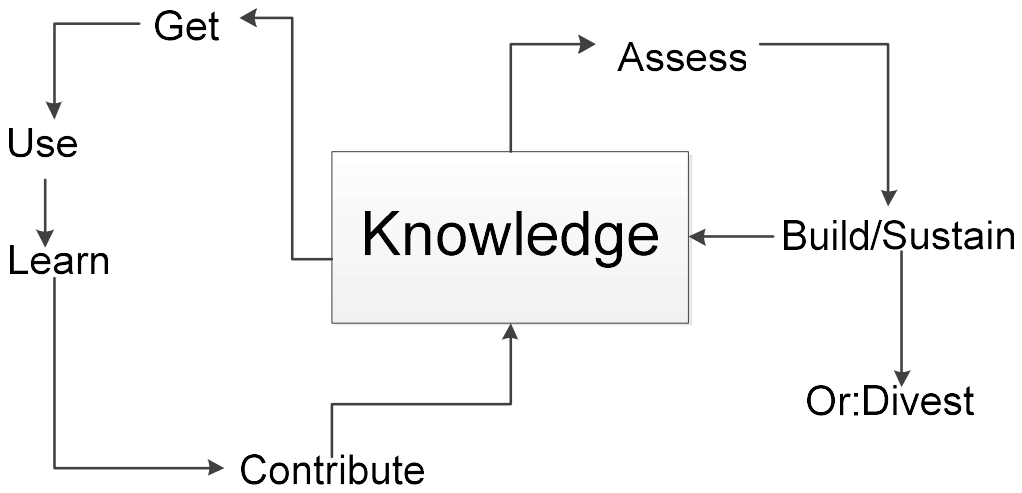

Figure 2-4: The Bukowitz and Williams' knowledge management cycle [36]

Dalkir Integrated KMC

After a study on the Wiig (1993), McElroy (1999), Meyer & Zack (1996) and Bukowitz & Williams (2003) knowledge management cycles, Dalkir proposed an integrated knowledge management cycle with three stages [25]:

1. Knowledge capture and/or creation
2. Knowledge sharing and dissemination
3. Knowledge acquisition and application

As illustrated in figure 2-5 [25], there is a transition between these three main stages; which effectively means that the stages for this integrated cycle are capture/create, assess, share/disseminate, contextualise, acquire/apply and update. The transition from knowledge capture and/or creation to knowledge sharing and dissemination requires an assessment of the knowledge content [25]. After knowledge has been shared and disseminated, it is contextualised "in order to be understood ("acquisition") and used ("application")" [25, p 43]. Then the knowledge can then be updated, starting the whole cycle again.

Knowledge capture refers to the "identification and subsequent codification" of existing knowledge in the organisation; while knowledge creation refers to new knowledge being created in the organisation [25, p43]. The step that is required next is to assess the knowledge; determining whether the content is valid and whether it will add value [25]. Once the knowledge has been assessed and validated, it will be either shared through different platforms or disseminated to the organisation. The next step will be to contextualise the knowledge, to ensure that sharing and disseminating is effective, this can be done through for example indexing. Then the next stage is using the knowledge or acquiring/internalising it as an individual. Thereafter the process starts over again, after updating the knowledge.

This integrated model took into account the strengths of the models studied and incorporated them into a consolidated cycle; for example, the model considers both explicit and tacit knowledge in its phrasing of the stages, just as Wiig did; it also assesses knowledge, just as McElroy's knowledge validation stage and Meyer and Zack's knowledge refinery process. And also integrates the Bukowitz and Williams' stage of divesting knowledge. The integrated model provides a holistic knowledge management cycle.

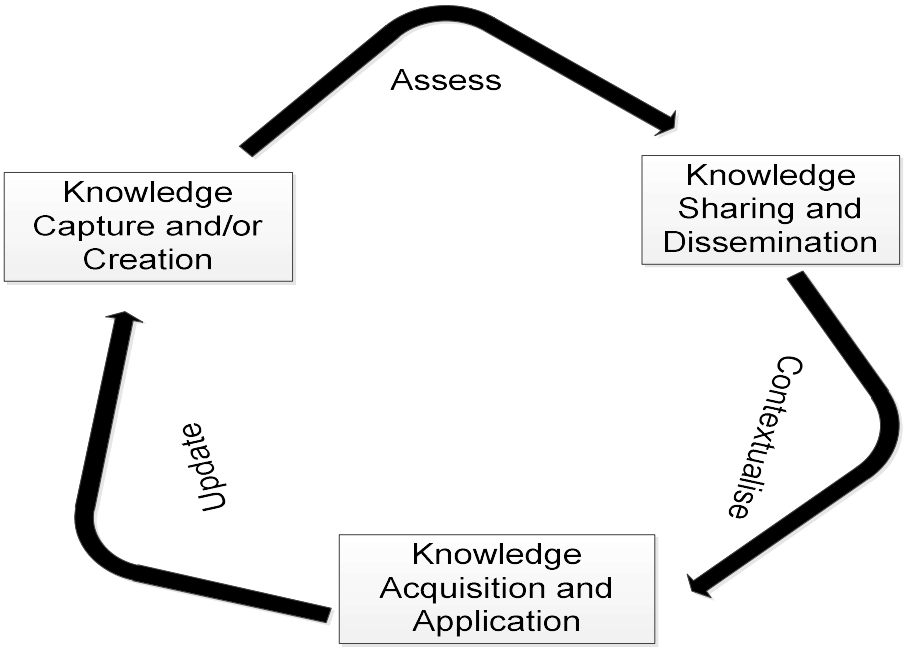

Figure 2-5: An integrated knowledge management cycle [25]

Heisig's Consolidated Cycle

In an attempt to consolidate and "harmonise" the frameworks, Heisig [37] surveyed 160 knowledge management frameworks, reviewing the knowledge management cycle. The research found that despite inconsistencies in the description of the stages of the knowledge management cycle, there is consensus on the knowledge management activities, reflected in figure 2-6 [37]. The advantage of the study is the consolidation of important activities required for any knowledge management cycle; this can be utilised as a foundation for organisations embarking on knowledge management initiatives.

However, the findings of Heisig's [37] survey intentionally excludes activities that were not synonymous between the surveys; this has the shortcoming that important activities that should form part of a knowledge management life-cycle model can be left out even though it has a significant impact on the effectiveness of knowledge management in certain organisations or sectors. Thus, the development of knowledge management cycles should be customised for the application or organisation; though the general activities in the process may be the same, there might be activities that need to be added to make knowledge management more effective.

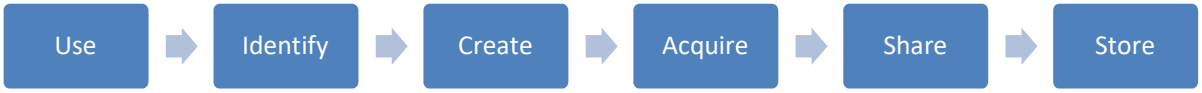

Figure 2-6: Common knowledge management cycle activities [37]

2.5. The SECI Model

The approach of knowledge management from other researchers focuses extensively on how to process the knowledge that is acquired, mostly getting the right information to the right person at the right time and not so much on how the knowledge is created. Nonaka [38] argues that it is more critical for an organisation to focus on how it creates knowledge rather than how it processes it.

To manage the creation and sharing of knowledge, Nonaka and Takeuchi [39] introduced the Socialisation, Externalisation, Combination and Internalisation (SECI) model to create and share tacit & explicit knowledge. The two types of knowledge, tacit & explicit, through social interaction between individuals can create new knowledge through a conversion process [38]. There are four conversion modes; (1) tacit to tacit, (2) explicit to explicit, (3) tacit to explicit and (4) explicit to tacit; refer to figure 2-7 for this model [40].

The socialisation process creates new tacit knowledge, and this can happen through shared experiences such as face-to-face knowledge sharing and social interactions [25; 38]. This process can occur through observations, brainstorming, mentoring or apprenticeship [25; 38]. In the socialisation process, the knowledge remains tacit making it difficult to disseminate to the organisation and thus this process cannot be sufficient on its own [25]. The externalisation process creates explicit knowledge from tacit knowledge [38]. The externalisation process requires individuals to articulate their knowledge, making it easier to codify [25]. Once tacit knowledge is converted to explicit knowledge, it becomes easier to disseminate and it becomes knowledge that is accessible to be used and leveraged when required [25].

The next stage of the SECI model is the combination process which creates a “new representation or combination of existing” explicit knowledge from currently existing explicit knowledge [25]. This can be achieved through different forms of processing existing knowledge [38] and recombining pieces of explicit knowledge [25]. This process, since it reconfigures explicit knowledge, is easier to re-disseminate the “new” knowledge throughout the organisation. The last conversion mode is that of internalisation where explicit knowledge creates new tacit knowledge, this is explicit knowledge being internalised by an individual converting the knowledge to tacit and requires learning by doing [25, 38].

The main advantage of SECI is that an individual can broaden their knowledge base, by creating and sharing knowledge, which has a direct impact on organisational performance. The simplicity of the model also allows organisations to quickly understand and apply the model [25]. However, the simplicity offered or assumed in converting knowledge does not take into account the dynamics of organisations and organisation culture and it may therefore be more complicated than the simple model as presented [33]. In addition, another drawback of the model is that it does not consider all stages involved in managing knowledge and thus cannot provide an organisation with benefits of applying the knowledge created or shared [25].

And thus it is important to translate the conversion process to the overall knowledge management process to ensure organisational benefit. The implementation of this required the organisations to consider the tools that are required to ensure that the conversion processes between tacit and explicit knowledge are enabled

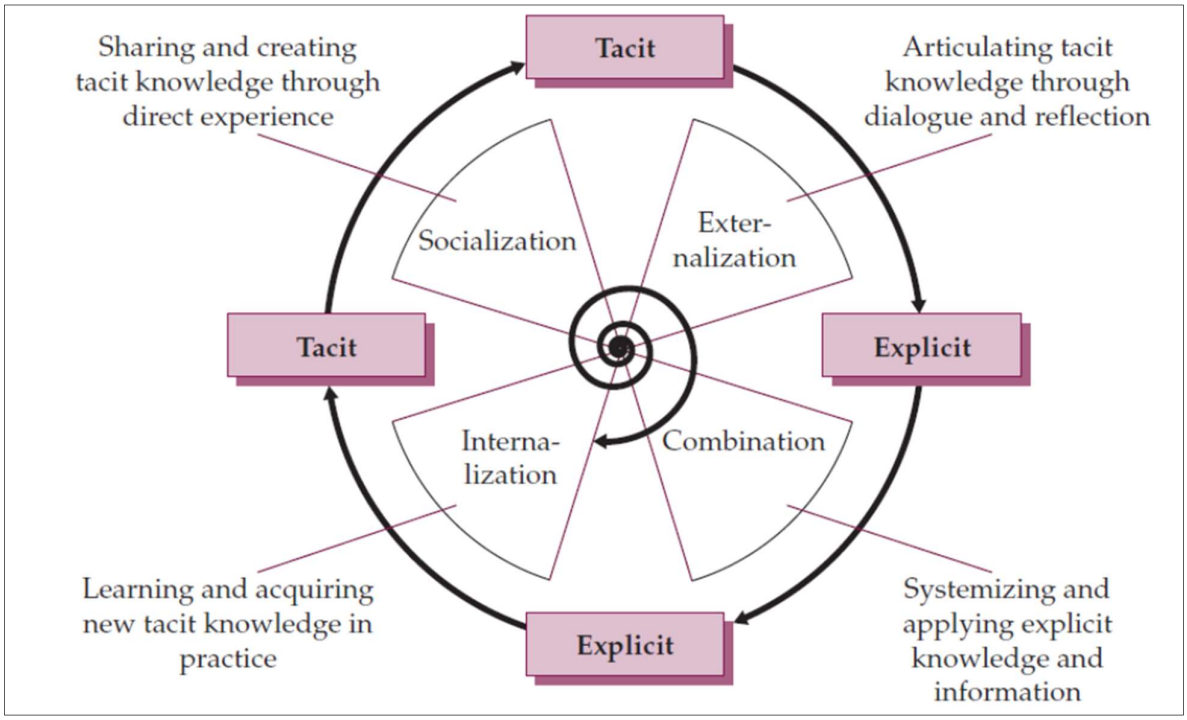

Figure 2-7: The SECI model [40]

2.6. Knowledge Management Tools

This section reviews the different knowledge management tools that are required to support knowledge management in an organisation. There are a number of tools available for knowledge management implementation, and it is therefore important that organisations choose the right tools to ensure that the organisational goals are addressed [41]. Knowledge management tools refer to both IT and non-IT tools [41]. Gallupe (2001) cited in [42, p3] also states that knowledge management tools are not information management tools since they should be "capable of handling the richness, the content, and the context of the information and not just the information itself".

Anumba *et al*. [41, p84] also cites Ruggles (1997) defining knowledge management tools as "technologies used to enhance and enable the implementation of the sub-processes of knowledge management, e.g. knowledge generation, codification and transfer" [41]. The term KM techniques is used to distinguish Non-IT tools from IT tools, which are referred to as KM technologies [41]; table 2-2 shows the differences between the two [41, p84].

Table 2-2: A comparison between KM techniques and technologies [41]

KM Tools	
KM techniques	**KM technologies**
Require strategies for learning	Require IT infrastructure
More involvement of people	Require IT skills
Affordable to most organisations	Expensive to acquire/maintain
Easy to implement and maintain	Sophisticated implementation/maintenance
More focus on tacit knowledge	More focus on explicit knowledge
Examples of tools • Brainstorming • Community of practice • Face-to-face interactions • Recruitment • Training	Examples of tools: • Data and text mining • Groupware • Intranets/extranets • Knowledge bases • Taxonomies/ontologies

Knowledge Management Techniques

Knowledge management techniques are non-IT tools that do not require technology to support them, and they can exist in several forms [41]. These tools include but are not limited to brainstorming, community of practice, face-to-face interactions, recruitment and training [41]. These knowledge management techniques are affordable, easy to implement and maintain and also increases the organisation's tacit knowledge [41]. Knowledge management techniques are not new and most organisations have been implementing a few of these techniques but not classifying them under KM [42].

Brainstorming is a process where a group of people come together to resolve a specific challenge or problem in the organisation [41]. The process is usually informal, allowing people to come up with different ideas which are not evaluated on the spot, and to also piggy back on other people's ideas and expand them [41]. All the ideas are noted until the brainstorming session comes to an end and only then will the ideas be evaluated to see if they address the problem at hand [41]. Brainstorming is used when new ideas or options are required [43]. Brainstorming, therefore, facilitates an important process of knowledge creation, which is a vital activity in the knowledge management cycle. However, brainstorming is not appropriate where a problem has possibly one correct solution which requires analysis [43].

Community of practices (CoPs) are groups of people usually with different skill sets and experiences who usually come together because of shared goals [41]. Community of practices also facilitate essential activities required in the knowledge management cycle including access to knowledge, knowledge grouping, sharing of tacit knowledge, new knowledge creation and externalisation of tacit knowledge through best practice guides resulting in dissemination of knowledge to the organisation [44]. Three of the four knowledge

conversion modes of SECI are found in this technique: socialisation, internalisation and externalisation. CoPs are important for sharing knowledge [45] but also require enablers such as management support, passionate people, incentives and possibly IT infrastructure to be efficient [43].

Face-to-face interaction is associated with the socialisation process on the SECI model; this is traditionally how employees of an organisation share tacit knowledge [41]. Face-to-face interaction is usually an informal process and helps with "increasing the organisational memory, developing trust and encountering effective learning" [41, p85]. Through face-to-face interaction, employees in an organisation acquire collective understanding and develop social ties [42]. This technique contributes to knowledge creation through sharing, knowledge validation, since there is the same knowledge understanding, and sense making processes [41]. To enable this, the physical workspace in the organisation must create an environment that allows for and support knowledge sharing and creation [43].

Recruitment refers to buying knowledge from outside the organisation [41]. This is done through recruiting an expert who has the required tacit knowledge; this knowledge will be used to increase the organisation's knowledge base, shared, transferred and disseminated throughout the organisation to get value from the knowledge asset [41]. Training is also used to increase the knowledge base of the organisation; it helps in improving skills and increasing knowledge [41; 42]. Apprenticeship and coaching/mentoring are other techniques that can be used in knowledge management implementation, and apprenticeship usually takes the form of an apprentice working alongside experienced persons to learn through practice and get the required experience to perform the work whereas mentoring is usually coaching of an individual through career development [41].

Post-project reviews are sessions used to highlight the lessons learnt from a specific project [41]. The lessons learnt typically include what went wrong, what went right, what could be done better and how challenges were resolved or averted [43]. The lessons learnt can then be transferred to other subsequent projects to avoid failures and identify best practices for implementation thereby increasing the effectiveness of learning [41; 43]. Post-project reviews contribute to learning, knowledge codification, externalisation, socialisation, internalisation, knowledge dissemination and knowledge application activities of knowledge management.

Knowledge Management Technologies

Knowledge management technologies relate to knowledge management tools that rely on information technology [41]. These IT tools are a combination of hardware technologies and software technologies [41]. The hardware technologies are the platforms for software technologies and also in enabling organisation to store, share and access their knowledge assets, examples include personal computers, network servers, open architecture, applications and fibre optics, multi-media technology, internet, intranets and extranets [41].

Software technologies play an important part in knowledge management implementation; there are a number of software packages for knowledge management and a number of approaches that an organisation can take in its implementation [41]. However, software technologies are better described using software groups such as data and text mining, groupware, intranets/extranets, knowledge bases, taxonomies and ontologies [41].

Data and text mining refers to retrieving or extracting data/knowledge from a massive amount of data [41]. Data mining also enables relationships between different sets of data or knowledge to be discovered, and in this way creating new knowledge [46]. The disadvantage of data mining is that it requires expert data miners to extract information from the corporate portal [46]. Groupware is a tool that can be used for collaborating; it can be used between different organisations or in the same organisation where people are geographically dispersed [41; 46]. It is a platform for sharing and communicating knowledge [42].

Intranet is a software tool that only allows access to the organisation's employees and restricts external access. Extranet is similar to intranet but provides limited access to external people to access specific information [41]. These technologies are used mainly as a repository for knowledge; with the advantage that anyone in the organisation, despite the geographical area, can access organisational knowledge [41]. Knowledge bases are repositories storing knowledge about critical topics in an organised manner [41; 42; 43]. Knowledge bases are not databases where information is captured, they should be used as a means to develop new knowledge and expand on existing knowledge [43]. These tools support knowledge acquisition and application activities of knowledge management.

2.7. Knowledge Management in Construction Projects

The PMBOK guide defines ten knowledge areas of project management [12] and inherently uses some concepts of knowledge management to define the knowledge areas and the best practices for the project management discipline. However, knowledge management, though mentioned, is not explicit in the critical knowledge areas identified by the PMBOK guide. There have been recommendations to "systemise" knowledge management in the PMBOK guide by introducing it as a knowledge area [47; 48]. Knowledge should be explicitly managed to get benefit from the process.

The State of Project Management Survey in 2017 covered 392 organisations across different sectors to determine the state of project management [14]. On project performance, 37% and 42% of projects were delivered on time and budget respectively [14]. Lessons learnt was one of the processes that proved challenging to implement within project management [14]. In another survey, conducted by KPMG in 2017; only 31% and 29% of organisations are likely to deliver projects on time and on budget respectively [49]. Knowledge management is one of the strategies that were identified by the surveyed organisations to improve business benefits realisation [49]. Projects fail for many reasons; this is evident in the surveys and the literature

on project failure or success [50; 51; 52; 53; 54; 55; 56]. Good project management is based on experience, however, you can also learn from the experience of others [50].

The project team get to experience the construction of an asset and gain experiential knowledge which is mostly converted to tacit knowledge throughout the project [5]. The transfer of tacit knowledge is essential to "making knowledge actionable and operational in construction" [5, p526]. Poor delivery of information to construction sites and the lack of an effective knowledge transfer system/framework between the people involved in construction is a major challenge to the improvement of productivity [57]. Construction knowledge integration relies on information from different sources to achieve the desired outcomes [57] and this should be planned and formal to make implementation easier [4].

The importance of knowledge management has also been highlighted and is deemed critical in the construction industry [58]. The nature of construction projects, the knowledge that is required to successfully execute these projects, mostly existing in people's minds, the labour and skills intensive nature of the projects make knowledge management strategies an essential strategy for construction organisation [58]. Robinson et al., (2001) cited in [58] found that the most important reasons for knowledge management in construction organisations were "1) dissemination of best practices to key sets of employees 2) retention of the tacit knowledge of key employees 3) continuous improvement 4) the need for quick customer response and 6) the need to share knowledge" [58, p3].

The key benefits of knowledge management in construction organisations, from various literature studies including Anumba et al.(2005), Egbu (2004), Al-Ghassani et al. (2004), Carillo et al.(2004) and Robinson et al. (2001); are summarised in [58, p6] as "1) Innovation, 2) Improved performance, 3) Improved construction project delivery, 4) Facilitate the transfer of knowledge across a variety of project interface, 5) Increased intellectual capital, 6) Better placed to respond quickly to clients' needs and other external factors, 7) Improved support for teams of knowledge workers, 8) Retain the tacit knowledge, 9) Increased value, 10) Construction organisations can be more agile and better able to respond to organisational changes, 11) To respond to organisational changes and12) Risk minimisation".

There are barriers to knowledge management in the construction industry; Robinson et al's studies showed that organisational culture is a crucial barrier to the success of knowledge management [59]. The associated barriers and results emanating from organisational culture are people's attitudes and resistance to knowledge sharing; other barriers include lack of top management support, poor IT infrastructure, KM initiative "overload" and conflicting priorities between knowledge management and other business functions [59]. Therefore, to realise the benefits of knowledge management in the construction of projects, these barriers should be addressed, and the benefits of knowledge management effectively communicated throughout the organisation. A case study indicating the experiences of a company in the construction sector before and after

the implementation of a knowledge management enabling initiative corroborates the importance of management support, the right tools and technologies, alignment to organisational strategy and organisational culture [60].

2.8. Conclusion

This chapter reviewed the literature available on knowledge management and knowledge management implementation in construction projects. The literature review first started with defining knowledge management by defining core concepts and providing a view that would be taken by the research on definitions of knowledge, data and information. Plato [18] defined knowledge as justified true belief and this is the definition that the study will carry moving into the research design stage.

Knowledge was also differentiated from data and information through the use of different literature; it is therefore concluded that knowledge is "information combined with understanding and capability" [21, p3] and that it is an evolving process that emanates from data and information [22]. Different types of knowledge were explored; with the conclusion that tacit and explicit knowledge are the types of knowledge relevant to this research study and that tacit knowledge is considered most important for construction projects, though both knowledge types are required for holistic knowledge management solutions.

The study adopted a more holistic definition of knowledge management rather than focusing on one approach and instead focused on a more process-oriented approach that looks at both human and technology requirements. The benefits and enablers for knowledge management implementation were also discussed; these will be taken into account when developing the methodology for knowledge transfer enhancement. The enablers consolidated from different literature are senior leadership, learning culture, people and the tools required for knowledge management.

Different knowledge management cycles were reviewed and included a consolidation of 160 life-cycle models where it was found that there is a consensus regarding the activities that must be part of the knowledge management cycle. These activities are *use, identify, create, acquire, share and store knowledge*. These activities should form part of any knowledge management implementation in any organisation and for the purpose of this research in any construction project. The review also noted that due to the study's process of eliminating activities that were not synonymous, additional activities can be added due to the nature of construction projects if required.

The SECI model was also presented and it provided a conceptual framework of how knowledge activities, particularly those that are used to create and share knowledge, defined in the knowledge management cycle can be implemented. Different knowledge management tools, divided into technologies and techniques were also discussed. These tools are enablers to knowledge management activities and are important in the

implementation of knowledge management. Different techniques and technologies can be mapped to the different knowledge management cycle activities, and in this was an organisation can purposely introduce different KM tools at different stages of projects and learning processes.

Lastly, knowledge management in construction projects was reviewed and identified as a critical element for construction project success. Enablers or barriers for successful implementation of knowledge management initiatives are summarized as organisational culture and environment, organisational strategies and how they are linked to knowledge management strategies, knowledge management tools and management support.

To conclude the literature review and to also provide direction for the research inquiry and design, a conceptual framework based on the theoretical constructs and the relationships identified in the literature is developed. This is done to correlate the different concepts of knowledge management and identify the relationships that exist for knowledge management to be effective. The factors that are required to ensure knowledge transfer occurs are people, the organisation, knowledge management tools (techniques and technologies) and knowledge management processes/activities (KMC). The interaction between these four is a critical aspect of knowledge management success and efficacy of knowledge transfer.

What is also important is the knowledge management strategy that is employed by the organisation and how it should be linked to the organisational strategies and goals to ensure that it is implemented within the framework of the organisation and benefits of its implementation are realised [29]. Coupled with the implementation of knowledge management are the barriers and the enablers to its implementation; which is important to consider if you are to enhance the process. With all these considerations, the conceptual framework developed is indicated in figure 2-8.

Consequently the important concepts of knowledge management are woven in the following themes:

1. Knowledge Management Strategy and the Organisation
2. Knowledge Management Processes
3. Knowledge Management Tools – Techniques and Technologies
4. People involved in Knowledge Management
5. Barriers and Enablers

These themes will be used to direct and guide the research to ensure that the research question is answered and the objectives fulfilled.



Figure 2-8: Conceptual framework for knowledge management

CHAPTER 3: KNOWLEDGE MANAGEMENT FRAMEWORKS FOR CONSTRUCTION PROJECTS

3.1 Introduction

There has been an increasing focus on knowledge management for construction projects, and frameworks have been designed to manage the knowledge on construction sites effectively. This chapter provides an extensive review on construction based knowledge management frameworks. After which, the most applicable framework to be used as a benchmark to enhance knowledge transfer in NWOU's construction projects will be determined. This will be determined using the themes that emerged from the conceptual framework and comparing the frameworks against these themes.

3.2 Construction Activity-Based Knowledge Management (ConABKM) System

Tserng & Lin [61] refer to the main framework of knowledge management used in construction projects, and it has six stages, 1) Problem Happening, 2) Create Knowledge, 3) Share Knowledge, 4) Record Knowledge, 5) Knowledge Storage and 6) Knowledge Reuse. A problem occurring in the project would trigger knowledge management; the second and third stage is to come together as the project team to identify possible solutions and thereby creating and sharing knowledge. The fourth and fifth stage is to record the solution and then store the knowledge in a centralised relevant database for knowledge reuse for other projects.

Figure 3-1 shows the concept of knowledge management in the construction of projects; it shows the integrated approach of how knowledge is created, shared, stored, applied, re-used and presented [61]. Along with the activities that are required for knowledge management, the model also highlights the people that are involved in the knowledge management process; these are the experts, senior engineers, knowledge workers etc. It also incorporates the techniques of knowledge management which are to create and share learnings as well as the technologies to record and store that knowledge.

The knowledge is stored in a knowledge bank or database and represented in the form of activities. The advantage of activity-based knowledge management in construction projects is the ease of acquiring and applying the knowledge, since the knowledge is stored per activity it is easier to refer to similar past project activities and create a "knowledge asset" for that activity on the current project [57], this is illustrated in figure 3-2. By clicking an activity of the construction project phase, the system will then show all the knowledge that is related to that activity and also link to similar activities from past projects [61].

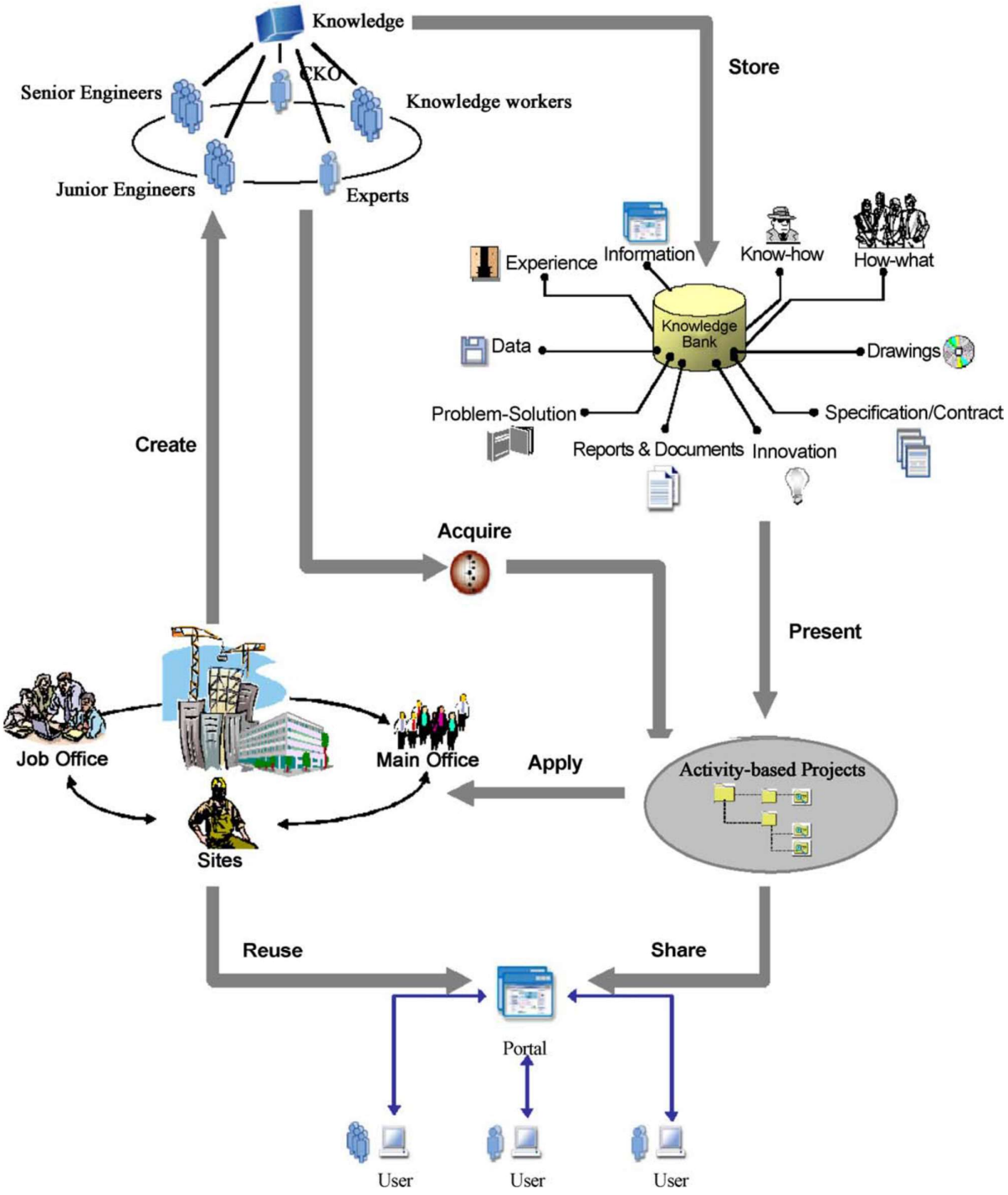

Figure 3-1: The concept of knowledge management in the construction phase of a project [61].

Tserng & Lin [61] argue that capturing and managing knowledge during the construction phase of a project is beneficial to future projects. However, it is also important to use the knowledge of a project during construction on other projects that are concurrently under construction. The learning or transfer of knowledge should then happen at a faster rate and the knowledge management framework should be flexible enough to support this functionality.

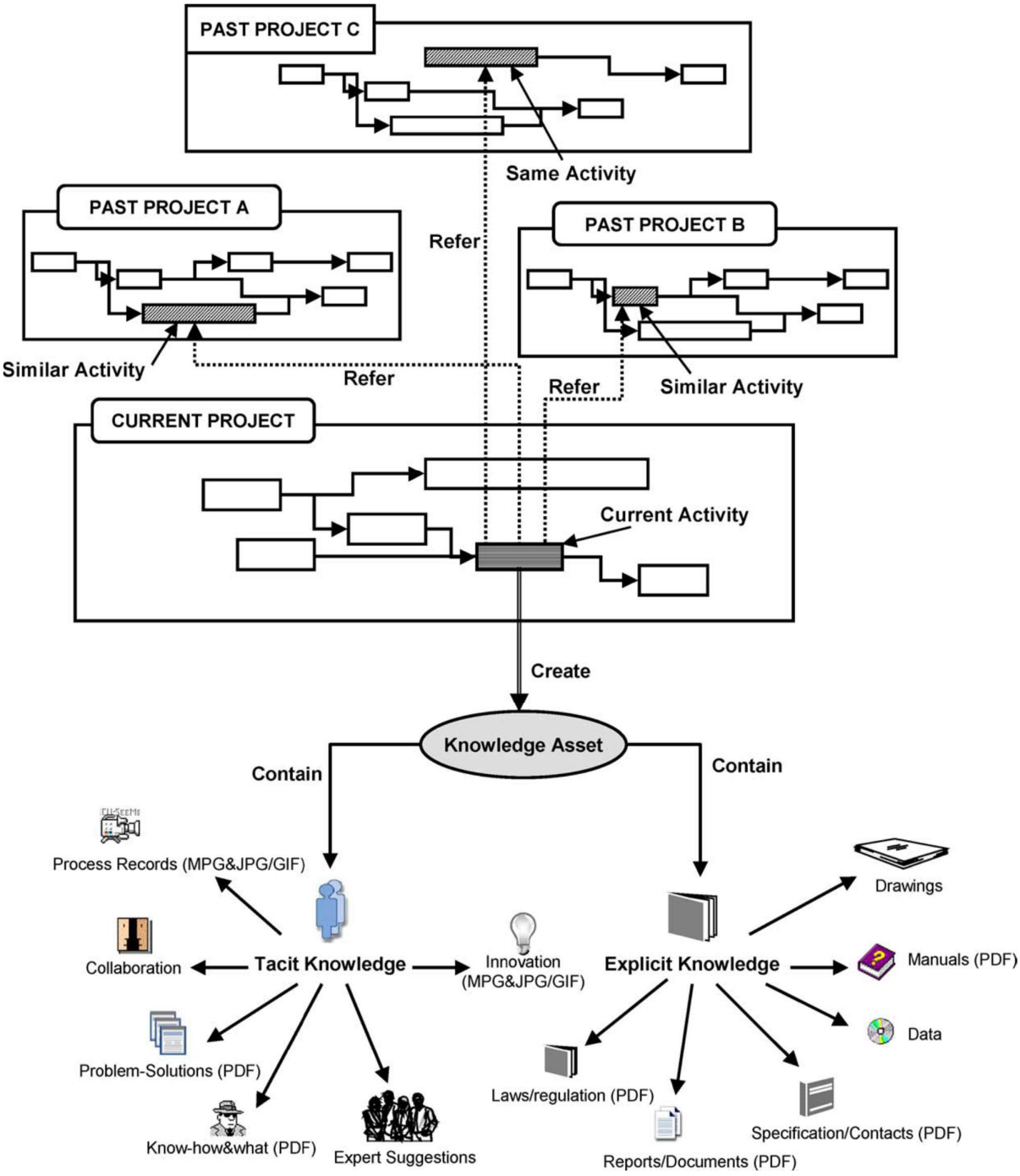

Figure 3-2: Concept for Construction Activity-Based Knowledge Management (ConABKM) [57]

The Construction Activity-Based Knowledge Management (ConABKM) system for general contractors was applied to a retrospective case study of a highway project in Taiwan, where the bridge had already been built [61]. The framework enabled "knowledge management of construction projects with reference to activities in a project" by defining the activities, procedures and content [61]. The ConABKM was designed using an IDEF (Integrated DEFinition function modelling) to support the information and complexity of the construction phase information or knowledge as it is able to support complex and changing systems [54].

ConABKM Framework Analysis

The stages for knowledge management activities in the ConABKM are much like the stages reviewed in the knowledge management cycle models and thoroughly cover the different knowledge management processes/activities required. The tools, techniques and technologies, are an integral part of the framework which provides a complete knowledge management solution for construction projects. The framework also focuses on tacit and explicit knowledge simultaneously making knowledge management more effective. The implementation of an activity-based knowledge management system also makes knowledge management and knowledge transfer easier. It offers a holistic approach that focuses on people, processes and tools.

3.3 CAPRIKON

The Capture and Re-use of Project Knowledge in Construction (CAPRIKON) project was concerned with the live capture of knowledge and developed a methodology to improve the live capture of reusable knowledge in construction projects [62]. This looked at the organisation, human dimensions and knowledge management tools [62]. The conceptual framework/system is illustrated in figure 3-3 [62] and is initiated by a "learning event" and that is documented through a "project knowledge file" and an "integrated workflow system" making the knowledge available for sharing [62].

The project knowledge file contains information that is deemed critical to project construction but focuses on knowledge that can be reused in project execution and also knowledge that can be used after [62]. The type of project knowledge that should be stored in the file is agreed on by the project participants who are then required to store the knowledge throughout the project [62].

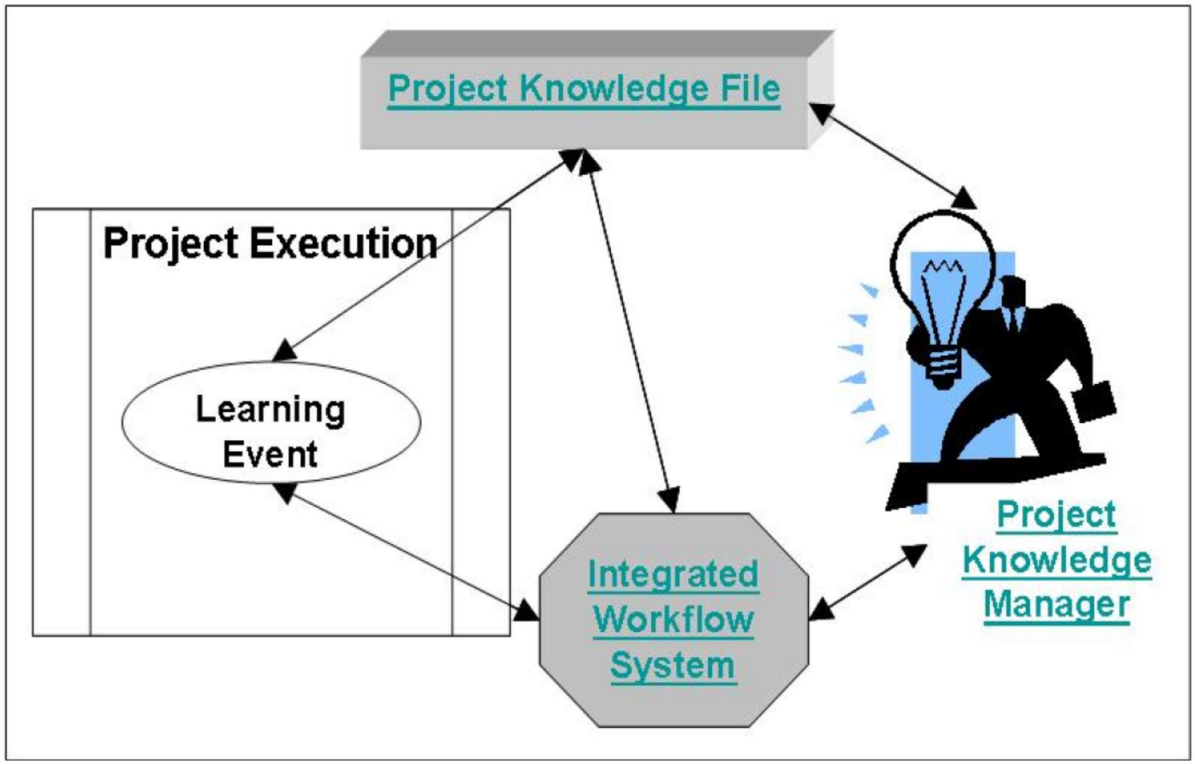

Figure 3-3: Overview of a knowledge capture system [62]

The integrated workflow system is for the implementation of the project knowledge file in real-time [62]. The system will be triggered when there is a learning event, which can be a challenge on site or new ideas on how to do things. The triggering mechanism can either be automated or manual; if it is automatic, then there must be data and text mining capabilities to ensure that the system can pick up the learning event and direct it to the correct participant. If it is a manual approach, then the project knowledge manager can be the person responsible for initiating the system [62].

Once the learning event happens, then the participants or the project knowledge manager will document the issues and solutions [62]. The knowledge or project team will determine the types of knowledge tools that would be most appropriate for the project knowledge at hand [62]; this is also illustrated in figure 3-4 [63]. There are three approaches, which result in different knowledge management techniques and technologies being applied, the learning even could require knowledge from an individual, knowledge from a group or knowledge from project documents [63]. As illustrated in the diagram, only knowledge from an individual and knowledge from documents should be validated before storing it in the project knowledge file [63].

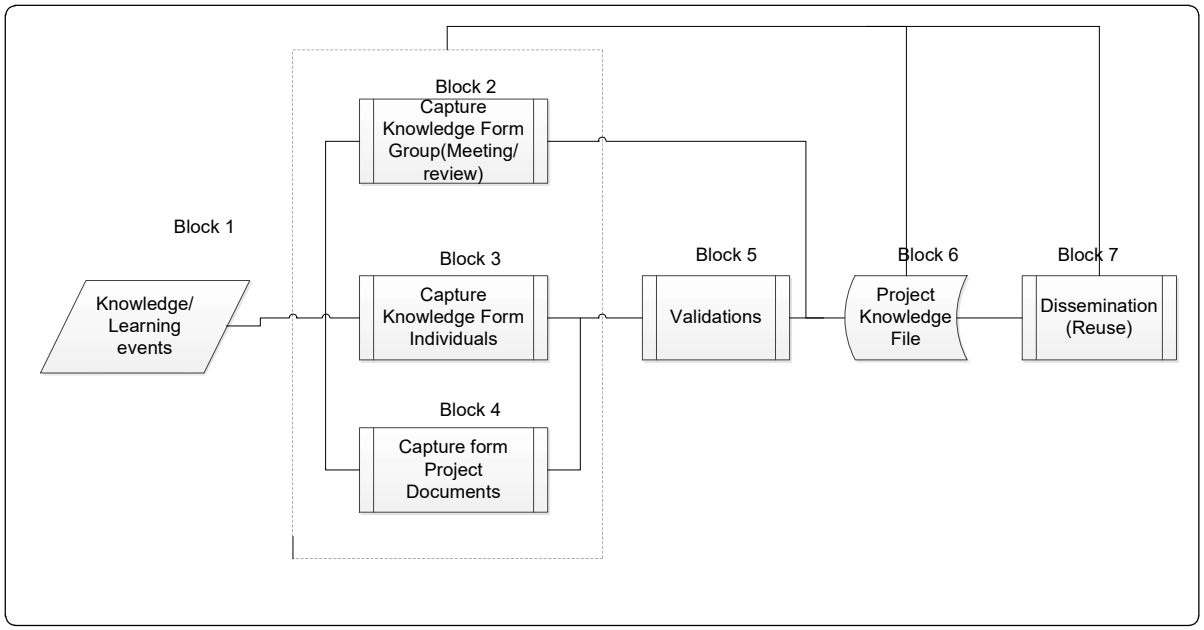

Figure 3-4: Project Learning Event Framework [63]

The knowledge will then form part of the project history and can be used for subsequent stages of the project or for future projects. The workflow system is required to have filtering capabilities to ensure that the relevant knowledge is recorded and that there are not any knowledge overloads [62]. Further to the framework, a web-based application for capturing and reusing "live" project knowledge was developed [63].

CAPRIKON Framework Analysis

The CAPRIKON framework deals with knowledge management activities at a high level. The framework does not explicitly state the process to be followed to manage knowledge in construction projects as it was developed to deal with live capture and reuse. However, it does make mention of sharing, creating, recording, storing and reusing knowledge. The knowledge management tools are extensively specified in the framework as the purpose of CAPRIKON is to ensure that tools can be utilised better to capture and reuse immediately. The framework also requires unique infrastructure to utilise the integrated workflow study effectively and for effective live capture of knowledge, it also requires an application, CAPRI.NET to make the process more efficient. The approach taken by the CAPRIKON framework can be classified as holistic even though the primary focus is on tools; processes and people are implicitly integrated.

3.4 Process Frameworks

The literature also has process frameworks for construction projects that aim to improve knowledge management in construction projects. These frameworks are discussed in this section.

3.4.1. CLEVER Framework

The CLEVER (*C*ross-sectoral *LE*arning in the *V*irtual ent*ER*prise) project focused on developing a process framework that can be used for knowledge management across different projects [64]. This was done by addressing the need for knowledge transfer from one project to another through research of best knowledge management practices in the manufacturing and construction sectors.

The CLEVER project identified that for better construction project performance, the knowledge that is acquired from one project should be transferred to and learnings used in other projects. The CLEVER project focused on projects at three levels: "1) intra-project – across departmental, functional and organisational boundaries, 2) inter-project – to other projects and the organisation, 3) cross-sectoral – for long term learning opportunities for a range of sectors" [65, p1105]. This approach enables the process framework to be used by different companies to assist them with selecting strategies that can be used for knowledge management in multi-project environments [65].

The CLEVER process framework focuses on organisational and cultural aspects of knowledge management rather than the techno-centric approach that other knowledge management initiatives take. The framework has four stages, and the main aim of this framework is to "clarify a 'vague' knowledge management problem(s) into a set of specific knowledge management issues, set within a business context" [64, p207]; these will then be translated into a set of knowledge management issues; after which preferred solutions and knowledge management processes will be identified [65]. The four stages are shown in figure 3-5 [64].

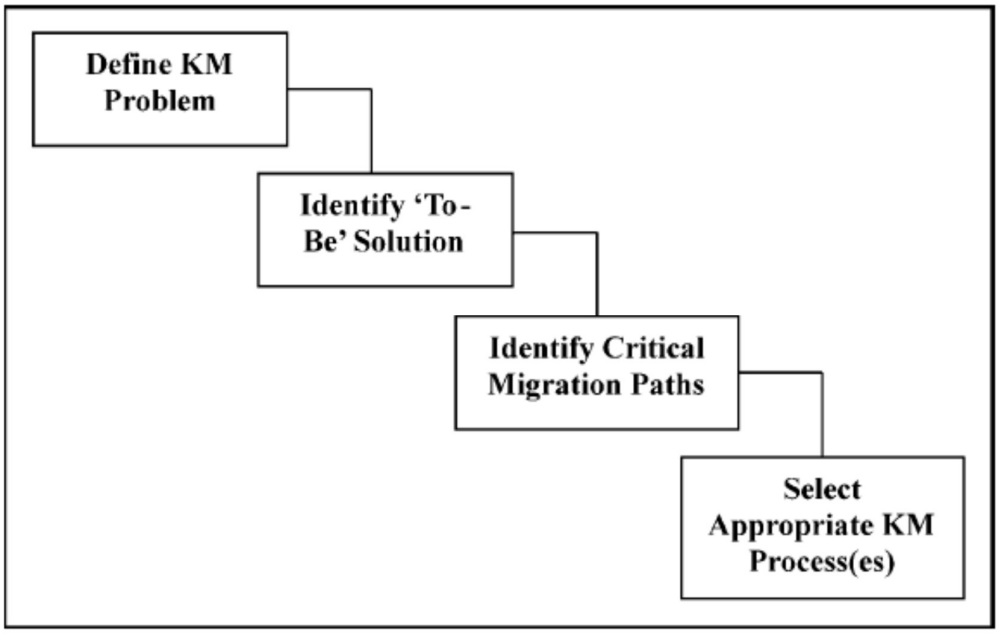

Figure 3-5: The CLEVER framework [64]

Stage 1: Define KM problem

The first stage of the framework is to define the knowledge management problem of the organisation; this includes a "description of the perceived problem, this stage utilises the *problem definition template* to clarify the knowledge management problem of the organisation within a business context [64, p208]. The result of this stage is a better-clarified understanding of the knowledge management problem that the organisation faces, within the specific business context, and a set of knowledge management issues that are derived from the knowledge management problem [65]. The problem definition template is illustrated in figure A-1 of Appendix A and is used for stage 1 of the framework [64].

Stage 2: Identify the "To-Be" Solution

The second stage explores the organisation's current state of knowledge management based on a set of predefined "generic knowledge dimensions' and also identifies where the organisation wants to be on those generic knowledge dimensions [65]. By comparing the "as-is" and the "to-be" states, the problem areas on which the organisation should focus are highlighted by the disparity in these two states. This stage serves as a gap analysis in knowledge management practices. The "knowledge dimensions guide" used for this stage is shown in figure A-2 of Appendix A [65]. The specific issues highlighted by this gap analysis can now be taken to the next stage of the framework.

Stage 3: Identify critical migration paths

The specific knowledge management problems can now be taken through a process to identify "critical migration paths" from the "as-is" to the "to-be" state. Through this process, required actions by the organisation can be identified for each specific knowledge management problem and at the end have a set of migration paths required to address the whole knowledge management problem [65]. This is done by using "the critical migration paths tool which uses a set of squares that correspond to the dimensions where a problem characteristic has been indicated" [65]. Figure A-3 of Appendix A illustrates this, "X" is the current state and the ticks show the desired states, this is done for each dimension and each set of squares in that dimension.

Stage 4: Select appropriate KM processes

The set of migration paths will then be used to select appropriate knowledge management processes and also ensure that the knowledge management intervention can be implemented by the organisation [58]. This stage provides organisations with a methodology through knowledge management processes of addressing the identified knowledge management problems. There is a list of predefined knowledge management processes that the user must choose from for each migration path that has been identified. The processes are: 1) obtain or capture knowledge, 2) locate and access knowledge, 3) propagate knowledge, 4) transfer knowledge and 5) maintain and modify knowledge; table A-4 in Appendix A shows an example of the selection of processes [65].

After the user decides on the process to achieve a certain migration path, that specific process template can be used to determine the methodology. Each process template has enablers and resistors that can either facilitate or inhibit the implementation of the selected process [65]. It is then for the user to identify those that are specific to the organisation under consideration. An example of a generic template for the "transfer knowledge" process is shown in figure A-4 in Appendix A [64]. The user then needs to go through all the boxes in the process template to identify the necessary activities to enable the implementation of the process. Going through the different migration paths and processes will provide an overall methodology for the organisation to address the identified knowledge management problem.

CLEVER Framework Analysis

The CLEVER framework provides the process required to determine the knowledge management challenges, address them through the process and recommend required activities to enhance knowledge management. During the practical application of the tool, the users found the terminology and the format of the tool to be rather complicated, and it required a few iterations to understand [65]. The other disadvantage of this particular framework is that it can be cumbersome to go through the stages of the process, especially identifying the critical migration paths. This framework also ignores the technological requirements of knowledge management and focuses on the human aspects of knowledge management. The framework does not necessarily provide a benchmark but instead goes through the process to determine the required knowledge management processes for an organisation.

3.4.2. IMPaKT Framework

The IMPaKT (*I*mproving *M*anagement *P*erformance through *K*nowledge *T*ransformation) framework is a three-stage framework aimed at linking knowledge management initiatives to business performance [66]. Knowledge management initiatives are most of the time expensive and organisations need the assurance that the knowledge management initiatives will yield better business performance; the IMPaKT framework was developed to enable organisations to develop a business case for knowledge management strategies and its implementation, and aligning these strategies to the organisation's strategic objectives [66].

The three stages of the IMPaKT framework are indicated in figure 3-6 and are [66]:

1) Stage 1: Developing a business improvement strategy
2) Stage 2: Developing a KM strategy
3) Stage 3: Developing a KM evaluation strategy

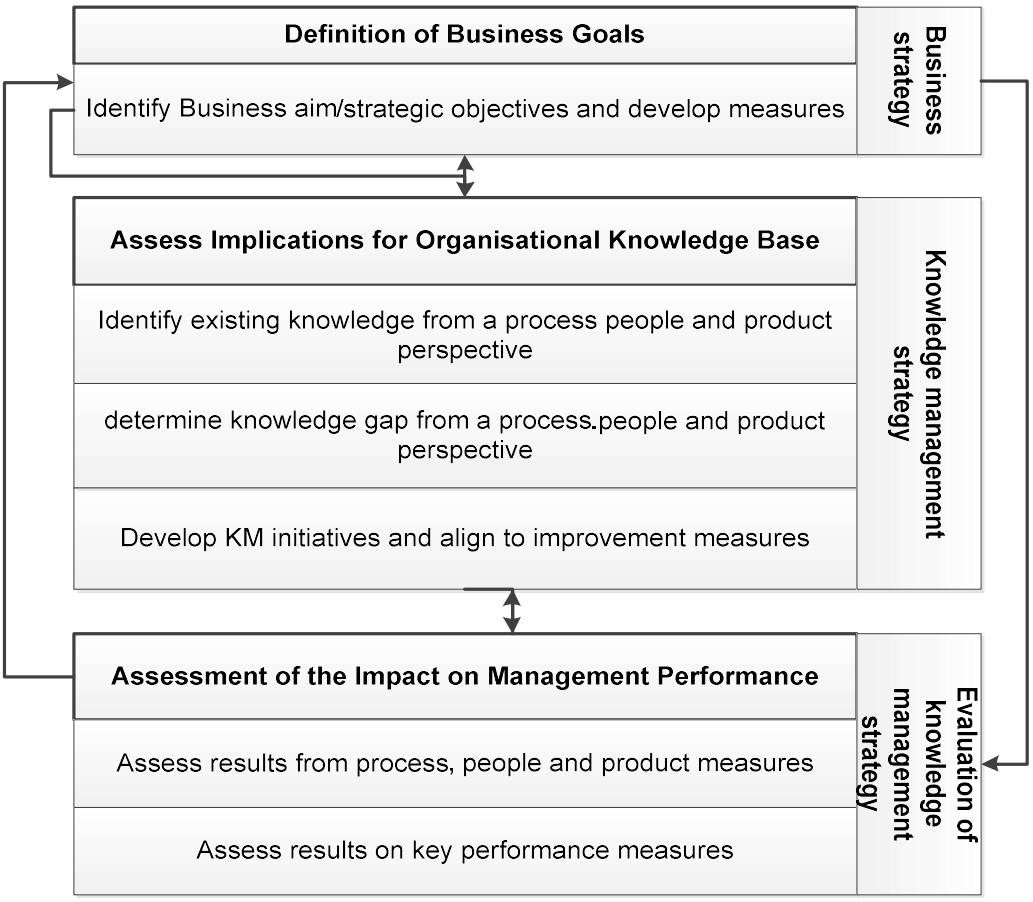

Figure 3-6: The three stages of the IMPaKT framework [66]

Stage 1: Developing a business improvement strategy

The aim of the first stage is to formulate a strategic business plan [66] and it consists of four steps. The first step in this stage is to identify a business problem and then analyse what knowledge problems may be causing the business problem. The next step will then be to "place" the business problem in a strategic context [66]. Then select appropriate performance monitoring measures [66]. The outcome of stage 1 of the IMPaKT framework is a "business improvement plan with performance targets and measurable indicators to assess performance" [66, p2]

Stage 2: Developing a KM strategy

Stage 2 aims to determine the business problem and to develop knowledge management initiatives to address this problem [66]. The first step is to clarify the knowledge management problem/dimension related to the business problem; this is done by identifying the knowledge management processes associated with the business problem [66]. Next, is to develop the knowledge management initiatives that are required to address the business problem and then identify the different tools to enable the processes identified. The fourth step is to align the initiatives to performance measures and indicate how they impact on the business' strategic objectives [66]. The last step will be to prepare for the implementation of the knowledge management

initiatives; this will require for example change management plans [66]. The outcome of this stage is a "knowledge management strategy with a set of initiatives and tools that will support business improvement" [66].

Stage 3: Developing a KM evaluation strategy and implementation plan

After the identification of the knowledge management initiatives; stage 3 aims to "provide a structured approach for evaluating the impact of knowledge management initiatives on business performance" [66, p4]. This is done through five steps, the first step is to utilise the cause-and-effect map as shown in figure A-5 in Appendix A to determine the relationships between the initiative, the performance measures and the strategic objectives, resulting in understanding the impact of the initiatives to the performance [66].

After this, the next step is to determine how effective the KM initiative will be in business performance; one KM initiative may have an impact on different performance measures, and also the impact will be different, based on some weight or ranking, on different performance measures [66]. In this way, the most effective knowledge management initiative can be determined. The next step will be to determine the most efficient KM initiative; this step looks at the processes that are required to implement the initiative, this includes tools and human resources; the cost associated with these initiatives are also considered. This step also determines the benefits of implementing these KM initiatives; to determine a cost-benefit analysis for the initiatives.

Knowledge management initiatives are then evaluated based on what is required to be done and what the benefits and costs are [66]. The last step of this stage is to prioritise the knowledge management initiatives based on the effectiveness and efficiency of the initiatives [66].

IMPaKT Framework Analysis

The IMPaKT framework is for the sole purpose of ensuring that knowledge management is linked to business performance and that people see the benefits of knowledge management and will, therefore, be inclined to implement the initiatives and improve business performance. The IMPaKT framework process identifies knowledge management processes or activities required to address the business problem and also identify the tools to enable these processes and initiatives. The process also looks at a change management plan addressed to the people of the organisation and in so doing it provides a holistic approach to knowledge management. The disadvantage of this framework for this study is that the process framework requires that the user goes through the steps to identify these solutions and does not provide a benchmark to compare with.

3.4.3. SeLEKT Framework

The SeLEKT (*S*earching and *L*ocating *E*ffective *K*nowledge *T*ools) framework is a methodology of choosing the right knowledge management tools for an organisation [41]; these tools can be divided into technologies and techniques as explained in the above sections of the literature review. The approach has 3 stages, and these are [41]:

1) Identifying organisational KM dimensions
2) Identifying required KM sub-processes
3) Identifying commercial software applications for the technology categories.

Stage 1: Identifying organisational KM dimensions

The aim of this stage is to identify the organisation's current knowledge dimensions and also to identify the organisation's future or desired knowledge dimensions. Three dimensions are used within the SeLEKT approach; these are the "knowledge transfer domains" (internal-external), "knowledge ownership domain" (individual-group) and the "knowledge conversion types" (tacit-explicit) [41, p]. Each of these dimensions has four possible combinations (internal to internal, internal to external, external to external and external to internal) [41].

The knowledge transfer domains evaluate whether the knowledge exists internally, i.e. within the organisation or externally; in so doing, the organisation can be able to determine the type of technologies and techniques required to manage knowledge [41]. The knowledge ownership dimension is also important in identifying the tools required which depends on who owns the knowledge [41]. The last knowledge dimension that needs to be evaluated is one that deals with knowledge types, tacit and explicit knowledge, depending on the type of knowledge conversion that is required; there will be different tools that can be employed [41]. Table 3-1 shows the tool that evaluates the 3 dimensions in their current state and the desired state [41].

Stage 2: Identifying required KM sub-processes

After determining the required knowledge management dimensions; then the next stage is to determine the knowledge management sub-process that will enable the organisation to move from the current to the required dimension. The knowledge management sub-processes in SeLEKT are locating and accessing, capturing, representing, sharing and creating new knowledge [41]. Based on the current and desired knowledge dimensions; two sub-processes will be determined to move from the current dimension to the required dimension; this may also include identifying sources and receivers of knowledge [41]. If the two sub-processes that are identified is "capturing" and "sharing" then the relevant technologies or techniques should be determined to facilitate these processes. The outcome of stage 2 is linking the identified knowledge management sub-processes to tool (technologies and techniques) categories.

Table 3-1: KM dimensions and possible combinations [41]

KM Dimensions				Required Dimensions							
	Transfer Domains			Internal				External			
		Ownership Forms		Individual		Group		Individual		Group	
			Conversion Types	Tacit	Explicit	Tacit	Explicit	Tacit	Explicit	Tacit	Explicit
Current Dimensions	Internal	Individual	Tacit								
			Explicit								
		Group	Tacit								
			Explicit								
	External	Individual	Tacit								
			Explicit								
		Group	Tacit								
			Explicit								

Stage 3: Identifying commercial software applications for the technology categories

After linking the tools to the knowledge management sub-processes; suitable software can then be chosen from the database to meet the technology requirements, and suitable techniques should also be chosen from the KM techniques database.

SeLEKT Framework Analysis

The SeLEKT approach is mostly concerned about the type of technologies and techniques that should be used for an organisation. The process, looking at tacit and explicit knowledge, is concerned with aspects that affect the selection of tools for the organisation and doesn't holistically view the knowledge management problem. The SeLEKT framework also requires that the organisation be aware of its desired knowledge management status which is the aim of the benchmark framework that is required for this study.

3.5. Chapter 3 Conclusion

Knowledge management frameworks for construction projects, namely ConABKM, CAPRIKON, CLEVER, IMPaKT and SeLEKT were reviewed to determine the most appropriate framework that can be used as a benchmark for this research study. The review discussed and provided an analysis of the different frameworks, looking at the different knowledge management theories previously discussed and consolidated in the conceptual framework namely:

1. Knowledge Management Strategy and the Organisation
2. Knowledge Management Processes
3. Knowledge Management Tools – Techniques and Technologies

Table 3-2 consolidates the evaluation of the construction based frameworks that can be used as benchmarks. The ConABKM framework meets the requirements for an effective knowledge management system and has the added advantage of handling knowledge per activity to ensure that the right knowledge can be found effortlessly. Therefore ConABKM will be utilised as a benchmark framework for enhancing knowledge transfer between concomitant projects under construction. This construction based knowledge management framework should obviously be supported by organisational culture; people involved in knowledge management activities and will be affected by the number of enablers or barriers on the organisation.

Table 3-2: Evaluation of Construction Frameworks

Framework	KM Processes/Cycle	KM Tools	KM Strategy	Advantages/Enablers of KM
ConABKM	X	X	Holistic	• Activity-based KM • No additional IT requirements
CAPRIKON	X	X	Holistic but focus on KM tools	• Live capture and reuse
CLEVER	X		People	• Guides the process of defining and resolving the KM problems
IMPaKT	X	X	Holistic	
SeLEKT	X	X	Technology	• Specifies tools for KM

CHAPTER 4: RESEARCH METHODS

4.1 Introduction

The aim of this research is to develop a methodology to enhance knowledge transfer between concomitant projects under construction in the North West Operating Unit of the Eskom Distribution division. This chapter will describe the research methodology followed to answer the research question and fulfil its objectives. This chapter will discuss the research design, which includes the research philosophy, approach and strategies, sampling techniques, instrumentation and the data collection process. The process of developing the methodology to enhance knowledge transfer will be explained along with reliability, validity and ethical considerations for the research.

4.2 Research Design

The research design for this study will be guided by the "research onion" [67, p108], depicted in figure 4-1, which guides the user through different philosophical and methodological approaches. The research onion guides the user in terms of the appropriate approach to answering the research question; the different approaches will be based on the most effective way to answer the research question. The first two layers of the research onion refer to a more philosophical approach and will determine how the research is conducted going forward. This will inform the research strategy and data collection techniques and procedures.

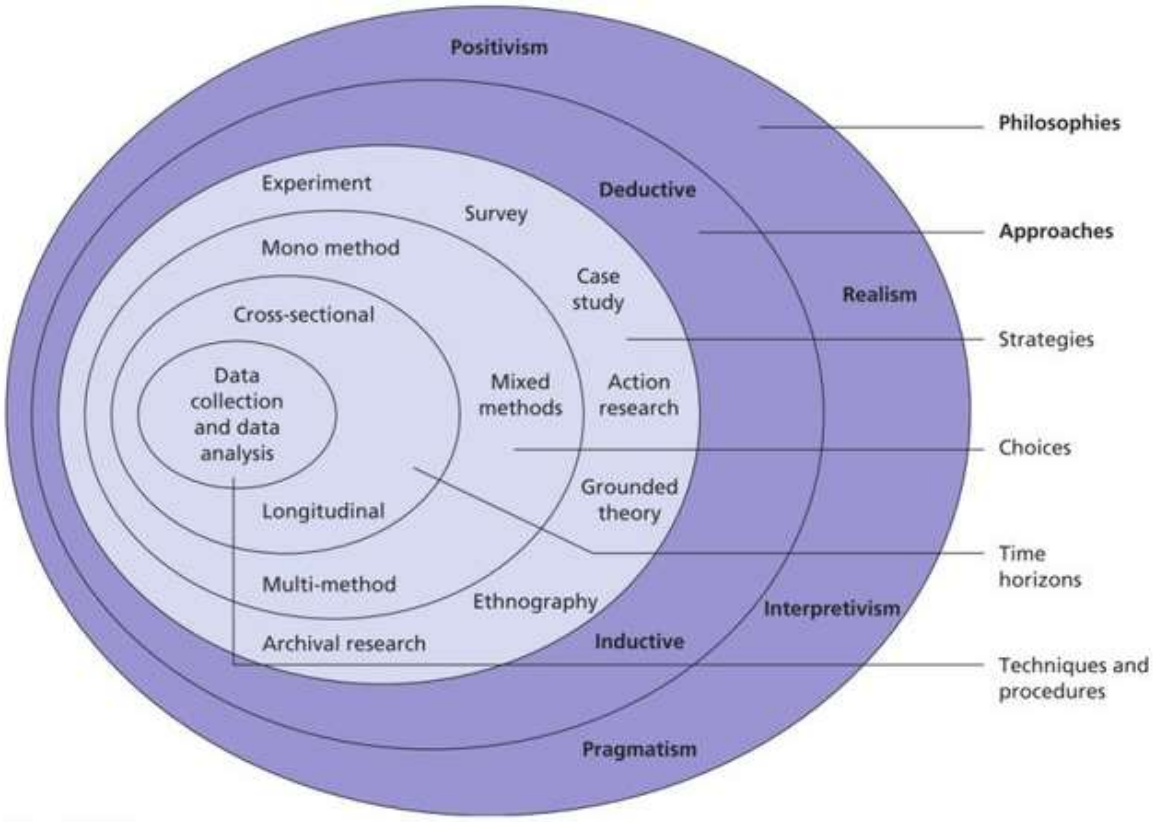

Figure 4-1: The research onion [67]

4.2.1. The Research Philosophy and Approach

Research philosophy relates to "the development of knowledge and the nature of that knowledge" [67, p107]. The research philosophy or "philosophical worldview" as termed by Creswell in [68, p6] is guided by the questions that the researcher aims to answer, the researcher's perspective on "the knowledge and the process by which it is developed" as well as some practical considerations which will, in turn, guide the approach and strategies of the research [68]. Creswell explains this as a framework for research design, where the interconnection of the philosophical worldviews, strategies and research methods occur [68]. Four research philosophies to be considered are positivism, realism, interpretivism and pragmatism.

The philosophy of positivism is mostly related to that of the "natural scientist" and "quantifiable observations" that can be analysed [67, p114]. The philosophy of realism is similar to that of positivism in that they both "assume a scientific approach to the development of knowledge" through data collection and analysis [67, p115]. Realism philosophy states that reality exists outside of and is "independent of the human mind" [67, p115]. Whereas, in the philosophy of interpretivism the beliefs, truths and perspectives of humans as social actors influence their behaviours and thus the world in which the research occurs. Pragmatism argues the use of both positivism and interpretivism in research because "one may be more appropriate than the other for answering particular questions" in the research [67, p109].

Knowledge management and the application of knowledge management is inherently a process driven by social actors and thus the philosophical view of the research should primarily take that into account. The research question of this study requires both positivist and interpretivist philosophies to fully address the objectives. The benchmark construction framework that will be used to guide the methodology will be generalised through positivism however the identification and management of knowledge-transfer activities and processes should be approached from an interpretivist philosophy as the worldview of the social actors/participants will influence the methodology.

There are two main approaches to research; these are deduction and induction [67]. The deductive research approach is one that "develops a hypothesis and designs a research strategy to test the hypothesis" while the inductive research approach uses "collected data and develops a theory as a result of the analysis" [67, p124]. The inductive research approach is adopted in this research project; knowledge transfer is a process that is dependent on the social actors and their beliefs, perceptions and truth, therefore the approach would be to engage with the social actors to understand their perceptions, barriers and make sense of the data collected by analysing the data [67]. This approach would then result in the formulation of a knowledge transfer methodology that is accepted, addresses the needs and most likely implemented by the social actors. Also, the inductive approach emphasises the importance of the "research context" and the "less concern with the need to generalise" [67, p127]. The environment (research context) in which the knowledge transfer takes place is

of importance to the study because depending on the environment and the organisational culture different methodologies can be applied to enhance knowledge transfer.

One of the objectives of this study is to explore the knowledge management practices in the organisation, understand the environment in which these practices are occurring and get a better understanding of the underlying issues in the management of knowledge for construction projects, and thus the study is classified as an exploratory study. The exploratory study is useful for finding out more information about a problem, getting a better understanding of the situation at hand and providing clarity of the issues involved [67].

4.2.2. The Research Strategy

The research strategy is concerned with the method of data collection and thus indicates the quantitative or qualitative nature of the research. Various strategies can be used to collect data, and these include experiment, survey, case study, action research, grounded theory, ethnography and archival research [67]. This research will make use of a qualitative data collection strategy administered through semi-structured interviews. The qualitative data collection strategy is chosen so that the dynamics of knowledge management can be understood better and the context appreciated throughout the research.

The use of a survey strategy is not suitable for the knowledge management problem that is being addressed in this research study, insights into the knowledge management practices of the actors is essential in effectively answering the research question, generalised questions and answers do not provide the necessary insights into these processes. Surveys also limit the ability of the respondents to elaborate on issues that they feel are important to the study, and in this way, critical information can be left out [67]. Therefore the chosen research design for this study is a qualitative, interpretivist, exploratory study using semi-structured interviews.

4.3. Sampling Technique

The primary data will be collected through semi-structured interviews. The population is the project team from the North West Operating Unit involved in projects under construction. This includes Portfolio Managers, Programme Managers, Project Managers, Project Coordinators, Clerk of Works and Senior Engineers. The level of involvement of the different participants is also critical in the study; the team that is responsible for project construction and involved in construction activities are more suitable to the research study and the sampling technique needs to ensure that they are fairly represented in the study.

The study utilises a non-probability sampling technique using the research objectives to determine the relevant participants to provide information on the current practices of knowledge management in the organisation and in the construction of projects. The purposive sampling technique is used for this study to ensure that the

sample is representative of the different disciplines in the construction of projects and that the people that are most involved and experienced in the construction of projects are included in the study.

The sampling frame for the study is the list of employees, involved in construction projects, specifically from the engineering and project execution departments of the North West Operating Unit. The initial sample size for the study was +/- 15 participants from a sampling frame of around 50 participants. The approach taken was that if the data reaches saturation then the researcher can consider the number of interviews at that stage sufficient or if more information is required, due to conflicting arguments, after the initial 15 interviews, the researcher will conduct additional interviews to gather more information. The saturation point will be determined from two perspectives, when the data does not result in new themes and when focus on the already existing themes does not provide any new information [67].

The purposive sampling was administered through the judgement of the relevant participants that can add richness to the study as well as based on their convenience and availability. The interviews were arranged in order of exposure to construction activities. The first interviews were arranged with the available Portfolio and Programme Managers and Project Coordinators, then moved to the Project Engineers, then moved to other departments that are directly involved with project construction at some point and also moved to departments that were not directly involved in construction of projects but have an interest in the completion of projects.

The interviews reached saturation at 11 interviews, which included 2 Portfolio Managers, 1 Programme Manager, 1 Middle Manager who has experience as a Portfolio Manager, 2 Senior Project Engineers, 1 Senior Advisor, 2 Specialists and 2 Project Coordinators. On the 7th interview, the preliminary data analysis showed recurring themes of knowledge management practices; these themes also emerged in the remaining interviews without additional themes being discovered. After the 7th interview, the already emergent themes were given priority and discussed at length to determine if there is further information that could emerge. However, the information was similar, and similar themes kept on emerging in the process resulting in the researcher hearing the same information over and over again. At this point, saturation was declared and data analysis continued.

4.4. Instrumentation

Interviews can be classified into three: 1) structured interviews, 2) semi-structured interviews and 3) unstructured in-depth interviews [67]. Structured interviews use a structured questionnaire with predetermined questions in a formal meeting with the respondent, this type of interview is mostly referred to as quantitative because it is limited to the questions and answers given and based on some pre-determined responses [67]. The semi-structured interviews are more inquisitive compared to the structured interviews; the interviewer has a range of questions but depending on the discussions in the interview, some questions

may be left out or added and more insight into specific themes given the appropriate attention, this provides the interviewer with more insight and also better control of the interview process.

The unstructured interviews are informal and mostly led by the respondent, which means that the interviewer will not have specific questions but will let the respondent express their opinions, beliefs and perceptions on the subject matter. The unstructured interviews can be used for studies where the researcher has very little knowledge about the subject matter. The data collection and analysis of this strategy is also time-consuming and complicated and is thus rejected for this research study due to these reasons.

To adequately answer the research question, an extensive literature review of knowledge management and semi-structured interviews are chosen as the appropriate instruments for this study. The semi-structured interviews allow the interviewer to have control over the process and direct the conversation to what is required by the research. A further advantage of the semi-structured interviews for this study is that it allows respondents to elaborate on issues and thereby providing rich context and data for the study.

The semi-structured interviews were conducted using a questionnaire that is a combination of open-ended and closed-ended questions. The interview questionnaire is centred on themes that were discovered in literature for effective knowledge management and provides a guide to probing questions and options that can be provided to the interviewee when required. This allows the interviewees to understand the concepts better and to be directed to the topics that need more in-depth thinking. Nine out of eleven interviews were face-to-face while two out of the eleven was via telephone. An audio recording tape was also used to record the interviews to refer and later to transcribe. The interview questionnaire can be found in Appendix B.

4.5. Data Collection and Analysis Procedures

The research methodology followed to fulfil the research objectives is shown in figure 4-2. The first two objectives are to identify a knowledge management construction based framework to use as a benchmark and to determine the current state of knowledge management within the organisation and in the NWOU. To identify the benchmark framework an extensive literature review has been done on the different knowledge management concepts, knowledge management in construction and finally knowledge management construction frameworks. The literature theory and the properties of the construction frameworks were used in the preceding chapter to identify the best knowledge management construction framework that can be used as a benchmark for the study; this was found to be the ConABKM framework.

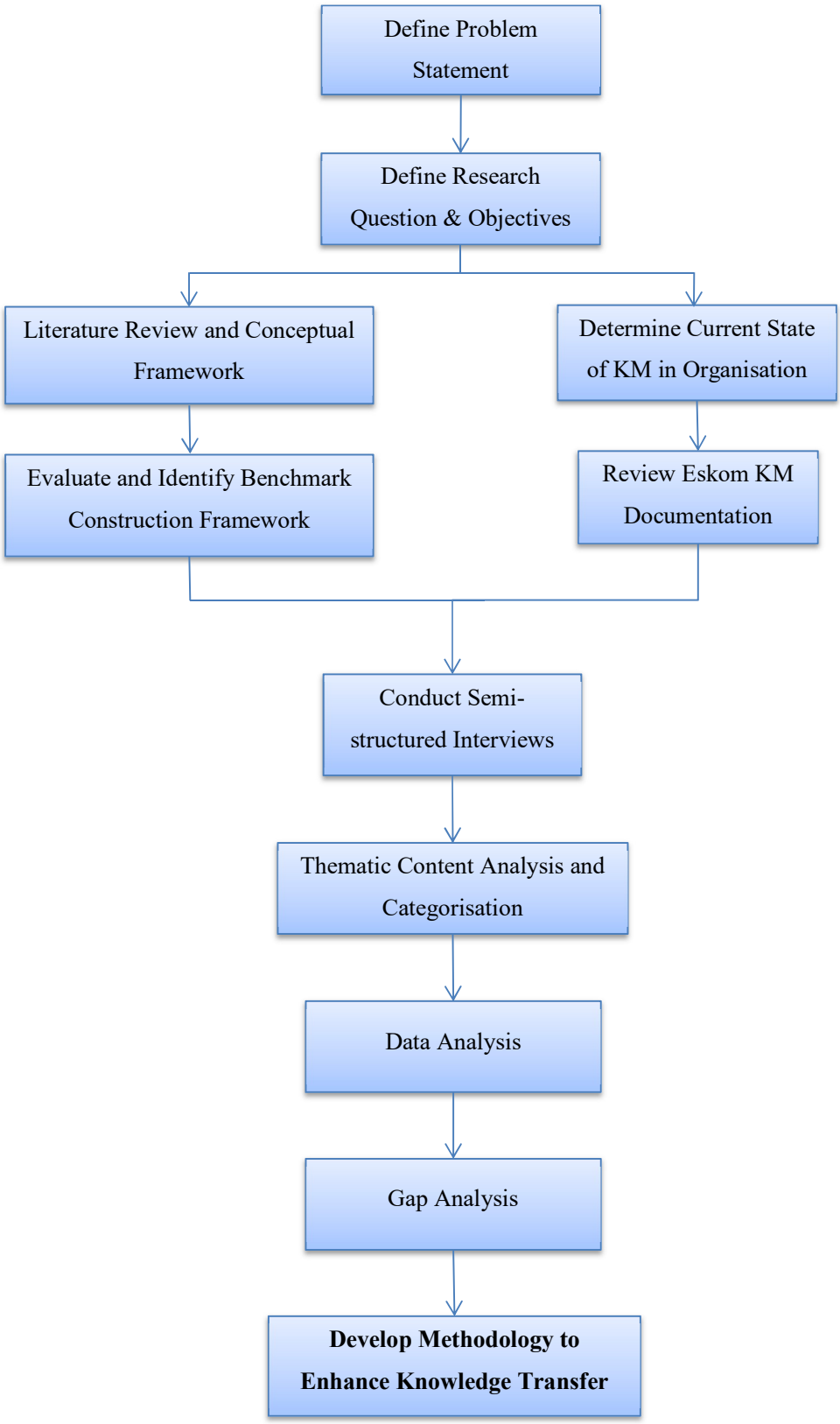

Figure 4-2: The data collection and analysis methodology

To determine the current status of knowledge management practices within the organisation and within the NWOU, a two-staged approach was used, which included primary and secondary data collection and analysis. First, the Eskom documentation was reviewed to understand the organisation's stance on knowledge management and how this might impact the NWOU. Relevant information such as the knowledge management strategy, processes and tools were then fed into the second stage of determining the current status of knowledge management practices through semi-structured interviews; the participants were allowed the opportunity to go in-depth on issues that are critical in their perspectives. In this way, the participant can add valuable knowledge and information, not considered before, that can help address the research question [67].

Due to logistical and location challenges, 2 out of the 11 interviews had to be conducted telephonically. The interviews were arranged at the convenience of the participant and always carried out in a closed office. The purpose of the research study and the concepts of knowledge management were explained to the participants; the level of explanation was based on individual understanding and questions. This was done to provide context to the topic that will be under discussion to ensure that the interview added value to the study and was not in any way too much information that may provide bias to the responses by the participants.

During the interviews, questions were clarified with real-life examples of construction projects to allow the participants to understand the questions better and also provide relevant and accurate insights. Questions were also rephrased where required when the participant did not understand or correctly interpret the initial question. Concepts of knowledge management were also explained in some instances where the participant required clarity during the interview. The interview was also made to flow easier by following up on the answers provided by the participants rather than following the structure of the questionnaire; this provided an easy flowing interview which resulted in participants elaborating and providing more insights into the issues. All the interviews were recorded, with the permission of the interviewees, with a recording device and transcribed verbatim.

The literature theory on knowledge management concepts, frameworks and Eskom's existing documentation informed the interview questionnaire. To identify the existing knowledge management practices in NWOU the interview questionnaire focused on the following themes, which were identified through the conceptual framework in Chapter 2:

- Knowledge management awareness and strategies
- Knowledge management processes/activities in construction projects
- Knowledge management tools in construction projects
- Barriers of knowledge management implementation in project construction

The interviews aimed to firstly understand the individual's awareness of knowledge management, its processes and activities as well as the awareness or knowledge of the organisation's knowledge management

strategies and goals. The interview also looked at uncovering whether knowledge management processes are part and parcel of the construction management processes of the organisation and how these are implemented on a project construction site so as to understand whether there is or there is no knowledge management processes embedded within project construction processes in the organisation, whether formally or informally.

The second part of the interview process was to determine the existing knowledge management practices in the construction of projects, and to understand what knowledge management activities or processes are followed, ranging from storing, creating, accessing, validation, sharing, transferring, disseminating to updating and retiring knowledge. Part of this discovery process was also to understand the existing knowledge management tools (techniques and technologies) that are available to the participants and whether they are used or not and also whether there are required tools that are not available in the organisation.

A major discussion point around existing knowledge management practices in construction projects was lessons learnt and best practices that are experienced on construction sites. And of significant importance in the interviews was how these lessons are communicated from one construction project to another and how the lessons learnt and best practices, the knowledge gathered, are captured for use in future or concomitant projects under construction. Lessons learnt are considered an effective way of sharing knowledge for construction projects and it was therefore discussed at length in the interviews.

Information on the type of knowledge required to improve construction project performance and the source of this knowledge was also discussed; this was to understand where the knowledge lies and what issues may arise with the location of the knowledge, these questions were adopted from the CLEVER framework as a guide to understanding some of the underlying issues that need to be resolved. The advantage of the CLEVER framework is that it is used to understand underlying issues that may not be evident. The last part of the interview process focused on the barriers and enablers of knowledge management activities in project construction as well as looking at the impact of the organisation and its leadership on such activities.

As the interviews were being conducted, there was intermittent preliminary data analysis taking place to determine if there were similar themes coming from the interviews and therefore allowing the interviewer to get more insights from the interviews that would follow. The same questions, but not in the same order, were asked to all interviewees to ensure that there is fairness in the process and credibility of the results. The last interviews were however more direct in terms of questioning since key themes were already identified at that stage which resulted in more concise interviews.

The preliminary analysis was done after every interview, the recording would be transcribed and themes would be identified. Themes were identified by noting similarities in the transcripts and then grouped in a separate document for consolidation and analysis. Only two interviews were conducted per day with an average of a day in between the interviews; this allowed time to contextualise and recall the interview and do a preliminary analysis. After the transcription and data cleaning of all the transcripts to ensure that the transcripts are accurate for all the interviews, the qualitative analysis process continued.

The next step in the research methodology is the thematic content analysis; this is used to determine critical themes and patterns to streamline the data analysis. The thematic content analysis considers the themes identified in the conceptual framework, the benchmarked construction framework and the preliminary data analysis from the semi-structured interviews. All the themes from these different sources are identified and the themes are used to categorise the collected data from the semi-structured interviews.

After categorising the data, "units of data" will be allocated to the appropriate categories; where a "unit of data" can be a sentence, paragraph or textual data that is described by the category [67]. After this, the data will then be analysed per category/theme and also noting the inter-dependencies of the different themes. After data analysis, a gap analysis will be done, based on the themes identified in the thematic content analysis, between the benchmark framework and the current status of the NWOU. This will then provide a platform for the development of a methodology to improve knowledge transfer between concomitant projects under construction.

4.6. Reliability and Validity

For this study, the criteria of validity will be considered from a qualitative perspective. Bryman [69] cites Lincoln and Guba (1985) in the proposition of two primary criteria to assess the validity of a qualitative study: trustworthiness and authenticity, the latter is more inclined to action research. The criteria that are used to assess trustworthiness are *credibility*, *transferability*, *dependability* and *confirmability* [69]. The four criteria are also aligned with the popular criteria used in quantitative research [69]:

1. Credibility is aligned with internal validity
2. Transferability is aligned with external validity
3. Dependability is aligned with reliability
4. Confirmability is aligned with objectivity

The credibility criterion focuses on the credibility of arriving at the findings and assessing whether the findings are an accurate reflection of the social world [69]. This study will ensure credibility through negative case analysis; negative cases that are not according to theory or other research findings will be explicitly stated in the study and the analysis will seek alternative explanations to arrive at credible findings [69]. Transferability focuses on the possible transferability of findings to other studies; this can be measured

through the amount of contextual information that the researcher offers allowing other researchers to transfer the findings [69]. This research study offers a detailed explanation of strategies and most importantly the data collection process [69]. The purposive sampling technique chosen for the study also provides an element of transferability because the participants are chosen based on their involvement in the construction of projects and thus another researcher may be able to compare with their context.

Dependability focuses on the records used in the entire research process that they should be scrutinised or be able to be audited [69]. For the study, the interview recordings and the accurate interview transcripts will be kept to ensure that they can be audited if required, the interviews were listened to several times while transcribing ensuring that the written account is dependable. The coding of data was also revisited with every transcript and this ensured that the categorisation and analysis of data was consistently applied.

The confirmability criterion refers to the findings not being inclined to the perceptions or beliefs of the researcher but rather those of the participants [69]. In this study the researcher is involved in the organisation under study and may therefore be prone to lack of confirmability due to own experiences. However the analysis of data will be done purely from an objective point of view as the researcher is interested in truthful results that will advance the organisation.

The interview questionnaire was validated through content validity; measuring the extent to which it measures what is intended [70]. The aim of the semi-structured interviews was to determine the practices of the organisation with regards to knowledge management, the different themes covered in the research questionnaire, developed from theory and existing knowledge management documentation in the organisation and the supplement of the CLEVER process framework ensured that the state of knowledge management can be determined from the questionnaire.

4.7. Ethical Issues

This study uses organisational data and data collection from employees to meet its objectives. Due to this interaction, ethical considerations are important for the study. To gain access to information required, an application was made to the organisation through the formal processes and approval was granted to continue with the study however information was to be regarded as confidential. The University also granted ethical clearance for the study to continue. It is also important that throughout the duration of the study the researcher is ethical in approach. The data collection phase of the study requires direct contact with persons and thus ethical considerations need to be explicitly made.

The participants were accurately informed of the objectives of the study and their rights as participants (right to be informed, to confidentiality and anonymity, to consent and to withdraw) [67]. The study was conducted in a way that does not in any way harm the participants. Informed consent was obtained through signed forms. The data collected will be treated with confidentiality; during interviews, no reference will be made to other interviews and the collected data will be stored in password protected files using codes.

4.8. Chapter 4 Conclusion

This chapter details the research design and methodology followed to answer the research question and fulfil the objectives as set out in the beginning of the study. To effectively answer the research question the design philosophy and approach that is used is that of an interpretivist working through the process inductively to capture and ensure that the experience of the social actors in the study is foremost in the process. And thus the research strategy chosen is that of a qualitative exploratory nature, using semi-structured interviews to collect the primary data required.

To determine the benchmark construction framework, the extensive literature review conducted on knowledge management theory resulting in a conceptual framework was used to evaluate the properties of the different frameworks. To determine the current status of knowledge management in the organisation a review of Eskom's knowledge management practices through documentation was done and primary data was collected through semi-structured interviews.

The number of participants interviewed were 11 and a purposive sampling technique was used as this is considered the most appropriate technique for this research study. The semi-structured interviews were conducted using a questionnaire that had a combination of open-ended and closed-ended questions. An audio-recording device was used to record the interviews for referring and transcribing purposes. The questionnaire focused on the following themes:

- Knowledge management awareness and strategies
- Knowledge management processes/activities in construction projects
- Knowledge management tools in construction projects
- Barriers of knowledge management implementation in project construction

All the themes emerging from the conceptual framework and the semi-structured interviews will then be used in a thematic content analysis to determine common themes to structure the qualitative data in different categories for analysis. After the data categorisation and analysis, a gap analysis will be conducted and a knowledge management methodology to enhance knowledge transfer recommended.

CHAPTER 5: DATA ANALYSIS AND RESULTS

5.1. Introduction

The analysis and results of the data collected are presented in this chapter. The Eskom knowledge management documents will be analysed to determine the current status of knowledge management development in the organisation. To structure the analysis of the collected data, themes emerging from the conceptual framework will be used to define the categories that will be used in the categorisation and analysis of the data. The findings will then be presented accordingly. The themes are as follows:

1. Knowledge Management Strategy and the Organisation
2. Knowledge Management Processes
3. Knowledge Management Tools
4. People involved in Knowledge Management
5. Barriers and Enablers

5.2. Eskom Knowledge Management Analysis

This section provides a synopsis and analysis of the current documentation on knowledge management developments within Eskom. There are five documents that were reviewed and analysed from Eskom's database, these are:

1. Process Control Manual for Knowledge Management [15]
2. Procedure for Development: Knowledge Management [16]
3. Eskom Enterprise Division Knowledge Management Strategy [71]
4. CED Skills and Knowledge Transfer Procedure [72]
5. Lessons Learned Implementation Procedure – Capital Projects [73]

The process control manual refers to processes and activities that must be undertaken for knowledge management in the organisation. These processes are 1) Establish KM, 2) Implement KM and 3) Evaluate KM [15]. The review and analysis show that these processes fully represent the processes required for effective knowledge management and that they are aligned to Dalkir's integrated knowledge management cycle reviewed in the literature [25] and also aligned to the ConABKM benchmark framework's activities.

The procedure for the development of knowledge management can be summarised in terms of the Eskom integrated knowledge management framework shown in figure 5-1. The framework analysis indicates that all the required knowledge management elements are taken into consideration; these include the knowledge management strategy, the desired culture, practices, assets, tools and enablers. Along with this, there is also a change management plan for awareness, integrating KM into business processes and developing a transformation road-map [16]. The approach taken by the framework and the Eskom strategy is holistic in nature as it takes into account people, processes, SECI and tools. Eskom has invested millions in collaborative

technologies which include Hyperwave amongst others, to manage knowledge assets and thus, part of the strategy is to utilise these tools to realise the return on investment [71].

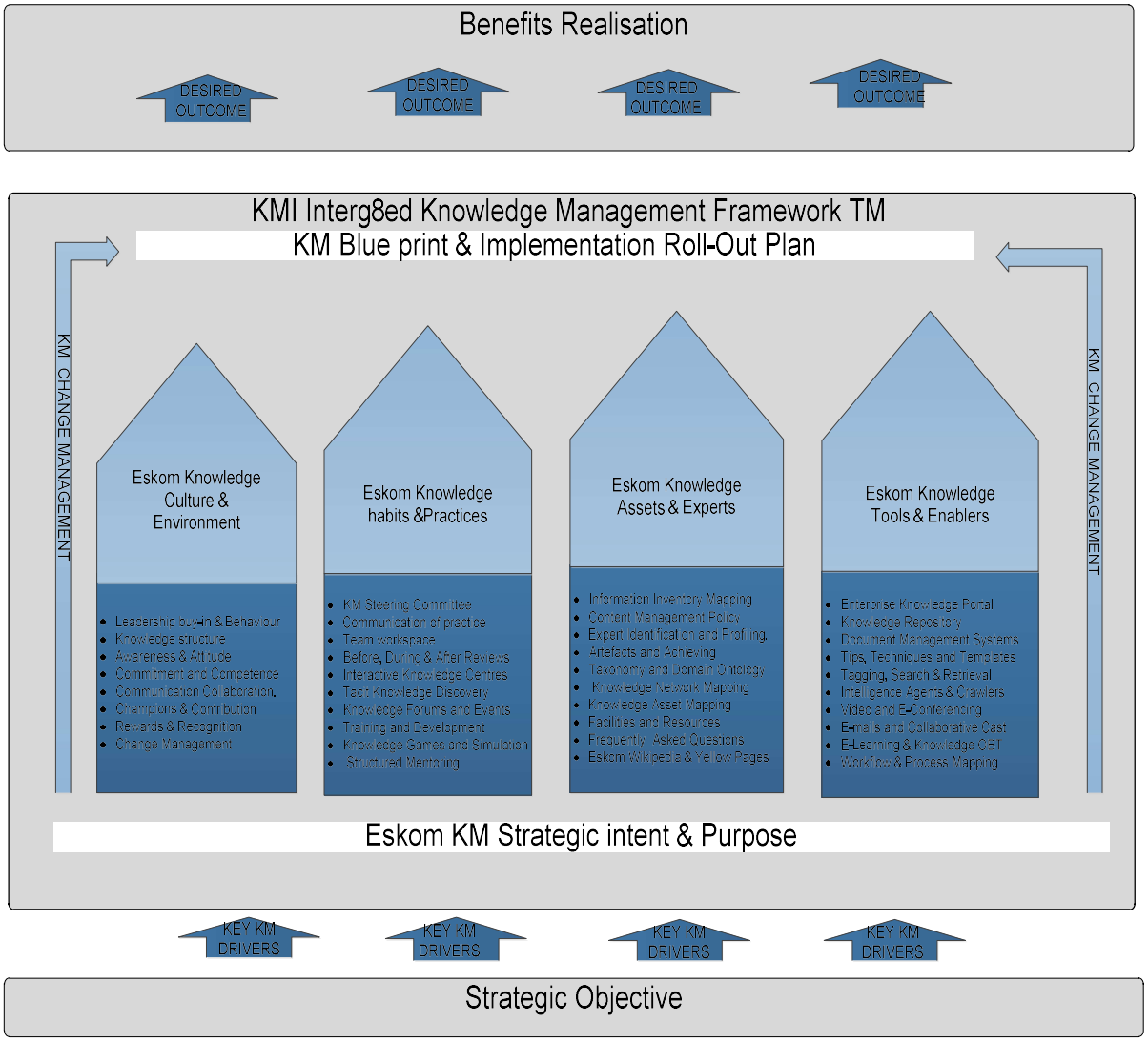

Figure 5-1: The Eskom Integrated Knowledge Management Framework [71]

Lessons learnt are referred to in most of the Eskom documents and procedures on knowledge management and out of the different interventions of knowledge management; there is a procedure that addresses the process of this specific intervention. The purpose of lessons learnt is to "reduce and prevent repetitions of mistakes and failures and to repeat successes and continuously improve project delivery (time, cost, and quality) and operational performance" [73]. The lessons learnt life cycle is shown in figure 5-2 [73]. The process is detailed and when analysed closely is similar to the ConABKM framework process for when a learning event happens on site. The Eskom knowledge management review indicates a well-structured and integrated system. The different documents strengthen the case for knowledge management and relate to each other. The documents provide an overall integrated knowledge management system that can be used to manage knowledge effectively.

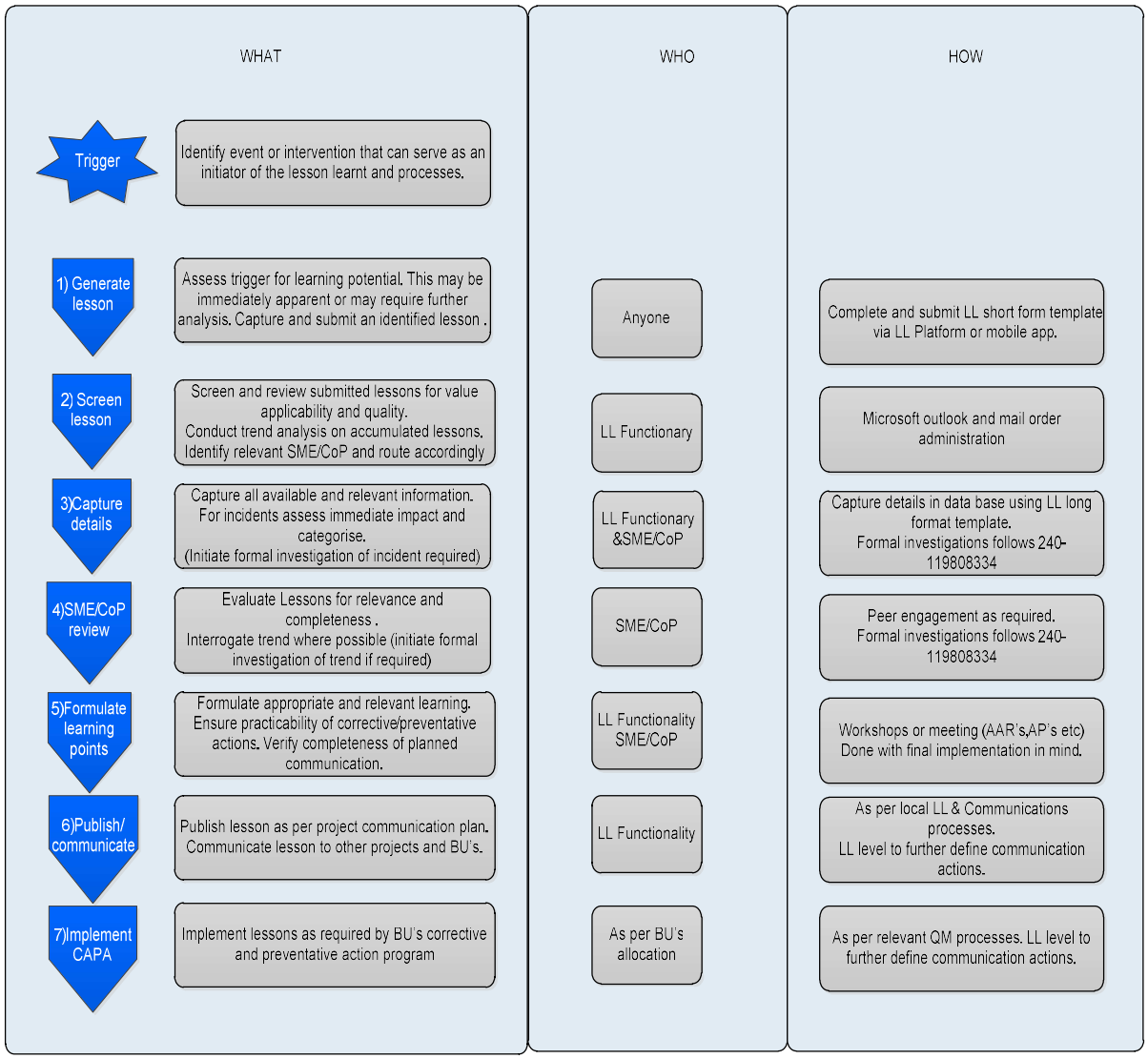

Figure 5-2: Lessons learnt life cycle [73]

5.3. Primary Data Analysis and Results

The participants involved in the interviews included 2 Portfolio Managers, 1 Programme Manager, 1 Middle Manager who has experience as a Portfolio Manager, 2 Senior Project Engineers, 1 Senior Advisor, 2 Specialists and 2 Project Coordinators. Between the 11 individuals, there is 107 years' worth of project construction knowledge and experience. All of the participants who are directly involved with construction projects have been involved in more than 20 projects each. From the 11 participants, 10 have been involved in substation construction projects, 8 in high voltage line construction projects, 7 in minor reticulation construction projects, 7 in major reticulation construction projects and 7 in electrification construction projects, and thus the experience ranges throughout the different type of projects that are available within the organisation.

5.3.1. Knowledge Management Strategy and the Organisation

The organisation plays an important part in the successful implementation of knowledge management, there are enablers in the organisation that lead to effective knowledge management, these are creating an organisational culture that supports learning and sharing, having a knowledge management strategy that is linked to the organisational strategy as well as ensuring that there is sufficient senior leadership support to ensure successful implementation of knowledge management [29]. The sub-categories identified for this section are derived from the literature theory and conceptual framework, and these are leadership support, organisational culture/environment and knowledge management strategies.

Leadership Support

With regards to leadership support for knowledge management initiatives, there appears to be a lack of support for knowledge management from senior leadership, one of the senior project engineers admits that the senior leadership is aware of the issues on site and the need for knowledge management, but nothing has been put in place to address the issues. More than half of the participants emphasised that senior leaders only concentrate on the results, which is construction completed for the projects rather than the process of getting there. Challenges are overlooked, and no learning from a leadership perspective happens, resulting in the same challenges occurring time and time again.

The leadership support for acknowledging the process that the project has to go through, understand and get involved as a major stakeholder is lacking; which can also negatively impact decisions that are made for projects as there is no understanding of the problems, risks and so forth. One participant recalls a construction project that was done where a senior manager was involved and, as a consequence, it ran smoother than any other project in that period. And thus believes that for improving the practice of knowledge management activities senior leaders have a big role to play as it is currently a problem. Emphasising this point is one of the specialists, who also indicated that there is absolutely no leadership support when it comes to knowledge management interventions.

Another issue raised is that there has not been any leadership intervention or talks with regards to knowledge management. Furthermore, there is no direction with regards to addressing the knowledge management challenges, and this has implications on the practice of knowledge management activities. One of the middle managers says that the initiative is left to departmental managers or an individual to implement; however, acknowledges that leadership support is not there and that it is required.

There is also a view that there is support from the Eskom Project Management Office (EPMO) for knowledge management and that the senior leadership is in support of these initiatives. However, there is also conflicting statements which state that there are other bigger priorities currently being dealt with that distract this process. The portfolio managers also echo this sentiment, stating that knowledge management is not prioritised by the

leadership but if support can be requested for it, it may be provided. However, initiatives for knowledge management are sometimes rejected by senior management. One project coordinator indicated that there was a plan to share knowledge at a forum, but this was rejected by the leadership and the reasons for this were not clear.

The leadership also sits in committees where the lessons learnt for the construction project are shared, and all the participants who have had to present or be part of the presentation admit that not once does the leadership ask about the lessons learnt. No value is attached to knowledge management techniques by the leadership. All participants agree that there currently is no leadership support from the NWOU for knowledge management and its associated activities.

Organisational Culture/Environment

The organisational culture and the environment in which knowledge management is being implemented are also of equal importance to the success of knowledge management. Creating learning and knowledge creating environment supports and enhances knowledge transfer. Only one of the participants mentioned the current financial situation in the company as demoralising to the people that are supposed to be part of the knowledge management activities, but also indicated that the organisation itself is open for learning and that it is up to individuals to take it upon themselves. However, the participant also contradicts this statement saying that the platform for sharing in the organisation is not set up and even though an individual is willing to share, it can be a bit difficult. There is however a consensus that there is no platform for disagreeing, debating and finding solutions within the organisation.

There seems to have been a culture shift in the past few years, participants who have been in the organisation for some time suggests that the organisation used to invest in knowledge management, requiring individuals to do training and study further. But that at the moment it is not the case, knowledge and experience is no longer prioritised, which could be a consequence of the current financial challenges of the company. In the current environment, projects are taking longer than they normally should and this, according to a couple of participants is normalised, and people do not see the need to share and learn.

The organisation has experienced and less experienced personnel, and there seems to be a big knowledge gap between these types of people in the organisation. The participants acknowledge that the gap can be closed and managed if the right strategies are put into place. The current environment, however, creates a culture of not knowing and no willingness to learn and there are no initiatives to change this culture. With the exception of one participant, there is a consensus that the knowledge is there in the organisation; it is just a matter of tapping into it and creating the right platforms to encourage sharing and learning to create a learning organisation.

The data analysis also shows that there are ‘silos’ that have been created in the environment of project construction by the project teams. The ‘silos’ are categorised in terms of the departments that are involved in the projects and even within the departments, there seem to be silos that are created and knowledge shared only within those silos. Most of the participants keep referring to knowledge shared in their department or their sections and do not include the rest of the project team, even within some of the departments the lessons are only shared in specific sections and not with others, even though the lesson may be applicable.

The environment that has been created in the project construction environment is not one that promotes sharing and learning. Participants agree that senior leaders apply punitive measures when people make mistakes, instead of addressing the root cause and understanding how the organisation can learn from it. The organisational approach focuses on punishment and not corrective action, and thus the environment tends to be that of people hiding issues on site or blaming other people rather than sharing and learning. Participants added that the organisation applies a lot of pressure on people to perform and people do not have the time to pause, correct and report on issues adequately, and this also contributes to the increased issues on sites.

Also, the project construction environment has not implemented the knowledge management processes or embedded such processes in the daily project construction activities. Only 1 participant has a contrary belief, that through the EPMO the knowledge management strategy is being incorporated in construction management processes. This is in contrast with other participants’ views; their experience is that currently there is no application of knowledge management processes in construction management and there is no plan to address it. One other participant however referred to the EPMO having a plan to introduce knowledge management practices in the processes but also noted that there is no appetite for it in the implementation of projects. The only knowledge management activity that participants think of that forms part of construction management is lessons learnt which are supposed to be shared at the end of the project; however, these are never conducted.

In the project construction environment, in the construction of substations, lines and electrification projects, most of the challenges, moving from one project to the other are relatively similar, but future projects always have the very same challenges. The participants agree that most of the challenges are the same and that there may be unique challenges but the majority of the time the challenges encountered in this environment are similar. The reoccurrence of similar challenges on construction sites indicates an embedded knowledge management problem in the NWOU.

Knowledge Management Strategies

The organisation has a knowledge management framework in place [71]; the scope of the developed strategy focuses on learning throughout the project life cycle, and this includes learning before, during and after each cycle [71]. The strategy emphasises leadership support in enforcing knowledge management, knowledge management standards for implementation of knowledge management, knowledge management teams, alignment of goals and objectives to the knowledge management strategy and relating performance management to knowledge management and others [71].

In order for the knowledge management strategy to be implemented, it needs to be known and understood by people in the organisation. Out of the 11 participants interviewed, only 3 participants had knowledge of the existence of a knowledge management strategy within the organisation, which is only 27% of the participants. And out of the 3 participants that had knowledge of the existence of the strategy, only 2 could briefly explain the goals of the strategy, the other participant had never read it and could not articulate the goals of the strategy. One of the participants who knew about the strategy also indicated that the strategy is there, but it is not known by people on the ground.

The main goals of Eskom's knowledge management strategy are to [71]:

1. Continuously improve the level of project performance in bringing new capacity to the grid;
2. Regain a positive reputation and financial rating;
3. Build the capability of young, inexperienced individuals and project teams;
4. Retain knowledge, expertise and experience in an aggressively competitive global market.

The participants that were aware of the knowledge management strategy explained the goals as sharing experiences and knowledge and to improve the quality of projects and to ensure that the lessons in between the experiences and processes are kept and recurrence of poor project performance avoided and improvement of performance on upcoming projects. And only 1 of the 2 participants who were knowledgeable about the knowledge management strategy knew about the existence of a knowledge management team to effect knowledge management in the organisation but did not know about the organisational framework for knowledge management.

The other participant was aware of the existence of the framework but acknowledged that the framework had not been communicated nor implemented. Clearly, the knowledge management strategy for the organisation is not known and not well understood, all the different participants try to navigate their way through the meaning and what the knowledge management strategy could be based on their own experiences and what they think knowledge management is.

When asked about the importance of knowledge management and when participants extended the knowledge management strategy to their own understanding, there is some alignment of these thoughts to the goals of the knowledge management strategy, including achieving targets as a business, skills transfer, teaching other people and using systems like Hyperwave and ProjectWise to store and access information. The references made by the participants are mostly on the knowledge management activities and tools and does not adequately address the knowledge management strategy and the understanding that is required in order for knowledge management to be effective in its implementation.

5.3.2. Knowledge Management Processes

Knowledge management processes are the activities that the people in the organisation go through for effective knowledge management. These activities need not happen sequentially but are all essential for the organisation's knowledge management to be effective and efficient.

In terms of the ConABKM system, which is the framework that has been identified as a benchmark for the construction projects, the knowledge management process starts with an event happening on site and then the following processes need to occur: Create Knowledge, Share Knowledge, Record Knowledge, Knowledge Storage and Knowledge Reuse. Knowledge management would be triggered by a problem occurring in the project. The second and third stage is to come together as the project team to identify possible solutions and thereby creating and sharing knowledge. The fourth and fifth stage is to record the solution and then store the knowledge in a centralised relevant database for knowledge reuse for other projects at a later stage. The analysis will be done looking at these stages as sub-categories.

Create Knowledge

To create knowledge in concomitant projects that are under construction requires sharing of experiences, sharing knowledge amongst the project teams and accessing knowledge from other projects or other people through the techniques and technologies that are available to the project team. If there is a challenge on site, some of the project managers will call a site meeting where the project team discusses the issues and comes with a solution which will then be implemented to address the challenge, this sharing of knowledge creates new knowledge in individuals that didn't have this knowledge before and enhances the already existing knowledge in some of the other individuals.

Accessing knowledge in the form of referring to subject matter experts to create new knowledge for construction challenges on site is part of resolving issues on site for the engineers. The engineers that were interviewed admitted that there is a constant referral to subject matter experts when there are issues on site that they cannot resolve themselves and that they know where and how to access the information required. However, the location of this knowledge at times sits with subject matter experts that are geographically far from the engineers and the project sites and that it is sometimes necessary for face-to-face interactions to

understand the content of drawings or documents sent to the engineers in an effort to resolve challenges on site and this limits the knowledge creation process.

However, there are also instances where the subject matter experts will go to the site that is experiencing the challenge, and this will be in situations where there are unique challenges that haven't been experienced before. And through these interactions, there are new ideas and proposals to resolve the issues, and in that way, knowledge is created amongst the project team. The process of creating new knowledge on the construction site can happen in this way, as has been discussed above, or it can also happen with challenges that have happened before. Then, the sharing of knowledge from more experienced individuals creates new knowledge in those that are without that experience; but this is also dependant on the dynamics of the relationships between the project team, the ones with experience and the ones without.

Some of the challenges that occur with construction projects are repeated from project to project, and mostly with the same project team. Participants admit that it is usually the same challenges that are faced in concomitant construction projects and in future projects as well and that it seems that people are not learning from their mistakes, essentially not creating any new knowledge to circumvent the challenges. However there is knowledge that is created, this is knowledge of how to deal with the challenge once it has occurred, but this is usually constrained to the person who experiences the challenge and not the team or other projects. Therefore the learning is mostly corrective than preventative and is localised to individuals. There is only one example given by the project coordinator where a challenge was pro-actively prevented by the project team.

Knowledge and experience can also come from an external party such as a contractor, some of the contractors have experience and knowledge that can prevent or resolve construction challenges, the knowledge and experience if shared with the project team can create new knowledge. This is usually when a contractor foresees a challenge or proposes a solution to correct challenges on site; these solutions will then be reviewed by the engineers to check if they are appropriate and a final decision can be made. This process also creates new knowledge within the individuals that are reviewing these changes in design, but the knowledge is also created locally and may only be with a certain individual if not shared.

There are also knowledge bases in the company that are used to maintain standards and specifications, and usually, engineers refer to these for designs. One participant states that the knowledge base is important because it standardises the application and engineers with less experience can always refer back to these to create new knowledge. However, the participant also admits that the knowledge base creates an environment of people not being creative and creating new knowledge by thinking differently from the standard or applying something that is different from the standard.

Share Knowledge

Sharing knowledge is a critical component of transferring knowledge and enhancing the transfer between concomitant projects under construction and project teams. Sharing of knowledge is mostly facilitated by knowledge management techniques such as face-to-face interactions, lessons learnt, community of practices, interaction with subject matter experts, coaching, mentoring and so on.

For concomitant projects under construction, the sharing of information should happen as quickly as possible to ensure that challenges are prevented or the impact is minimised. When asked about knowledge sharing between projects under construction, engineering mostly referred to design reviews, which is the process of reviewing designs before construction starts and during project construction, the information sharing would happen between the engineers and the subject matter experts for that particular project and not between projects under construction. But there is sometimes reference made to projects that were done before, where someone shares information on what they did from another project to resolve a specific challenge.

Participants indicated that the sharing of knowledge is a struggle in one project between project team members, and therefore even worse between projects that are under construction at the same time. There is also a struggle to share knowledge between departments and sections. Also, for issues and challenges that occur on site, there are no post-project reviews or lessons learnt sessions before, during or after the project to share the issues, perform a root cause analysis, determine what improvements can be made and how the challenges can be avoided. This is not done on any project under construction, and therefore there is no knowledge that can be shared in this context to other projects under construction.

There is also limited engagement and communication between project managers of different projects under construction, between engineers of different projects under construction and between the project teams which can be a combination of the same people in different projects. Thus because there is a lack of engagement and communication, there is no sharing of experiences and learnings between projects and individuals. The only information sharing that was enforced was due to a safety incident on site to check what went wrong and what could be done better. However this sharing session was not conducted with the whole project team, but with one section of a specific department, also that was the only sharing session that was noted since. Thus, if there is sharing, it is reactive rather than proactive.

Lessons learnt are not done for projects, and therefore there is no platform for sharing learnings for projects to enable better performance for those projects and concomitant projects under construction. All the participants admitted that they have not been part of lessons learnt sessions and that these are never arranged. The reaction to issues usually is just to resolve them and carry on and hope that nothing comes up again. All the participants also agree that sharing through post-mortems or lessons learnt would be beneficial to projects under construction and that a lot of the mistakes would be avoided and dealt with.

The accidental way of sharing lessons learnt as explained by one of the participants is when an individual happens to talk about a challenge, and someone overhears the conversation or the individual is talking to someone who has experienced that challenge before. The experienced individual will then share what they did to get through the challenge, noting that this only happens if the other individual is willing to share the knowledge. Other than that there are no other formal platforms used to share knowledge. Concomitant projects under construction can be experiencing the same challenge, and no one knows, or if one of the project managers knows about the other manager's challenge, they do not engage each other and share.

Mentoring and coaching are there in different departments; new employees are usually taken through the ropes by more experienced employees. Knowledge is then shared in this sense, but this is not particularly for specific project challenges but rather on an ad-hoc basis. Sharing of information is sometimes between older experienced personnel and younger inexperienced personnel, and this dynamic is said to be a challenge by some of the participants, and this may be due to the generational gap and the different ways of doing things. Sometimes the issue is that people do not have the time to share the information, as it is deemed not a priority. The result is that there is insufficient knowledge sharing in the environment of construction projects.

Record Knowledge

Recording knowledge ensures that knowledge can easily be reused and referral for other projects under construction and future projects is made possible. The general outcome of the interviews with regards to the activity of recording knowledge for projects under construction was negative.

From the interviews, the lessons learnt are not shared and therefore cannot be recorded; there is no project where there is a document that refers to the lessons or the challenges and resolutions of that project. One participant says that this process requires willingness from individuals; it's a matter of sitting down and documenting the experiences so that people can refer to the document when they experience the same challenges. For the lessons learnt session that was discussed in the "Create Knowledge" section the lessons were incorporated and documented in the minutes, but there was no attempt to look at and update the standards. People will be able at times to tell the other party what they did, but there will not be a document that refers to what they did.

When referring to the knowledge that is recorded for projects that are under construction, the consensus is that knowledge is not captured for projects, which requires the project team to refer to individuals that may have the solution based on their previous experiences. Sometimes the knowledge that is required to resolve the problem comes in the form of a document which may be a standard that exists, but at times when referring to people, there will be no document to refer to. The knowledge is not recorded, but it is in a tacit form, from the person's experience. This also raises confusion sometimes as what the standards and guidelines say may be different from the experience of individuals.

Thus, there is a lot of knowledge through experiences, but there is no recording of this to facilitate better construction management and enhance knowledge transfer between projects. Participants acknowledge that if construction knowledge was recorded, it would make project performance better because people can refer. Another risk raised due to the lack of recording knowledge was that when people leave the organisation or departments they go with that knowledge and at times it is impossible to retrieve. Without documenting the knowledge, the people that were not there cannot refer to this knowledge and the people that were part of that experience may also forget aspects of the solution.

In engineering, there is sometimes difficulty in capturing specific knowledge because it will be a unique situation and not necessarily the general configuration and thus standards will not be updated with the new knowledge based on this. However, such unique situations should be recorded in the project repository, but due to the lack of recording, the knowledge does not get documented for future referral. There is also a perception that to document knowledge from an individual is quite a challenge but this is only because these processes are not embedded in the systems and procedures.

Addressing construction challenges can take one of two ways; where the project manager or project coordinator call a meeting on site to address the problem formally or where the project manager calls the responsible person directly; in both these situations, recording and documenting the challenges, resolution and root causes is not done. Also, the minutes for the meetings, if there are minutes, are sometimes not complete and also lack context and conviction to understand the information and knowledge.

Knowledge Storage

For easy, efficient and effective access to knowledge, the ConABKM framework stores knowledge per construction activity. This facilitates the ease of acquiring and applying the knowledge as you can refer to similar past and current projects' activities to assist a current activity in a project and to also create a knowledge base for the current activity in the current project.

All of the participants indicated that construction projects' knowledge is stored in one of two places, the first is a person's laptop, and the other is a person's mind. There was however mention of Eskom's storage system, Hyperwave. One of the participants indicated that from his experience the information that a person requires for projects under construction could be found 40% of the time in Hyperwave and 60% of the time with someone or in someone's laptop. Others indicated that the majority of the time the knowledge is stored in the mind. There is no central location where project construction knowledge is stored.

For projects that are under construction, most of these documents are stored in an individual's laptop or personal computer; this is also not one individual but different people. For example, as explained to the interviewer, the planning proposal is on the desktop of the planner and the planner probably shared it with the

designer who also stored it on the desktop; if these two people go, there is no way of getting the information. The design is also on the engineer's laptop and shared with only the project manager. There is much information that is kept in files on desktops and not centrally located where it can be easily accessed.

Some of the project information can be found on site where the construction is taking place; this is called a site file and should have all the relevant information for the project, but it is usually printed copies in a physical file. However, even this physically stored information is sometimes not available for projects under construction, one participant indicated that 40% of projects under construction would not have any information and 60% will have some information, but will usually be incomplete information. While another said 50% of the construction projects do not have the project file and also indicated that 50% of projects that would have the file, the information is incomplete or outdated.

The engineering documents may be found in some of the knowledge bases and also Hyperwave, but not all designs are stored there. Also, if the design is stored on Hyperwave or a knowledge base, usually only the engineers know where the documents are stored, and the rest of the project team doesn't know as the documents are stored by the engineer in a folder that is under the department rather than the project because the project itself doesn't have a repository in Hyperwave. The other issue might be that those folders are restricted and the access is limited.

When looking for knowledge to resolve a challenge on site, an individual will either search in Hyperwave or a knowledge base or ask other people. It is not easy to find information on Hyperwave if the individual does not know exactly where to go as there are massive amounts of documents for the organisation stored there. For one project under construction, there are many different sources of knowledge that one needs to go to or to go through to get the required knowledge. To get the relevant information, individuals have to go to different people; one participant when asked where the source of his required information is, responded by saying *everywhere* and because of this, the time delay before you get the information that is also required impacts on the projects' performance. One of the participants states that to get the information they go to people and not bother with any storage system.

Systems for storing knowledge are available in the organisation, Hyperwave, SharePoint, knowledge bases, intranets etc., but they are not being utilised. Access to project construction knowledge is then extremely poor in the current environment. There are currently some efforts to resolve the issues of knowledge storage where the project managers are being encouraged to save the project knowledge on Hyperwave. There are also efforts of utilising SAP Portfolio and Project Management (PPM) software, with the aim of centralising all systems and linking them to SAP to ensure that project knowledge is available in one storage system. However, the challenge of ensuring that people understand the importance of and utilise the storage systems remains.

Knowledge Reuse

Knowledge reuse refers to the reuse of knowledge that has been acquired from previous or concomitant projects under construction to resolve challenges or prevent them from occurring.

When discussing lessons learnt and applying or reusing the knowledge, the participants mostly agree that there is no reuse of knowledge from lessons learnt because the sessions or the process of learning and creating knowledge is not done, see figure 5-3. Knowledge from other projects is not transferred and reused in other projects. However, there is sometimes referrals that occur but this is referral to standards and specifications, and sometimes the solution for the challenge was implemented in a previous project, but because there is nothing to refer to or the people do not or find it difficult to refer to someone or a system, there are efforts in trying to come up with a new solution.

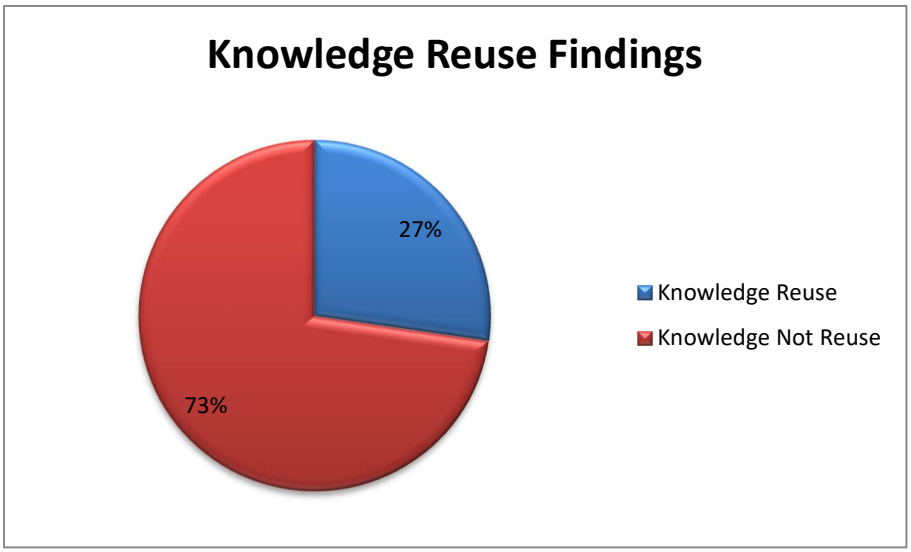

Figure 5-3: Knowledge reuse findings

Challenges and solutions are not captured and thus not easily available to reuse the solution. Throughout the interviews the general consensus is that the challenges are similar in nature from project to project and that this goes on even with the same project team; which simply means that there is absolutely no reuse of new knowledge and that most of the time there is re-use of knowledge to resolve the challenge rather than to prevent it.

From an engineering perspective, there seem to be knowledge bases where engineers can refer, these include standards and specifications, and so in that sense from engineering, there is reuse of knowledge. However this is knowledge reused to develop the plan or come up with the design; no knowledge base refers to lessons learnt or best practices for challenges in construction projects. The final design considers the standards, specifications and guidelines, and applies those to the specific project however, there are still design challenges in construction and this then sometimes requires subject matter experts to assist and because there

are no lessons learnt or best practices sessions, the knowledge is reused to correct the challenge and knowledge is neither created nor reused to prevent the challenges.

From the experience of the participants, if there is a challenge on site and there is an experienced person, most of the time the solution that comes from the experienced individual is implemented, which means that there is reuse of tacit knowledge. However, the reuse of tacit knowledge by an individual is also an issue; one challenge can be experienced in projects managed by one individual, there is no reuse of knowledge to do things better even when that knowledge is tacit. To find explicit knowledge to reuse to resolve a challenge on site is also an issue since knowledge is not recorded or centrally stored.

5.3.3. Knowledge Management Tools

Knowledge management tools are used to support knowledge management implementation, there are a number of tools available, and it is therefore important that organisations choose the right tools to ensure that the organisational goals are addressed [41]. The knowledge management tools can be categorised into technologies, referring to mostly information technology (IT) tools, and techniques, referring to non-IT tools [41]. The following two sections discuss the analysis of the data collected relating to knowledge management tools. The examples that were given to some of the participants who needed clarity and to facilitate the discussions on the tools that are used to enable knowledge management are brainstorming sessions; community of practice; face-to-face interactions; recruitment training; data and text mining; groupware; intranets/extranets; knowledge bases; taxonomies/ontologies; lessons learnt sessions; email; video-conferencing and cellular phone applications.

5.3.4.1. Knowledge Management Technologies

Knowledge management technologies relate to knowledge management tools that rely on information technology [39]. These IT tools are a combination of hardware technologies and software technologies [39].

WhatsApp, emails, telephones, Dropbox, laptops or personal computers and intranet are some of the technologies that are used in the project construction environment; there is also WEBEX that can be used to video conference, teleconference and share personal computer screens with different people but rarely taken advantage of for construction projects. All of the participants interviewed, when referring to the storage of documents and knowledge, mentioned Hyperwave. Hyperwave is a storage system that is accessible to all the employees with the aim of using it to store and access information. The implementation of storing and accessing information from Hyperwave is lacking; project construction knowledge is not stored. The system is not being utilised as it should be.

The issues raised with Hyperwave, by two individuals, are lack of access, limitations in terms of storage and difficulty in using. However, the participants also acknowledged that they had not been trained to use the system and therefore find it difficult.

Another technology that is available and also under-utilised is SharePoint; this system is for sharing information and collaborating, SharePoint has not been used in the project construction environment. Project Execution also uses Microsoft Projects for costing, and the history of the project expenditure is available for referral, and this provides some knowledge storage, sharing and reuse capabilities when required. Knowledge bases are also available in the organisation and have standard practices/specifications that are followed for construction projects but are usually only utilised by the engineers, and the other colleagues generally do not know where to find that information if they had to look for it. The technologies, WEBEX, Hyperwave, SharePoint and Intranets, are not utilised fully to enable knowledge management activities to occur. The infrastructure is there; however, the discipline and commitment to using these are lacking.

5.3.4.2. Knowledge Management Techniques

Knowledge management techniques are non-IT tools that do not require technology to support them, and they can exist in several forms [41]. These tools include brainstorming, community of practice, face-to-face interactions, recruitment and training [41]. These knowledge management techniques are affordable to most organisations because they do not require sophisticated infrastructure, are easy to implement and maintain and they focus on retaining and increasing the organisation's key asset: tacit knowledge [41].

For construction projects, one of the fundamental techniques that have been used is the lessons learnt sessions because the lessons that are learnt in one project can be transferred to subsequent projects to ensure that the failures are avoided and that best practices are re-implemented. The participants were therefore mostly asked about lessons learnt practices within the organisation to gauge the level of knowledge transfer at the construction phase of the projects; other techniques were also checked to see if there is an implementation of knowledge management techniques.

The use of knowledge management techniques in the organisation is very minimal. On lessons learnt, all the participants admitted that these are not done, whether before, during or after the project construction phase but also recognised and understood the importance of doing it. The programme manager interviewed reflected on personal reasons for not doing lessons learnt, stating that it has become of no value. The people that are required to participate in the sessions do not come, and when learnings are documented, they are stored on a laptop or desktop with no further reference to them.

Most participants indicated that lessons learnt are shared the end of the project, the FRA stage, with a committee to enable Project Execution to close the projects, but the process of conducting the lessons learnt

is not satisfactory. The lessons learnt are documented at a very high level and packaged into a presentation by the programme manager or project manager without the project team. The lessons are usually generalised and shared to a committee as part of the FRA presentation, and no value is attached to the lessons.

The lessons do not reach the project teams and end at the committee and as one of the participants said, the programme or project managers also forget about those lessons themselves. This is emphasised by other participants stating that people say they learn, but they then repeat the same mistakes over and over again. The way in which lessons learnt are being conducted is ineffective and is of no value to the organisation, it is not a post-project review that aims at improving project performance in the organisation but used as a means to close off the project and thus only done to comply.

Post project reviews were done in the past, and the lessons were recorded and shared with other programme managers; the perception is that in those years the post-project reviews were seen to be very important, whereas currently, they are not prioritised. One of the participants also suggested that at all different stages there must be lessons learnt sessions for that activity and that at the end there can be a session that consolidates the lessons for that project, which aligns to the ConABKM framework.

There are other techniques that can be used for knowledge management, and these were also discussed in the interviews; such as face-to-face interactions with subject matter experts, community of practices and brainstorming sessions. When discussing brainstorming, the only brainstorming sessions that are done for projects is at the stakeholder input meetings which usually happen before every stage of the project to get inputs on the project plan, design and implementation however there would not necessarily be a challenge that needs to be solved that people need to brainstorm about, it will just be a meeting for inputs to be given for a project. However, there are instances where when there is a challenge on site a meeting is called to resolve the issues but sometimes only the affected parties are called or told about the issues, and they must find a resolution to the problem by themselves and not necessarily a brainstorming session.

There are also face-to-face interactions in the organisation, but due to the dynamics of the relationship between colleagues, there can be interactions that do not yield the required results. Participants, when looking at the interaction between people in project construction indicated that there is no teamwork and that people are of individual minds, reserved and not sharing information. There are also interactions between different departments to share knowledge for challenges on site to be resolved; two of the participants asked about this say that the knowledge is sometimes sitting with people in other provinces or divisions that are far and that limits the amount of interaction that can be done. In that case, KM technologies are required, but they do not fully address the need for the interaction because to understand some of the concepts there needs to be face-to-face interaction where a person will go through the information enabling the other to understand.

Interactions can also be between technologically advanced people and technologically disadvantaged people, or between the newer and the older generation; where in this instance, the interactions can be tricky because of the way of doing things and sometimes different cultures. And so it is also important that the approach of interactions between individuals is thought through. One participant mentions that based on the current culture, people will be more willing to share if the platform is informal rather than a formal sharing platform and thus these need to be taken into account, especially with the older generation, to understand how things can be done and how they can be done better.

Other sections use WhatsApp as an instant messaging application to communicate challenges on site which assists with a quick and better resolution. Other meetings such as project progress meetings, which are used to report on the progress of the project, sometimes enable the sharing of challenges, though this is not a formal agenda item, if another person has gone through the same challenge they may share the solution or resolution that was taken which can be implemented in the current project. However, this is not sufficient since other participants see the meeting as a reactive reporting of the challenges and not sharing the root causes and the preventative measures. Tutorials were also mentioned as a way of learning and sharing information, that through this people can learn and understand, but these are no longer happening in the NWOU or departments.

5.3.4. People involved in Knowledge Management

All the knowledge management processes must be executed and implemented by the people in the organisation. In order for people to implement something, they must first understand it. Most of the participants do not understand what knowledge management is; they are also unaware of the strategies, policies and frameworks for the knowledge management in the organisation, see figure 5-4. They might be doing some knowledge management activities but unaware that it is knowledge management and in that way, it is less effective. There are numerous documents in the organisation regarding knowledge management, but the participants have not seen or heard of them; the ones that have seen them are not well conversant with the content of those strategies. There is no thorough understanding of the concept of knowledge management by people on the ground.

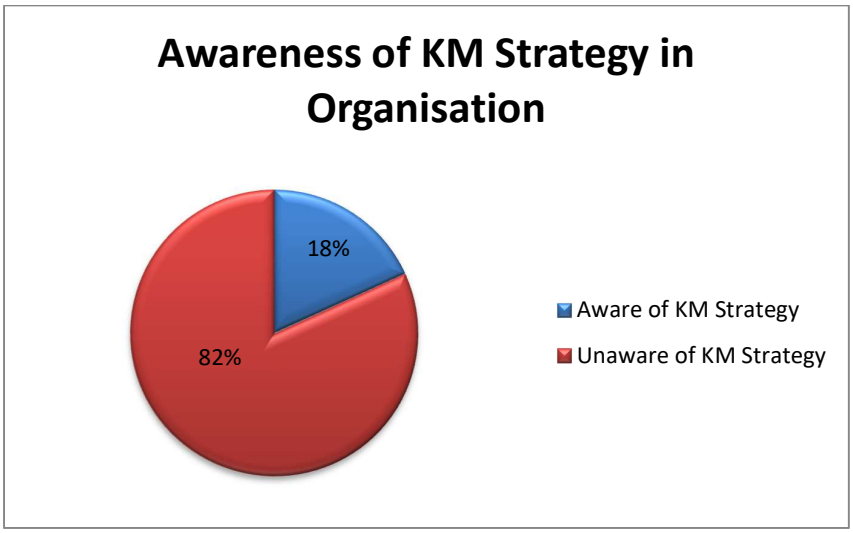

Figure 5-4: Awareness of KM strategies in the organisation findings

The application of lessons learnt, whether formal or informal and also individual learning is not happening in the business. The types of projects are similar in nature, and the people involved in the projects are usually the same time and time again, but the learnings from one project are not taken to the next project. There seem to be no reflections on projects, even on a sub-conscious level to learn and understand the challenges and how to resolve them. Also, that is also perpetuated by the fact the people do not have project close-out meeting or lessons learnt sessions.

One of the factors preventing people from learning is the attitude of the people in the environment. One participant referred to it as "don't care attitude" of some people. Ignorance, ego and pride were highlighted in the interviews as contributing factors to the culture of not learning and sharing. Self-preservation is also one of the issues that can prevent people in the organisation from sharing information. As one of the participants eluded, people can be selfish with information because it puts them in a better position to compete and to also have a sense of power. Also, because of self-preservation, everyone in the project team blames the next person because no one wants to take accountability of the issues and no one wants to be responsible.

The other trait that has come through from the interviews is that the people in this environment rarely admit to their mistakes and that is the reason why there is no learning from project to project. One participant says that people are not honest and they would rather hide the information rather than reveal it and resolve it. There will be a way of trying to hide and resolving them quietly or let the issues die naturally if that is possible. This results in people repeating the same mistakes over and over again; another participant also indicated that people hide their mistakes and do not learn from them and that only a few people will learn from the experience and try to do it better. And also added that individuals tend to defend blatant mistakes and because of that there is 100% surety that they will commit the same mistake again. If an individual does not accept that they made a mistake, they cannot learn from it.

To add to that, another participant acknowledged that it is the same people that repeat the mistakes and that they will most probably remember how they corrected the mistake and use those same methods to correct the same mistake in future projects. Therefore, it appears that people are not growing from these mistakes.
In terms of sharing knowledge, all the participants that were asked said that they are willing to share knowledge with other people and that the platform must be created for them to be able to do so. However, it was also raised that there is a serious lack of communication between people in the project environment and thus sharing of knowledge will be negatively affected. Another factor that perpetuates issues is the lack of teamwork in the project teams; there is a silo mentality that has crept in, affecting knowledge sharing.

Some of the knowledge management activities require that the project manager has good communication skills and the personality to be able to attract people to do the activities that are required. It is necessary that the project manager provides the right leadership for projects and follows due diligence and processes to ensure that the team is behind him at all times. The lack of information on projects is a contributing factor to people not being fully involved in the projects. This also goes hand in hand with communication about the projects, people who are not involved in the decision making processes and the general project tend to be distant and detached from the projects since they do not know what is happening.

Another participant added that people are self-reliant and rely on information they've kept for themselves and that they just choose not to store information. And also elaborated that storing of information by people can be a time consuming exercise but that is not the reason that people are not doing it, if it was a priority then it would be done, but the practice of not doing it is because people are unaware of the importance of knowledge management and lack the understanding of the importance of storing and transferring knowledge from one individual to another.

There are also a lot of people in the organisation that do not have the necessary experience or skill set as they joined the organisation in recent years. The age difference between people and the different cultures also make it difficult to share knowledge and to bridge the knowledge and experience gap. Participants also mentioned that sometimes the younger, less experienced group of people do not take the opportunities to learn from other more experienced people because of negative attitudes.

5.3.5. Barriers and Enablers

There are barriers and enablers to the implementation of knowledge management in any organisation; to understand how knowledge can be transferred more effectively, these need to be understood and the barriers removed/minimised and enablers put in place. This section explores and analyses the barriers and enablers in the project construction environment that were discussed during the data collection process.

Barriers

The key barriers to knowledge management that were identified are the attitude of people and the organisational culture and environment. Participants generally agree that some of the barriers created are people driven for example the lack of communication, people's egos, the silo mentalities and this emanates from the negative attitude that was discussed in the previous section and also perpetuated by the organisational culture.

With regards to the organisation, the culture that has been created in project construction, with projects taking long and no accountability also contributes to the barriers to knowledge transfer. The other factor that was highlighted is the pressure that the organisation exerts on the project teams; one participant refers to all projects being urgent, that probably the status and condition of the network forces the urgency and that the resources that are supposed to be doing these projects are spread thinly between the projects and therefore do not give the necessary attention to the individual projects and processes. One of the project coordinators also indicated that due to the time constraints on the projects, certain processes are not followed and there is usually no time for meetings that can formally or informally be used to share or transfer knowledge.

Leadership or the lack thereof also contributes to the barriers of knowledge management implementation; a few of participants strongly felt that the biggest challenge is purely leadership issues, the lack of management and the lack of willingness by managers to manage, believing that if the leadership challenges are resolved then a lot of the knowledge management issues and barriers can also be addressed. The other barrier inflicted by the leadership that has been mentioned before is the culture of punishing instead of correcting, leading to an environment of no learning, which in itself is a huge barrier to knowledge management implementation. This leadership style also affects the morale of people and creates a vicious cycle of non-learning.

Another barrier that was highlighted by the project coordinators is the storage system that is currently being utilised, Hyperwave; one admitted that the system is too complicated to use and that a simpler system should be implemented to ensure that storage of information can be more effective. While the other indicated that training and access is required for an individual to be able to use the system.

Enablers

To enable knowledge management in the NWOU requires an environment that will be conducive to learning. The leadership style is closely linked to whether the organisation can create a learning organisation or not. The leadership must acknowledge and also encourage people to implement knowledge management activities and create an environment where individuals can share and learn without fear of punishment. Creating a learning environment is crucial to enabling knowledge management and its implementation.

The other aspect raised is to ensure that project managers are more knowledgeable about project management, ensuring that projects can reach their goals. One of the participants mentioned that some of the roles and responsibilities are not understood and that people just do the work and not apply due diligence. The knowledge of knowledge management for the project managers and the project team is also an important factor; one participant mentions that the business needs to plant a seed on the importance of capturing the lessons learnt, sharing the knowledge, referring back to projects for knowledge that can be used when executing projects and that may assist in the improvement of knowledge management and consequently project performance.

Information Technology related enablers include ensuring that there is one platform for storing project construction knowledge and identify platforms for project managers to communicate with stakeholders on a regular basis. Knowledge management techniques such as lessons learnt were also identified as enablers to knowledge transfer. By ensuring that the right platforms are in place, knowledge management implementation can be made easier and knowledge transfer enhanced.

A suggestion to include the knowledge management processes as a formal procedure in the management of a project was also made. Also raised is the importance of learning and sharing throughout the period that the project is under construction; documentation, storage and sharing should be a continuous process within project management while ensuring that people have access to the information. Changing people's perceptions about the sharing of information is also important, the organisation must ensure that the value of sharing knowledge is communicated clearly to people and the benefits of knowledge sharing for individuals and the organisation is well understood; this is so that the barrier created by self-preservation can be dismantled.

5.4. Chapter 5 Conclusion

Eskom's existing knowledge management documents were analysed; the analysis indicated that the documentation in place is aligned to the requirements of an effective knowledge management system. After which, the primary data was categorised according to the following categories: Knowledge Management Strategy and the Organisation, Knowledge Management Processes, Knowledge Management Tools, People involved in Knowledge Management and Barriers and Enablers.

The data analysed revealed that there is insufficient leadership support for knowledge management in the organisation and that there is no prioritisation in terms of knowledge management in project construction management. There are strategies that exist in the organisation for knowledge management; however, these strategies are not known by the people who are supposed to be implementing them. There is a focus on completing projects under construction, but there is no focus on creating learning environments to enable completion of projects and better projects performance. The current organisational culture does not encourage learning.

There are essentially no platforms to create and share knowledge in the NWOUs environment of project construction. The platforms that are there are confined to localised learning where only the individual involved may or may not create and share that knowledge. There are limited interactions to share best practices and lessons learnt for projects under construction. Knowledge from construction projects is not recorded and thus remains as tacit knowledge for individuals who have internalised it. In terms of storing and reusing knowledge, the storage systems are available but are not being utilised, simply because there are no knowledge records to store and reuse.

Most of the participants are unware of the knowledge management strategy in the organisation. Further to that, there is little understanding of what knowledge management is and the benefits that it offers. The characteristics, attitude and behaviour of people has been highlighted as a barrier to learning and implementing some of the knowledge management activities. The data analysis also indicated lack of leadership support and organisational culture as other barriers to knowledge transfer.

CHAPTER 6: DISCUSSION

6.1. Introduction

This chapter aims to consolidate and discuss the findings of the research study. The existing knowledge management practices will be summarised from the data analysis and results and the Eskom documentation. Then the desired knowledge management practices from literature and the benchmark construction framework, ConABKM, will be summarised. To conclude the discussion, a gap analysis between the existing and the desired knowledge management practices will be done, this will further clarify the knowledge management issues in NWOU. The categories determined from the conceptual framework will be used once again in this chapter to direct the discussions:

1. Knowledge Management Strategy and the Organisation
2. Knowledge Management Processes
3. Knowledge Management Tools
4. People involved in Knowledge Management
5. Barriers and Enablers

6.2. Existing Knowledge Management Practices

The existing knowledge management practices were determined through Eskom's documentation on knowledge management and the semi-structured interviews conducted.

6.2.1. Knowledge Management Strategy and the Organisation

One of the evident findings in terms of knowledge management in the organisation is that there is a lack of leadership support for knowledge management activities. The leadership has not prioritised knowledge management, and there has not been any intentional effort to communicate knowledge management to people in the organisation. Without this support any knowledge management implementation or initiative, no matter how good, will not be effective. The NWOU has consequently not created a learning environment in the construction of projects; there is a consensus that the platforms required for knowledge management activities are not set up. There was a focus on learning in previous years, but that has since changed, and the culture of not learning is settling in.

One other challenge that arose in the dynamics of the organisation is that there is a gap between experienced people and those that may not be as experienced; and that the technology dynamics, cultural dynamics and the way that these two generations interact may also impede knowledge transfer between projects or in the NWOU itself. Thus, the relationship between the different groups of people creates an environment of isolation between the groups and consequently not promote learning and socialisation. There is also a 'silo' mentality that has hampered the ability of the project team to learn from each other and to share experiences, and this is a direct result of the organisation's environment.

The environment created in project construction does not enable sharing and learning; punitive measures are applied when people make mistakes instead of understanding and analysing the root causes, learning and correcting. As a result, people are not inclined to share their experiences and challenges. There is also much pressure applied on people to perform on projects, but there is no support for people to stop and reflect on issues that arose resulting in the continuation of the same processes, procedures and strategies that created the existing challenges. Challenges are then carried over from one project to the other.

The project construction environment does not implement any knowledge management processes in the project construction management processes. The organisation has not prioritised knowledge management and only concentrates on results. Efforts of incorporating knowledge management processes in the construction environment are underway but there is no priority attached to it, and there is no appetite to support and implement such processes. Lack of leadership support for knowledge management as a discipline in construction management comes up again as a barrier to creating a knowledge management environment.

The organisation has a knowledge management strategy, process control manual for knowledge management, knowledge transfer and lessons learnt procedures. The Eskom knowledge management review indicated documentation that if implemented in the organisation can provide an integrated knowledge management system and may possibly improve knowledge transfer in the organisation. However, most of the participants from the NWOU were not aware of these documents and their goals. If the people involved in the construction environment are unaware of the strategies, goals and intentions of knowledge management, they cannot be held accountable in its implementation and cannot be expected to implement it.

Leadership support for knowledge management is lacking and the importance or value of knowledge management as a discipline is not understood by senior leaders. The organisational culture and environment do not enable knowledge management activities and thus constraining knowledge transfer. This is evident in the same challenges being experienced in most of the projects under construction.

6.2.2. Knowledge Management Processes

The ConABKM benchmark framework has the following processes: Create Knowledge, Share Knowledge, Record Knowledge, Knowledge Storage and Knowledge Reuse. The process of creating new knowledge and sharing knowledge for construction projects can happen in different ways and is mostly supported by employing a number of different knowledge management techniques. There is insufficient utilisation of knowledge management techniques to create and share knowledge in the construction of projects in NWOU.

One of the critical techniques, lessons learnt or post-project reviews, is not implemented in the projects and therefore minimises the knowledge that can be created and shared throughout projects. In the case of creating knowledge, it was found that knowledge is created to correct challenges on sites rather than prevent them and also that since there are no platforms for sharing, the knowledge is localised to only the people that were part of the project at that time. However, some of these people do not internalise the knowledge created and projects fail due to the same mistakes again.

There is a lack of communication and engagement in project teams, linked to the 'silos' previously discussed, and this affects the knowledge sharing process that is vital in knowledge management. The lack of communication in project teams consequently means that there is no sharing of knowledge between concomitant projects that are under construction. Different experiences and cultures also have an impact on the ease of information sharing between individuals, resulting in a skills gap in the organisation. The lack of platforms for sharing knowledge and the organisational culture perpetuate the lack of knowledge sharing in the NWOU.

Creating and sharing knowledge without recording it means that the knowledge is only available to those that were involved in the projects as that knowledge becomes tacit, and it may also happen that people forget the resolutions and the knowledge is lost. In NWOU, no project knowledge is captured during the construction of projects. The central storage systems/databases that are available for construction projects are not utilised; there is no central location for project construction knowledge where one can refer. Project construction knowledge is not recorded and thus not stored and therefore makes it impossible to reuse. When looking for knowledge, it is usually stored in an individual's laptop or the individual's mind, which makes access and re-application of knowledge more difficult.

6.2.3. Knowledge Management Tools

The technologies, mostly referred to, namely Hyperwave, SharePoint, WEBEX, SAP and others, are available in the organisation to facilitate and support knowledge management, but these are not being utilised. All the participants agree that it is essential to use these technologies to manage both tacit and explicit knowledge, however people are not utilising them, and there is no leadership emphasis or direction on this. A couple of participants who are supposed to be using these technologies to manage knowledge in their construction projects indicated that they are not well conversant with the systems and thus training may be required to ensure that these technologies can be fully utilised.

Much like the use of technologies, the use of knowledge management techniques is also minimal, which also contributes to the project teams in all the projects repeating the same mistakes over and over again. Engineers consult subject matter experts for issues that cannot be easily resolved. However, this is usually just the engineer and the subject matter expert and not the whole project team, and again knowledge creation is

localised to the individual. There are no community of practices for construction projects; lessons learnt, brainstorming and best-practices sessions are merely not conducted during project construction. Other interactions are also restricted by the 'silo' mentality, cultural differences, environment and individual personalities.

6.2.4. People involved in Knowledge Management

The study found that the people in NWOU do not fully understand knowledge management and do not know about the strategies the organisation has put in place with regards to knowledge management. The organisational culture and environment is a mirror-image of the people that are in the organisation; there is a culture of not learning from previous issues. However, the major challenge noted from the study is the attitude of people in NWOU with regards to sharing, learning, communicating and other activities required for knowledge management. Ignorance, egos, pride and self-perseveration seem to play a massive part in the way that people relate in the project team, and most of the time it negatively impacts on the knowledge management processes and the projects performance.

6.2.5. Barriers and Enablers

The existing barriers can be summarised as:

1. Organisational culture
2. Lack of leadership
3. Low morale of the organisation
4. People's attitude
5. Silo mentality
6. Resources including time
7. Lack of training

The existing enablers are the Eskom knowledge management documents which include the knowledge management strategy, framework and procedures. These can be used as a base to develop construction specific strategies, frameworks and procedures for projects under construction in the NWOU. The available technologies, Hyperwave, SharePoint, WEBEX, SAP and others are also existing enablers to assist the NWOU to enhance knowledge transfer.

6.3. Desired Knowledge Management Practices

The desired knowledge management practices are a combination of the literature theory on knowledge management and the construction based benchmark framework, ConABKM.

6.3.1. Knowledge Management Strategy and the Organisation

The literature theory requires that an organisation has the following to ensure effective implementation of knowledge management:

1. A knowledge management strategy that is aligned to organisational strategies and goals
2. A framework of how knowledge management implementation will occur in the organisation
3. A knowledge management cycle suited to the operations of the organisation
4. Leadership support
5. Knowledge management team
6. An organisational culture of learning
7. Systematically incorporate knowledge management in the operations of the organisation

6.3.2. Knowledge Management Processes

ConABKM framework that is used as a benchmark for the study requires that the following knowledge management processes be implemented fully for effective knowledge management for projects under construction:

1. Create Knowledge – Both explicit and tacit knowledge types are created in construction projects and the organisation. This stage uses both knowledge management techniques and technologies to create new knowledge
2. Share Knowledge – Both explicit and tacit knowledge types are exchanged in the project team and also the organisation. Both knowledge management techniques and technologies can be used to share knowledge
3. Record Knowledge – Both explicit and tacit knowledge types are recorded and saved in a knowledge management platform
4. Store Knowledge – Both explicit and tacit knowledge types are then centrally stored in a system database
5. Reuse Knowledge – Reuse knowledge and save time and reduce cost, and also create value in other concomitant projects under construction by reusing the knowledge in those projects

6.3.3. Knowledge Management Tools

Both knowledge management techniques and technologies are essential for knowledge management in construction projects to be effective. The organisation can select tools based on their specific knowledge management needs. Examples of these technologies and techniques which are used frequently in organisations include brainstorming sessions, community of practice, face-to-face interactions, recruitment training, data and text mining, groupware, intranets/extranets, knowledge bases, taxonomies/ontologies, lessons learnt sessions, email, video-conferencing and cellular phone applications.

6.3.4. People involved in Knowledge Management

It is important that the attitude of the people in the organisation is positive and that people are willing to create, share, record, store and reuse knowledge to ensure that knowledge transfer can be enhanced in the construction environment. This is also enabled if people understand knowledge management, its benefits and its importance to the organisation. Frequent communication and change management is essential to ensure that the people in the organisation share the same vision with regards to knowledge management. Knowledge management implementation should be recognised and rewarded to motivate and align the behaviour of people with knowledge activities.

6.3.5. Barriers and Enablers

Barriers can exist; however, it is important to have enablers that will ensure that knowledge management is effective. Yeh et al. [29] consolidated four categories of knowledge management enablers:

1. Knowledge management strategy must be aligned to organisational strategy, and senior leadership should provide the necessary support to ensure successful implementation of knowledge management in the organisation
2. Corporate culture – Culture of learning and sharing must be created within the organisation
3. People – It is important to ensure that people are sharing and learning
4. Knowledge management tools – Ensure that the necessary technologies and techniques are available for effective knowledge management

For this study, an additional enabler to the enhancement of knowledge transfer between concomitant projects under construction is the activity based knowledge management system. Because knowledge can be captured and managed per activity, the management and reuse of knowledge are less complex, especially for big construction projects. Each activity will contain explicit and tacit knowledge gained over the construction of the project making it easier to search, access and reuse.

6.4. Gap Analysis

Table 6-1 highlights the gaps between the existing knowledge management practices and the desired knowledge management practices.

Table 6-1: Gap analysis between the current and desired knowledge management practices

	Current Knowledge Management Practices	Desired Knowledge Management Practices	Consolidated Analysis
Knowledge Management Strategy and the Organisation	• Lack of leadership support for knowledge management and knowledge management initiatives	• Leadership support and sponsor for knowledge management and knowledge management initiatives • A knowledge management team responsible for overseeing the effectiveness of knowledge management	1. The required leadership support for knowledge management is lacking resulting in an organisation that is not conducive to learning
	• The construction environment is currently not conducive for learning – A non-learning environment • No platform for learning and sharing • Silo mentality prevails in construction projects – no sharing of knowledge	• A learning organisation created through various sharing and learning platforms	2. There are no enablers to create learning and sharing in the NWOU. Effective sharing platforms for construction project knowledge are very minimal, and these are required to create a learning culture
	• Knowledge management processes are not embedded in construction management processes	• Knowledge management should be embedded in construction project management	3. Knowledge management processes are not prioritise in project construction management and are also seen as separate processes or procedures that need to be done outside of construction management

	• The knowledge management strategy, procedure and framework is in place and aligned to organisational strategy • Knowledge management strategies, frameworks and procedures are drafted, but people are not aware of them ✓ Only 27% of interviewees are aware of Eskom KM strategy ✓ Only 18% of interviewees can explain the goals of the strategy ✓ Only 9% of interviewees are aware of the knowledge management framework but cannot expand on it • Big knowledge gap in the project teams	• The knowledge management strategy must be in place and aligned to organisational strategy and goals	4. Knowledge management strategies are in place and are aligned to the desired status in terms of knowledge management theory. However, people who need to implement the management of knowledge lack awareness and understanding of these strategies, the framework and its benefits.
Knowledge Management Processes	• Create Knowledge: Knowledge is not created to avoid challenges but rather to correct challenges when they occur. Stakeholders are not adequately consulted to ensure that relevant knowledge is created. There are insufficient platforms to create	• Create Knowledge: Knowledge is created in construction projects and the organisation. This stage uses both knowledge management techniques and technologies to create new knowledge	5. There is insufficient efforts to create and share new knowledge in the construction of projects – Stakeholder management, communication and the implementation of knowledge management techniques to aid the

	knowledge in the project construction environment		creation and sharing of knowledge are lacking
	• Share Knowledge: No platforms actively exist to share knowledge in construction projects. Sharing of knowledge is localised to members affected by the challenge. Lack of communication and engagement between project teams hindering the ability to share knowledge	• Share Knowledge: Knowledge is exchanged in the project team and also in the organisation. Both knowledge management techniques and technologies should be used to share knowledge. Both formal and informal interventions should exist to allow individuals to share experiences and socialise and thereby enhancing knowledge	
	• Record Knowledge: Knowledge is generally not recorded for projects under construction	• Record Knowledge: Both explicit and tacit knowledge for construction projects are recorded and saved in a knowledge management platform. Recording knowledge forms part of the externalisation process of the SECI model and is used to conserve knowledge	6. For all the challenges on construction projects and the solutions that are invented, the relevant tacit and explicit knowledge is not recorded as required

	• Knowledge Storage: The storage systems are available but are not being utilised for construction projects. Construction knowledge is stored in personal laptops or individual minds • Knowledge Reuse: Knowledge is neither stored nor recorded, and thus it is difficult to reuse. Tacit knowledge is reused in construction projects when individuals are willing to share past experiences	• Knowledge Storage: Both explicit and tacit knowledge should be centralised in a system database • Knowledge Reuse: Reuse stored tacit and explicit knowledge from previous or concomitant projects under construction	7. Knowledge is either stored in a personal laptop or individual's mind; a central location system exists but is not being utilised making access and reapplication of knowledge difficult 8. There is no reuse of previous knowledge because the knowledge is not recorded or stored and thus there is no explicit construction knowledge to refer to and reuse. Tacit knowledge is reused through consultation
Knowledge Management Tools	• Knowledge management technologies are available within the organisation, but these are not fully utilised for projects under construction – Minimal use of MS Project and Knowledge Bases • Knowledge management techniques are not utilised to support knowledge management processes in projects	• Various knowledge management technologies should be utilised for sharing, recording and storing knowledge including Groupware, Intranets and Knowledge Bases etc. • Various knowledge management techniques should be utilised to create and share knowledge including CoP, Brainstorming, SMEs, and Lessons learnt/Post project reviews etc.	9. There is a lack of implementation of knowledge management techniques and technologies which negatively impacts the knowledge management activities required to have an effective knowledge management system

	under construction – Minimal and localised use of CoP and SMEs		
People involved in Knowledge Management	• People are not fully conversant and aware of knowledge management and knowledge management strategies in the organisation • There is no learning culture in the construction of projects • Poor attitude towards sharing knowledge	• People should fully understand the benefits of knowledge management and the importance of its implementation • People in the organisation should have a culture of sharing and learning	10. People do not fully understand the importance of knowledge management and as a result have developed a negative attitude towards sharing and learning which impact the whole knowledge management system, an also perpetuated by the NWOU environment
Barriers and Enablers	• Barriers: Company morale, People's attitude towards knowledge management activities, Silo mentalities in projects, Current organisational non-learning culture, Lack of leadership, lack of training for systems supporting knowledge management • Enablers: Technology tools available for knowledge management, Strategy is there and aligned to the organisational strategy	• Enablers: Strategy aligned to organisational strategy, Learning culture, People, Tools and an Activity-based knowledge management system	11. Ideally, there should not be any barriers to knowledge management as these can be controlled and minimised if managed correctly. The barriers and enablers are aligned to the requirements of an effective knowledge management system; barriers will be broken down and more enablers created by addressing People, Tools, Organisational Culture and KM Processes

6.5. Chapter 6 Conclusion

This chapter discusses the results of the data collected through the semi-structured interviews and the Eskom knowledge management documents. The discussion also summarised the required knowledge management practices for effective knowledge transfer. The gap analysis showed a number of shortcomings for each knowledge management theme analysed. These will then be used in the next chapter to develop a knowledge management methodology that will address the shortcomings and therefore enhance knowledge transfer.

To effectively manage knowledge, the processes and tools of knowledge management should be part of the construction management process. The knowledge management processes are intertwined, they all need to be implemented for knowledge management to be effective; creating and sharing knowledge should be encouraged, and the knowledge management techniques that enable these processes should be implemented; the platform for sharing knowledge should be created and utilised. It is also vital that the importance of recording knowledge is shared and that this is practiced across the project construction environment as this is currently not being done.

To be able to refer and reuse the knowledge, the knowledge must be recorded and stored. The storage systems are available but are not being utilised. The importance of storage and its implementation should be a focus to improve knowledge transfer between concomitant projects under construction. People should also be trained and encouraged to record and store the knowledge that is required. There is also an intervention that is required to deal with human resource issues before knowledge management can be implemented. The barriers and enablers of knowledge management are aligned to the issues discussed in knowledge management processes, tools, the organisation and its people if those issues can be addressed, the barriers will be broken down, and the enablers will be in full effect enhancing knowledge transfer between concomitant projects under construction.

CHAPTER 7: DEVELOPMENT OF A KNOWLEDGE MANAGEMENT METHODOLOGY TO ENHANCE KNOWLEDGE TRANSFER

7.1. Introduction

The development of a knowledge management methodology to enhance knowledge transfer between concomitant projects under construction will be presented in this chapter. The results of the gap analysis conducted in the preceding chapter are used to determine the steps to be taken to enhance knowledge transfer, and then these will be presented as a methodology for the organisation to implement to enhance knowledge transfer for concomitant projects under construction.

7.2. Knowledge Transfer Enhancement

Following the gap analysis in the preceding chapter, the following recommendations are made to enhance knowledge transfer between concomitant projects under construction.

Knowledge Management Strategy and the Organisation

- The leadership needs to understand the importance of knowledge management and make it part of the construction management process and drive its implementation for better project performance.
- A knowledge creating environment is required for knowledge management to become more effective; as this supports all the knowledge management processes and activities and encourages the people in the organisation to get more involved with knowledge management processes.
- To effectively manage knowledge, the dynamics of people need to be addressed by the organisation; mentoring and coaching can be used as techniques where people share experiences and can relate to one another.
- There is a need for constructive ways for the organisation to deal with mistakes/challenges that will encourage sharing, learning and correcting.
- For knowledge management effectiveness the processes should be embedded into the day to day activities of project construction; priority should be given to incorporating knowledge management in construction management processes.
- The strategies of knowledge management, the framework through which knowledge management is implemented, and the goals and benefits of knowledge management must be communicated and understood.

Knowledge Management Processes

- Knowledge management techniques must be re-introduced into construction management to ensure that knowledge can be created to avert challenges and also where required to resolve challenges more efficiently.
- Sharing platforms should be set up in different levels of the organisation to enable the enhancement of knowledge transfer. The channels of communication between concomitant project teams should be clearly defined to ensure that there is always engagement on issues and resolutions.
- Knowledge must be recorded for future referral and referral by other concomitant project teams; it is important that for every challenge and solution offered for any project that the knowledge is recorded for that activity.
- The existing storage and collaborating systems, Hyperwave and SharePoint, have the capability to store the required construction knowledge. It is important to ensure that people are aware of the importance of documenting and storing information and that they are trained to understand and use the systems. It is also essential that the taxonomy of the system allows the storage of knowledge per construction activity; the project teams must then decide on the construction activities, and standardise them throughout all the projects. Efforts of utilising SAP PPM as a central storage system can also be part of the methodology going forward to improve knowledge storage, access and reuse.
- Ensure that all the processes of knowledge management are implemented so that the knowledge can be reused by project teams to have better construction performance.

Knowledge Management Tools

- There should be enforcement from a leadership perspective for people to utilise the technologies that are available to them, and leadership should also enable the use of these technologies through the required training and encouragement to the project teams.
- All the relevant techniques that can be used for knowledge management in construction projects should be prioritised and implemented; much like the technologies, there needs to be leadership intervention to ensure that these are implemented. The identified techniques to enhance knowledge transfer between concomitant projects under construction are:
    - ✓ Post-project reviews/Lessons learnt sessions at the start and completion of each activity on site
    - ✓ Best practices sessions on a formal and informal basis inter-departmental and intra-departmental
    - ✓ Informal face-to-face interaction to be encouraged
    - ✓ Community of practices/Subject matter experts
    - ✓ Brainstorming sessions and others

People involved in Knowledge Management

There are a few factors that should be addressed to ensure that the people in the organisation or the construction environment take part in knowledge management activities. The following critical issues need to be addressed:

- Raise awareness of knowledge management, its goals, benefits and the importance of doing it
- Share the strategies, frameworks, process control manuals and lessons learnt implementation procedures
- Get input and feedback from people regarding the support required to implement knowledge management
- Create a learning environment where egos and pride of people are not warranted, but a culture where it is okay to make mistakes with the understanding of learning and growing from them
- Introduce performance measurement strategies for the application of knowledge management to encourage people to share and transfer knowledge
- Identify people who are willing to share who can spearhead the initiatives
- Address the silo mentalities that are present in the project construction environment
- Equip programme and project managers with the necessary leadership skills to run projects

Barriers & Enablers

The number one barrier for knowledge transfer is the people themselves, and this is due to a number of reasons. However, the recommendations made in the section prior to this will in many respects alleviate this barrier. Other barriers are also addressed by leadership support, implementation of knowledge management processes and tools. This is also true for knowledge management enablers; the right environment, right leadership style, implementation of techniques and technologies, application of processes and consultation with people involved in knowledge management; if these are done accurately, knowledge transfer will be enhanced between concomitant projects under construction.

7.3. Knowledge Management Methodology

From the gap analysis and the recommendations to enhance knowledge transfer, the following knowledge management methodology is recommended for the NWOU to enhance knowledge transfer between concomitant projects under construction.

Table 7-1: Methodology for enhancing knowledge management between concomitant projects under construction

1. Leadership Support	• Leadership should first be made aware or reminded of the importance and benefits of knowledge management for construction projects o Seminars and training on knowledge management to be conducted for the NWOUs leadership

	○ Identify the benefits and value of knowledge management and determine the cost savings that can be achieved. ○ Determine the key performance indicators to measure the effectiveness of the strategies in construction projects • The existing strategies, frameworks, process manuals for knowledge management must be reviewed by the leadership of the NWOU to align themselves with organisational strategies. Thereafter develop a knowledge management system (strategies, frameworks, processes etc.) specifically for the OUs operations and construction projects. • The organisation should perform a Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis on knowledge transfer in construction projects to identify key focus areas • Identify senior leaders who will be sponsors and be accountable for knowledge management implementation and its performance for construction projects
2. KM Team	• Identify and appoint a cross-functional team for knowledge management in construction projects supported by senior leadership to ○ Determine critical knowledge areas for projects under construction ○ Determine critical activities for projects under construction ○ Determine knowledge gaps in project construction ○ Review the strategies, policies and processes for knowledge management and determine relevance to the construction environment and make recommendations on the documents ○ Determine subject matter experts with the required tacit knowledge ○ Develop requirements/specifications for tools for effective knowledge management in construction projects • Responsible for maintenance and support of knowledge management initiatives and systems
3. KM Communication and Awareness	• Raise awareness to the project construction teams and communicate knowledge management using a communication or change management plan ○ Share the KM strategies and be open for inputs ○ Share the goals of the programme ○ Share the benefits of knowledge management and highlight the challenges addressed by knowledge management in the construction environment • Leadership continuing to advocate for knowledge management implementation within the construction environment

4. Leverage on existing technologies	• Identify training needs and provide training for the storage and collaborating systems (Hyperwave, SharePoint and WEBEX) that are available • Create a storage portal for knowledge for projects under construction with a standardised taxonomy for ease of use – as per the critical activities identified for projects under construction
5. Reintroduce KM techniques in project construction	• Create a physical office space that promotes interactions • Post-project reviews/lessons learnt sessions to be included as part of the project construction management process; these to be conducted at the start and completion of each activity on site • Best practices sessions on a formal and informal basis to be implemented inter-departmental and intra-departmental • Informal face-to-face interaction to be encouraged • Community of practices to be set up • Brainstorming sessions to happen on an ad-hoc basis for construction projects • Tutorials and training internally to be encouraged to ensure interactions
6. KM Process Implementation	• Continuously encourage, and audit lessons learnt and best practices activities which include o Creating knowledge o Sharing knowledge o Recording knowledge o Storing knowledge o Reusing knowledge
7. KM Implementation Recognition	• Determine performance measures for KM and evaluate the effectiveness of the knowledge management initiatives and correct where required. • Introduce KM recognition for individuals in the organisation

7.4. Chapter 7 Conclusion

This chapter developed a knowledge management methodology to enhance knowledge transfer for concomitant projects under construction for the NWOU. The methodology details the required steps that should be taken by the organisation to enhance knowledge transfer in construction projects; this is above any other efforts that the company has undertaken to improve knowledge management. Leadership support, improved awareness of knowledge management in the organisation and implementation of the knowledge management technologies and techniques will go far in addressing some of the issues and ensure better knowledge transfer between concomitant projects under construction.

CHAPTER 8: CONCLUSION AND RECOMMENDATIONS

8.1. Introduction

The purpose of the research study was to develop a methodology that will enhance knowledge transfer between concomitant projects under construction in the North West Operating Unit of Eskom's Distribution division. This would be done by identifying an applicable construction based knowledge management framework to use as a benchmark, identifying existing knowledge management practices in the organisation and finally to develop a methodology to enhance continuous knowledge transfer in construction projects.

8.2. Research Conclusion

There is one research question that the study intended to answer:

How does the NWOU enhance knowledge transfer between concomitant projects under construction?

This was to be achieved through:

1. Identifying an applicable construction based knowledge management framework to use as a benchmark for knowledge management application in construction projects in NWOU
    a. Critically analyse the literature to determine an applicable, existing knowledge management framework for construction projects to be used as a guide in identifying the methodology for knowledge management in NWOU.
2. Identifying existing knowledge management practices in the NWOU
    a. Obtain and document evidence of existing knowledge management practices in the organisation and the NWOU.
3. Developing a methodology to enhance continuous knowledge transfer in construction projects
    a. Perform an analysis between the existing knowledge management practices and the desired knowledge management practices using the benchmark framework and literature
    b. Determine the required steps to enhance knowledge transfer in concomitant projects under construction.

Identify an applicable construction based knowledge management framework to use as a benchmark

A literature review was conducted to understand the concepts of knowledge management and its application in construction projects. The literature review covered knowledge management concepts which included knowledge management approaches, tools, life-cycle activities, models and frameworks. To conclude the literature review, a conceptual framework was developed to understand the relationships of the KM concepts and to further guide the research process. The themes that were identified from the conceptual framework were as follows:

1. Knowledge Management Strategy and the Organisation
2. Knowledge Management Processes
3. Knowledge Management Tools

4. People involved in Knowledge Management
5. Barriers and Enablers

Five construction based knowledge management frameworks were reviewed, and the ConABKM framework was recommended for use as a benchmark for enhancing knowledge transfer between concomitant projects under construction for the NWOU and the methodology that would be developed. The ConABKM framework was chosen based on its activity-based approach and its focus on both tacit and explicit knowledge; the framework is an ideal knowledge transfer system that would enhance knowledge in the construction environment and particularly for NWOU. The CLEVER process framework was also identified to be used as a guide for the process of data collection for the study, and several aspects of the knowledge management problem identification process were incorporated into the data collection process.

Identify existing knowledge management practices in the NWOU

To identify the existing knowledge management practices within the NWOU, a two-stage approach was taken by the study. First, Eskom's existing knowledge management documentation was reviewed to determine the status of knowledge management development within the organisation. The strategies, frameworks and processes were found to be in line with the knowledge management literature and theories.

The second stage was primary data collection where the strategy of the study took on a qualitative, interpretivist, exploratory direction using semi-structured interviews. The study utilised a purposive sampling technique to ensure that the individuals that are involved and experienced in the project construction environment are intentionally chosen for the study. The total number of people interviewed was 11; the process of data collection and analysis included recording, transcribing and categorising data. The collected data was categorised into the themes identified through the conceptual framework.

The analysis found that the current organisational culture or environment is not a conducive environment for learning. There is no focus on the improvement of project performance through learning from previous mistakes. The strategies of knowledge management, even though they exist in the organisation, are not known by the people on the ground, who are supposed to be implementing them. There is also a lack of leadership support or emphasis on knowledge management activities and initiatives. There is also no priority given to knowledge management by senior leadership.

The analysis also found that there are generally minimal knowledge management activities or processes employed in the project construction environment in NWOU. There are technologies available for the implementation of these activities, but these are also not utilised for construction projects. The necessary platforms for the implementation of knowledge management techniques that enable some of the knowledge management processes are also not set-up.

The barriers and enablers discussed in the practice of knowledge management pointed to both the organisation and the people themselves. There is a lack of understanding of knowledge management and how the processes can have an impact on project performance. There are also behavioural issues that obstruct the implementation of knowledge management processes, and in addition to that, there is also training required to assist individuals with managing knowledge.

Develop a methodology to enhance continuous knowledge transfer in construction projects

A gap analysis between the existing and desired knowledge management practices within the construction environment of the NWOU was done and a methodology to enhance knowledge transfer in concomitant projects under construction was developed. Table 8-1 summarises the analysis and the aspects of the methodology that will address those gaps and as a consequence enhance knowledge transfer between concomitant projects under construction.

Table 8-1: Summary of existing and required knowledge management practices and methodology aspects

Existing KM Practice	**Desired KM Practice**	**Methodology Aspect**
Lack of leadership support	Leadership support for KM initiatives and implementation	• Leadership Support
Non-learning environment	Knowledge creating environment	• KM Communication and Awareness • KM Team • Reintroduce KM techniques in project construction • KM Implementation Recognition
Lack of KM awareness	Fully conversant with KM requirements, strategies and benefits	• KM Communication and Awareness
Insufficient use of KM techniques for projects	Continuous utilisation of KM techniques for projects	• Reintroduce KM techniques in project construction
Construction project knowledge is not being recorded	All construction project knowledge should be recorded per construction activity	• KM Process Implementation
Existing storage and collaborating systems are not utilised for projects	All construction project knowledge should be stored per construction activity	• Leverage on existing technologies

8.3. Recommendations for Future Work

Recommendations for future work with regards to this research would be to implement the methodology within the existing knowledge management framework to measure the impact on knowledge transfer between concomitant projects and the change in the performance of construction projects. The other recommendation would be to utilise the SeLEKT framework to determine the tools that are necessary to ensure that continuous knowledge transfer is enhanced further in project construction.

8.4. Limitations of the Study

The research is limited to the North West Operating Unit, a distribution division of Eskom Holding SOC Ltd (Eskom) and may not be applicable or generalizable to other distribution operating units and other Eskom divisions. The study is also not generalizable to other power utilities, organisations or sectors as the knowledge management practices and the data gathered is specific for the North West Operating Unit. The study may be used to guide researchers in other power utilities or organisations, but further studies in those organisations would be required to generalize these findings.

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APPENDIX A: KNOWLEDGE MANAGEMENT CONCEPTS

Table A-1: Taxonomies of knowledge sourced from Kakabadse et al. [22]

Authors (References)	Types, forms of knowledge and level of embodiments
Socrates (Plato, 1953)	• Mythos refers to that part of "knowledge" that is arguable and can be demonstrated and identified with precision and agreement – it is extremely personal • Logos derives from gathering, reading and coming to connote counting, reckoning, explanation, rules or principles and, finally, reasons. Although mythos and logos represent two realms that constitute knowledge, they are also complementary and interactive poles of knowledge
Bacon (1605)	• "Pure knowledge of nature and universality, a knowledge by the light where of man did give names unto other creature in paradise…" • "Proud knowledge of good and evil, which give intent in man to give law unto himself
Boswell (1979)	• "We know a subject ourselves" or • "We know where we can find information about it"
Polanyi (1958, 1996)	• Tacit (awareness of things that we may not be able to tell; all knowledge is either tacit or rooted in tacit knowledge) • Explicit (capable of being clearly stated)
Schank and Abelson (1977)	• General knowledge – information about, and interpretation of, human intention, disposition and relationships (satisfaction, enjoyment, achievement, preservation, crisis, instrumental) and "themes" (role themes, interpersonal themes and life themes) • Specific knowledge – a "script", a representation of the expected sequential flow of events in a particular situation (cooking, applying for a job) • Expert knowledge – "factual knowledge" (extensive data base about life matters) and "procedural knowledge" (mental procedures, heuristics)
Frantzich (1983)	• Resident knowledge – insider knowledge residing within networks and gate-keepers • Access knowledge – readily transferable information
Anderson (1985)	• Declarative knowledge or describing something • Procedural or how something occurs or is performed • Causal or why something occurs

Holiday and Chandler (1986)	• Knowledge as a general competence (a dimension that overlaps with local intelligence or technical ability) • Pragmatic knowledge – experienced based • Knowledge as a reflective or evaluative meta-analytical skills and abilities
Blacker *et al.* (1993)	• Embrained (conceptual skills and abilities) • Embodied (acquired by doing) • Encultured (acquired through socialisation) • Embedded (organisational routines) • Encoded (signs and symbols)
Nonaka and Takeuchi (1995)	• Technical ("know-how") • Cognitive ("mental modes")
Heron (1996)	• Propositional – theoretical ideas about things • Practical – action related know how • Experiential – things as actually experienced • Presentational – a feedback loop from experiential to propositional knowing in a form of a creative output
Tsoukas (1996)	• "Taxonomic" knowledge – knowledge that makes distinction between explicit and tacit knowledge
Edvinsson and Malone (1997)	• Product knowledge • Routine knowledge • Process knowledge

Table A-2: The classification of knowledge management definitions [27]

Reference	Definitions of KM
Focus: Need of KM	
1. CPA Journal, 1998	Knowledge management is concerned with organizing and analysing information in a company's computer databases so this knowledge can be readily shared throughout a company, instead of languishing in the department where it was created, inaccessible to other employees
2. Bair, 1997	Knowledge management aims to capture the knowledge that employees really need in a central repository and filter out the surplus. Use of technology to capture the knowledge residing in the minds of the employees so it can be easily shared across the enterprise
3. O'Leary, 1998	Enterprise knowledge management entails formally managing knowledge resources in order to facilitate access and reuse of knowledge, typically by using advanced information technology. KM is formal in that knowledge is classified and categorised according to a pre-specified – but evolving – ontology into structured and semi-structured data and knowledge bases
Focus: What KM demands	
4. Thomas et al., 2001	Knowledge management is seen primarily as a domain of capturing, organizing, and retrieving information, evoking notions of databases, documents, query languages, and data mining
5. Hannabuss, 1987	Finding out how and why information users think, what they know about the things they know, the knowledge and attitudes they possess, and the decision they make when interacting with others
6. Hibbard, 1997	Combining indexing, searching and push technology to help companies organise data stored in multiple sources and deliver only relevant information to users
7. Anthes, 1991	Policies, procedures and technologies employed for operating a continuously updated linked pair of networked databases
8. Gopal and Gagnon, 1995	Identification of categories of knowledge needed to support the overall business strategy, assessment of current state of the firm's knowledge and transformation of the current knowledge-base into a new and more powerful knowledge base by filling knowledge gaps
9. Chorafas, 1987	Ensuring a complete development and implementation environment designed for use n a specific function requiring expert systems support

Focus: KM practices

10.	Mack et al., 2001	Capturing knowledge and expertise created by knowledge workers as they go about their work and making it available to a larger community of colleagues. Technology can support these goals, and knowledge portals serve as a key tool for supporting knowledge work
11.	Birkett, 1995	Bringing tacit knowledge to the surface, consolidation it in usable forms by which it is more widely accessible, and promoting its continuing creation

Focus: KM and IT

12.	Strapko, 1990	Understanding the relationships of data; identifying and documenting rules for managing data; and assuring that data are accurate and integrity is maintained
13.	Zeleny, 1987	Facilitation of autonomous coordinability of decentralized subsystems that can state and adapt their own objectives
14.	Maglitta, 1995	Mapping knowledge and information resources both on-line and off-line; training, guiding and equipping users with knowledge access tools; monitoring outside news and information

Focus: KM processes

15.	Davenport, 1994	Processes of capturing, distributing, and effectively using knowledge
16.	Garvin, 1994	Creation, acquisition and transfer of knowledge and modification of organisational behaviour to reflect new knowledge and insights
17.	Albert, 1998	The process of collecting, organizing, classifying and disseminating information throughout an organisation, so as to make it purposeful to those who need it

Focus: Holistic nature of KM

18.	Alavi and Leidner, 1999	Knowledge management refers to a systemic and organisationally specified process for acquiring, organizing and communicating both tacit and explicit knowledge of employees so that other employees may make use of it to be more effective and productive in their work
19.	Maglitta, 1996	Knowledge management in general tries to organise and make available important know-how, wherever and whenever it is needed. This includes processes, procedures, patents, reference work, formulas, "best-practices", forecasts and fixes. Technologically, intranets, groupware, data warehouses, networks, bulletin boards and videoconferencing are key tools for storing and distributing this intelligence
20.	Zuckerman and Buell, 1998	Knowledge management is the strategic application of collective company knowledge and know-how to build profits and market share. Knowledge assets, both ideas or concepts and know-how, are created through the computerised collecting, storage, sharing and linking of corporate knowledge pools. Advanced technologies make it possible to mine the corporate mind

Table A-3: Comparison of knowledge management approaches [31]

Dimensions	**Technology –oriented KM**	**Human-oriented KM**	**"Bridging the gap" KM**
(1) Approach			
Orientation	Technology-oriented	Human-oriented	Process-oriented; knowledge processes integrate both orientations
Perspective	Engineering, cognitive	Cultivation, community	Socio-technical systems engineering
Definition of knowledge	Documented knowledge, separable from people	Knowledge exclusively in the heads of people	Documented knowledge is connected to knowledge in the heads of people and embedded in social networks according to (knowledge) processes
(2) Strategy			
KM strategy Goals	Codification	Personalization	Boundary spanning
Goals	Improve documentation and retention of knowledge, acquisition of external knowledge, turn implicit into explicit knowledge	Improve communication, training of newly recruited, improve knowledge sharing, improve personnel development	Improve visibility of knowledge, improve access to and use of existing tacit and explicit knowledge, improve innovation, change culture
(3) Organisation			
Roles	Author, knowledge (base) administrator, knowledge broker	Knowledge worker, expert, mentor, network chair, community manager, moderator	Knowledge partner and stakeholder, boundary spanner, coordinator for KM, subject matter specialist, owner/manager of knowledge processes
Tasks	Storing, semantic release and distribution, refinement, deletion/archiving of knowledge, acquisition of external knowledge	Establish, foster and moderate communities, document skills and expertise, organise knowledge sharing events	Develop knowledge maps connecting knowledge elements and people, develop profiles, develop knowledge portals, personalize organisational knowledge base

Culture	Technocratic	Socio-cultural	Socio-technical, discursive
(4) KM instruments and systems			
Instruments	Document and content management	Skill management, knowledge communities, knowledge networks	Knowledge maps, lessons learned/best practice management, continuous improvement
Contents	Knowledge about organisation, processes, products; internal studies, patents, on-line journals	Employees yellow pages, skills directories, directories of communities, knowledge about business partners	Ideas, proposals, lesson learned, best practices, community home spaces, valuations, comments, feedback to knowledge elements
Architecture	Integrative KMS	Interactive KMS	KMS bridging the gap
Functions	Publications, classifications, formalizing, organisation, search, presentation, visualization of knowledge elements	Asynchronous and synchronous communication, collaboration and cooperation, e-learning, community support	Profiling, personalization, contextualisation, recommendation, navigation from knowledge elements to people
(5) Economics			
Evaluation area	Content, integrative KMS	Communication, social networks, interactive KMS	Knowledge process, content communication, KMS bridging the gap
Evaluation categories	System quality, information and knowledge quality, use, user, satisfaction, impact on individuals	Community quality, knowledge-specific services, use, user satisfaction, impact on collectives	All evaluation categories

<table>
<tr><td>Type of Knowledge

1. What knowledge are you interested in?</td><td colspan="2">Technical knowledge
• Know what and how eg. what materials should be used on X and how (compliance with official legal standards are critical ithin R&D SBU)
• Current trends
• Knowledge of the industry
• Know who</td></tr>
<tr><td>2. Please select from the adjacent list, the class of knowledge that best describes this knowledge</td><td>(a) Best Practice
(b) Product knowledge
(c) Operational process/procedure
(d) Support process/procedures
(e) Strategies/policies</td><td>(f) Control procedures
(g) Equipment/tools
(h) Quality standards/processes
(i) Domain/function knowledge
(j) Human resources
(k) Other (please specify)</td></tr>
<tr><td>3. How does this knowledge relate to a particular set of business goals/concerns of the organisation?</td><td>Need to improve the efficiency of the R&D unit by enabling some of their core expertise to be made available more widely and automatically while still maintaining quality of output</td><td>Improve knowledge capture and re-use eg. from project reviews
Generation and maintenance of knowledge to avoid knowledge loss</td></tr>
<tr><td>Characteristics

1. What are the characteristics of this knowledge (select an option from the adjacent table)?</td><td colspan="2">Is the knowledge:</td></tr>
<tr><td></td><td>Explicit: can be captured, codified and formalised</td><td>Tacit: usually in people's heads, sometimes referred to as experience</td></tr>
<tr><td></td><td>Auxiliary: often general knowledge never necessary in isolation</td><td>Critical: core to operational effectiveness & achievement of business goals</td></tr>
<tr><td></td><td>Background: generalised used to support use of foreground knowledge</td><td>Foreground: relates to specific problem context or task</td></tr>
<tr><td></td><td>Slow change: knowledge tends to evolve rather than step changes</td><td>Rapid change: frequent generation of new or amended knowledge</td></tr>
<tr><td></td><td>Other (please specify)</td><td></td></tr>
<tr><td></td><td colspan="2">Is the location of the knowledge:</td></tr>
<tr><td>2. Where is it located?</td><td>External: knowledge exists outside the organisation, can be bought</td><td>Internal: knowledge exists within the organisation, tends to be owned</td></tr>
<tr><td></td><td>Individual: knowledge held by individual(s)</td><td>Shared: knowledge is shared and available across the organisation</td></tr>
<tr><td></td><td>Specific to problem: knowledge relates to defined problem context</td><td>Generic: knowledge can be applied across a range of project contexts</td></tr>
<tr><td></td><td>Other (please specify)</td><td></td></tr>
<tr><td></td><td colspan="2">Is acquisition (learning) by:</td></tr>
<tr><td>3. How is this knowledge acquired?</td><td>Formal Training: knowledge gained by action on task or tool formally XXXXX</td><td>Informal Interaction: knowledge gained by interpersonal relationships, networking XXXXX</td></tr>
<tr><td></td><td>Other (please specify)</td><td></td></tr>
<tr><td></td><td colspan="2">Drivers

Inhibitors

Enablers</td></tr>
</table>

Figure A-1: Example of the problem definition template [64]

Left Anchor	Continuum	Right anchor
Explicit: Automated/Process based Decision Making	*(Approach to Decision Making)*	*Tacit*: Human based decision making by discussion/consensus
Auxiliary: Focus on performance, efficiency and costs	*(Recognising Core Competence)*	*Critical*: Focus on knowledge as a competitive edge
Discipline based: Emphasis on developing single discipline knowledge domains	*(Openness to Change/Flexibilty)*	*Project based*: Focus on developing multi-disciplinary project knowledge
Slow change: Competitive edge depends on efficiency of knowledge	*(Requirements to Innovate)*	*Rapid change*: Competitive edge depends on ability to innovate
External: Emphasis is on managing knowledge which can be bought in as required	*(Knowledge Ownership & Availability)*	*Internal*: Emphasis is on owning knowledge that is particularly rare or valuable
Individual: Having access to the knowledge is more important than sharing it	*(Knowledge as an Organisational Asset)*	*Shared*: Knowledge is seen as an organisational asset to provide added value
Problem specific: Excellent for recurrent problems (runners and repeaters)	*(Re-use of Knowledge)*	*Generic*: Reuse of knowledge is important; allows wider allocation of work.
Learn by training: Ensure technical/professional competence	*(Propagation of Org. Culture)*	*Learn by interaction*: Assists transfer of organisational values

Figure A-2: Template of the knowledge dimensions guide [65]

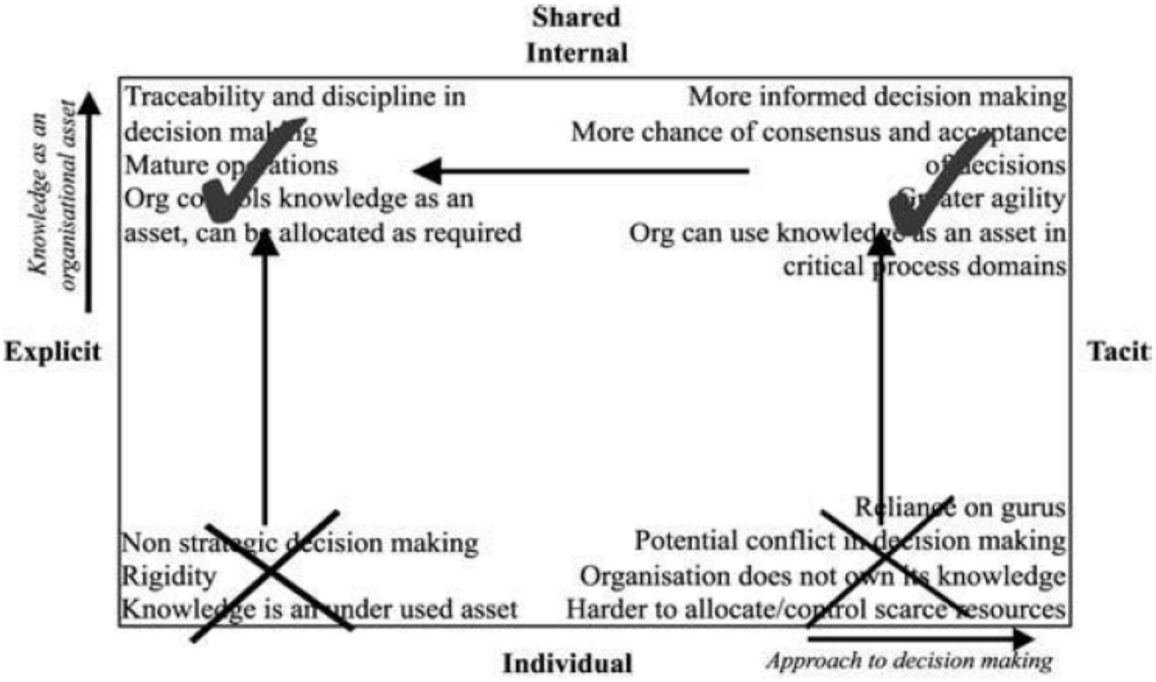

Figure A-3: Example of a completed square from one of the dimensions [65]

Table A-4: Example of a set of migration paths summarised from the set of squares [65]

Path	KM process
From individual tacit knowledge to shared tacit knowledge	Propagate knowledge
From individual explicit knowledge to shared explicit knowledge	Propagate knowledge
From shared tacit knowledge to shared explicit knowledge	Transfer knowledge
From individual critical knowledge to shared critical knowledge	Propagate knowledge
From individual internally owned knowledge to shared internally owned knowledge	Propagate knowledge
From individual problem specific knowledge to shared problem specific knowledge	Propagate knowledge
From individual project-based knowledge to shared project-based knowledge	Propagate knowledge
From shared problem specific knowledge to shared generic knowledge	Transfer knowledge

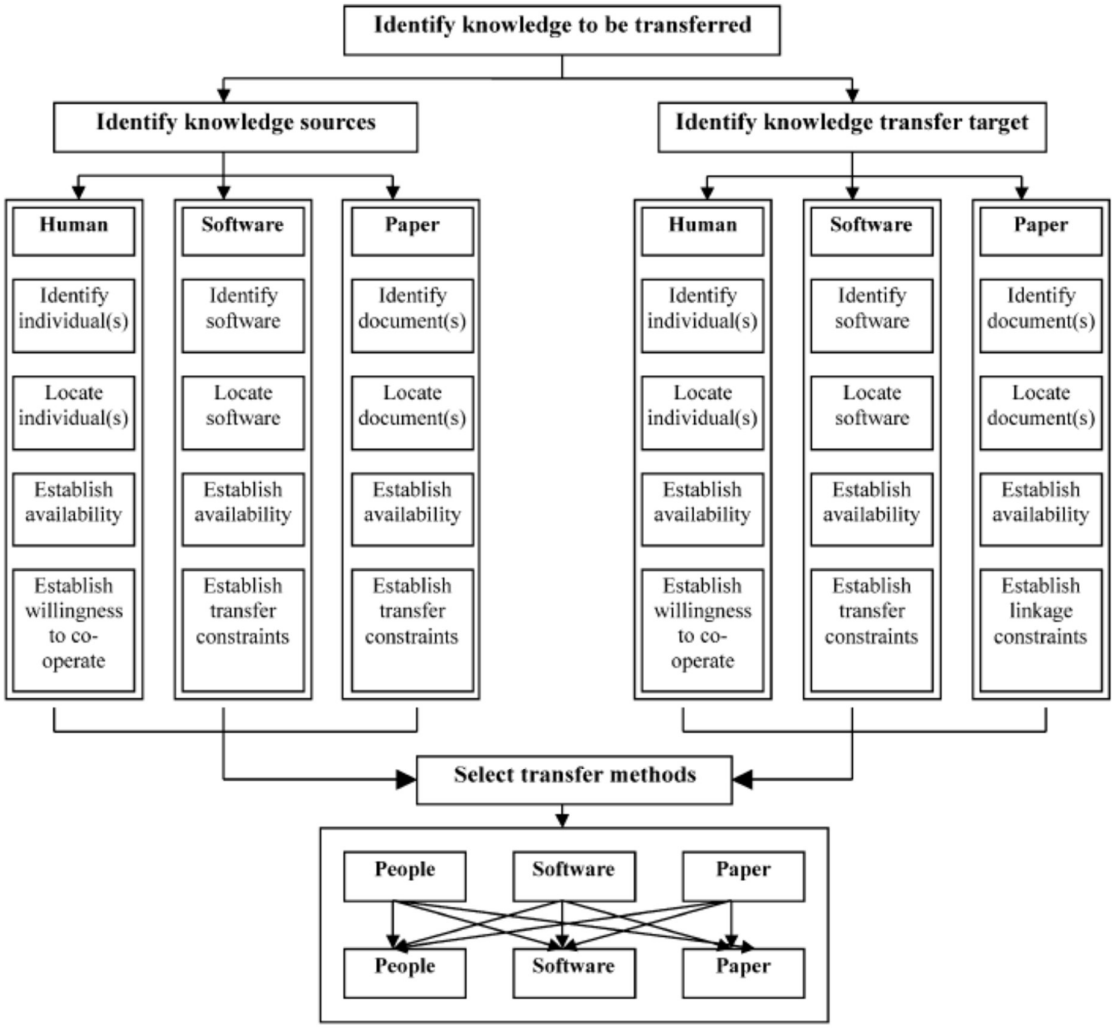

Figure A-4: A generic process model for knowledge transfer [64]

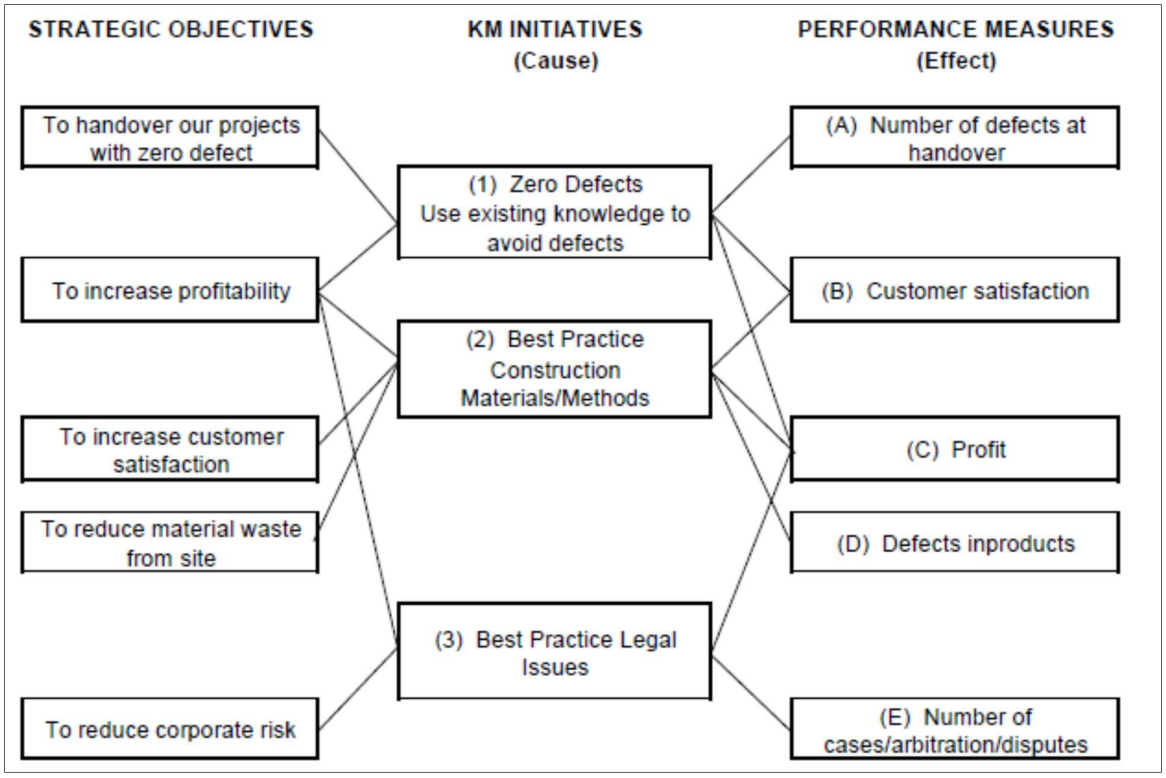

Figure A-5: Illustration of the cause and effect map [66]

APPENDIX B: SEMI-STRUCTURED FACE-TO-FACE INTERVIEW QUESTIONNAIRE

SECTION A: General information

Question 1: What department are you currently working for?

Question 2: What is your current position in that department?

Question 3: How many years have you been involved in construction projects? [1-5, 6-10, 11-15, 16-20, more than 20] Also indicate level of involvement.

Question 4: How many construction projects have you been involved in? [1-5, 6-10, 11-15, 16-20, more than 20]

Question 5: What type of projects have you been involved in? [Minor Retic, Electrification, Major Retic, Substations, HV lines]

SECTION B: Knowledge management awareness and strategies within the organisation

Question 1: Do you know about knowledge management? Have you encountered it in your organisation?

Question 2: Is there a knowledge management strategy in your organisation?

Probing Questions:

1. What is the importance and goals of this strategy?
2. Is there leadership support for knowledge management? Is it a priority?
3. Is the knowledge management strategy related to the organisational strategy?
4. Is there a team responsible for knowledge management initiatives or its implementation?
5. Is there a framework that addresses knowledge management requirements in the organisation?
6. What other strategies/policies are available, even if scattered/informal, to manage knowledge in the organisation?

Question 3: Does knowledge management processes/activities form part of project construction management and processes in your projects?

Probing Questions:

1. If yes, how is it implemented? On ad-hoc basis or as part of the daily project management?
2. If no, is there any plan to do so?
3.

SECTION C: Existing knowledge management practices in construction projects

Question 1: What type of information or knowledge is stored for construction projects in NWOU?

Probing Questions:

1. Who stores the information/knowledge? (Project manager, engineer, etc.)
2. How is this information/knowledge stored? (Paperwork, CDs, laptop, database, individual's mind etc.)

Question 2: Do you use the stored construction project information/knowledge?

Question 3: How do you find knowledge from similar construction projects to assist you with challenges on a project that is under construction?

Probing Questions:

1. If you encounter challenges during project construction, what are the different sources of knowledge that you utilise?
2. Do you know how to search for that knowledge/information?
3. Is there sufficient knowledge base to assist you in executing construction projects effectively and efficiently?

Question 4: What knowledge management tools (techniques and technologies) are utilised in by the project team during project construction? Are the required tools available?

Examples to be considered:

- *Brainstorming sessions*
- *Community of practice*
- *Face-to-face interactions*
- *Recruitment Training*
- *Data and text mining*
- *Groupware*
- *Intranets/extranets*
- *Knowledge bases*
- *Taxonomies/ontologies*
- *Lessons learnt sessions*
- *Email*
- *Video-conferencing*
- *Cellular phone applications*
- *Others: Specify*

Question 5: From your experience, what knowledge or information is critical to you during project construction?

Probing Questions:

1. Is this knowledge/information available?

Question 6: When do lessons learnt and best practices get shared for projects under construction?

Question 7: How are lessons learnt from one project communicated to another project/project team before the same mistake is made when similar projects are under construction?

Question 8: How is the knowledge (lessons) acquired from construction projects captured for future use for other projects?

Question 9: When a project is under construction and there is an event/challenge on site that requires a solution, what are the steps that would follow?

Question 10: After the solution has been provided for the challenge, what knowledge management processes/activities are completed?

Question 11: In your experience, most of time, what type of knowledge is required to resolve the challenges on site?

Examples to consider (Adopted from the CLEVER framework):

- *Explicit: can be captured, codified and formalised*
- *Tacit: usually in people's heads, sometimes referred to as experience*
- *Auxiliary: often general knowledge*
- *Critical: core to operational effectiveness & achievement of business goals*
- *Other: Specify*

Question 12: In your experience, most of time, where is this knowledge located?

Examples to consider (Adopted from the CLEVER framework):

- *External – outside organisation*
- *Internal – knowledge exists within organisation*
- *Individual – knowledge held by individuals*
- *Shared – knowledge is shared and available across the organisation*
- *Other: Specify*

SECTION D: Barriers and Enablers

Question 1: What are the barriers to knowledge transfer during and after project construction?

Question 2: What are the barriers to knowledge transfer between projects that are under construction at the same time?

Question 3: Which techniques and technologies can make a difference in improving sharing of knowledge between project construction sites?

Question 4: What will encourage you to better share and transfer knowledge?