A Framework for Knowledge Capture and Recovery in Whole Life Costing Practice

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CERTIFICATE OF ORIGINALITY

This is to certify that I am solely responsible for the work, which has been submitted within this thesis. Apart from where identified, by means of referencing, I confirm that the contents of the thesis are original and my own. I confirm also, that no part of the thesis has been submitted to any other institution or body in consideration for any other degree or qualification.

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ABSTRACT

In spite of the benefits of implementing whole life costing technique as a valuable approach for comparing alternative building designs allowing operational cost benefits to be evaluated against any initial cost increases and also as part of procurement in the construction industry, its adoption has been relatively slow due to the lack of tangible evidence, "know-how" skills and knowledge of the practice i.e. the lack of professionals in many establishments with knowledge and training on the use of whole life costing technique, this situation is compounded by the absence of available data on whole life costing from relevant projects, lack of data collection mechanisms and so on. This has proved to be very challenging to those who showed some willingness to employ the technique in a construction project. The knowledge generated from a project can be considered as best practices learned on how to carry out tasks in a more efficient way, or some negative lessons learned which have led to losses and slowed down the progress of the project and performance. Knowledge management in whole life costing practice can enhance whole life costing analysis execution in a construction project, as lessons learned from one project can be carried on to future projects, resulting in continuous improvement, providing knowledge that can be used in the operation and maintenance phases of an assets life span. This study aims to use knowledge management as a tool to address the obstacle of whole life costing outlined in this study by developing a framework for knowledge capture and recovery in whole life costing practice in construction.

An extensive literature review was first conducted on the concept of knowledge management and whole life costing. This was followed by a semi-structured interview to explore the existing and good practice knowledge management in whole life costing practice in a construction project. The data gathered from the semi-structured interview was analysed using content analysis and used to develop the framework. From the results obtained in the study, it shows that the practice of project review is the common method used in the capturing of knowledge and should be undertaken in an organised and accurate manner, and results should be presented in the form of instructions or in a checklist format, forming short and precise insights. In order to efficiently and swiftly recover knowledge from previous whole life costing project, the knowledge must be characterised based on whole life costing processes and activities, by means of an IT system with components designed to manage knowledge and locate expertise. However; the framework developed advised that irrespective of how effective the approach to knowledge capture and recovery, the absence of an environment for sharing knowledge, would render the approach ineffective. Open culture and resources are critical for providing a knowledge-sharing setting, and leadership has to sustain whole life costing knowledge capture and recovery, giving full support for its implementation. The framework has been evaluated by academics and practitioners who are experts in the area of whole life costing practice. The results have indicated that the framework and its components are both suitable and efficient.

Keywords: whole life costing, construction industry, knowledge management, knowledge capture, knowledge recovery, project review, framework

DEDICATION

This thesis is dedicated to the Almighty God, the source of all knowledge

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LIST OF ABBREVIATIONS

After-Action Review	AAR
Communities of Practice	CoP
Information Technology	IT
Information and Communication Technology	ICT
Knowledge Management	KM
Knowledge Management System	KMS
Project Review	PR
Post Completion Review	PCR
Post-Implementation Review	PIR
Project Post-Mortem	PPM
Post Project Review	PPR
Royal Institution of Chartered Surveyors	RICS
Whole Life Costing	WLC
Whole Life Costing Knowledge Capture and Recovery	WLCKCR
Whole Life Costing Analysis	WLCA
Whole Life Costing Planning	WLCP
Whole Life Costing Management	WLCM

CHAPTER 1 : RESEARCH OVERVIEW

"*A true teacher would never tell you what to do. But he would give you the knowledge with which you could decide what would be best for you to do*." **— Christopher Pike, Sati**

1.1 Introduction

This chapter presents the area of interest of the research and delivers the underpinning that underlies the study. It describes the problem which is being investigated and outlines the main aim and objectives which the researcher sets out to achieve side-by-side the propositions which the study also seeks to answer. Finally, the chapter describes the research design adopted and also the thesis structure.

1.2 Background of the Research

Project management in construction and its activities are mostly tied to poor performance (Alavi and Leidner, 2001). The ability of an organisation to acquire, synthesise, manipulate and exploit knowledge has been considered the key to the efficient execution of projects and a boost to organisational performance (Anumba et al., 2005; Egbu, 2004; Bresnen et al., 2003; Scarbrough et al., 1999). The management of these processes otherwise termed knowledge management (KM) has attracted much consideration in recent years in the construction sector. This does not by any means suggest that "knowledge" can be managed independently of those who possess it (Wilson, 2002). Many construction firms have begun to adopt project enhancement initiatives to boost the performance of their company (Carrillo and Chinowsky, 2006). Governments all over the world have made several efforts intended at enhancing project performance in the construction industry (Mohd Zin, 2014). The reason for these attempts is to ensure that the manner in which business is carried out is dynamic enough to match the changing nature of the competitive and challenging market environment. The application of KM practice in construction is acknowledged as one of the initiatives to enhance project performance in the construction sector (Mohd Zin, 2014; Carrillo and Chinowsky, 2006). KM in firms involves the management of knowledge processes (Carrillo and Chinowsky, 2006) including creation, capturing, transfer, recovery. Hong et al., (2011) and Wang and Noe, (2010) have acknowledged that the success of KM in an organisation is reliant on the efficient creation, capture, transfer and recovery approaches adopted. A number of studies have been conducted over the last two decades regarding the benefits of appropriate capturing, sharing and recovery of construction knowledge in organisations (Falqi, 2011; Hsu, 2008; Lin, 2008). It is evident in the literature that the capture, sharing and recovery of organisational knowledge can enhance performance and give a competitive edge to organisations (Falqi, 2011; Hsu, 2008; Lin, 2008). Nevertheless, it is sometimes unsuccessfully implemented (Hsu, 2008; Hansen et al., 1999). The manner in which construction organisations should boost and enable the capture and recovery of knowledge to enhance organisational performance is still an essential part of research enquiry which is on-going (Falqi, 2011). Although it has recently been attempted to

examine the gap in the KM literature, a handful of studies have investigated into the way knowledge capture and recovery strategies could be enhanced within the construction sector's unique setting (Falqi, 2011). For this reason, this has resulted in many construction firms being short of how knowledge capture and recovery strategies should be improved and developed in such a manner that could enhance organisational performance. This short-coming has placed emphasis on the need for continued knowledge capture and recovery investigation.

Many building firms are progressively finding knowledge to be greatest influential strength when executing construction projects (Kasimu et al., 2012; Kant and Singh, 2011; Graham, 2010). As Carrillo et al., (2004) state, "the construction sector has begun recognising the importance of knowledge capture, sharing and recovery, diffuse best practice, delivery of quick solutions to clients and decreased work being repeated". Notwithstanding these energies, the comprehension of the best ways to capture and recover knowledge is still minimal, and less is known about how to guarantee the availability of knowledge to other members of the project team and organisations (Falqi, 2011; Hsu, 2008; Carrillo et al., 2004). Also, building firms are often critiqued for the struggle to change and their failure towards implementing innovative methods to enhance future business performance (Ozorhon et al., 2010; Robinson et al., 2005a). Furthermore, Falqi, (2011); Egbu, (2004); Egbu and Botterill, (2001); and Robinson et al., (2001a) have in their various studies uncovered and emphasised the importance of the ability of construction firm to efficiently capture, recover and share the source of its knowledge, which eventually adds value to their capacity for performance and organisational innovation. Their investigation did not, however, show how knowledge can be captured and recovered.

Woo et al., (2004); Hari et al., (2005), underlined the fact that no matter how knowledge-intensive construction project can be during project execution, the creation of knowledge still occurs and the new knowledge created remains in the heads of individuals. However, unless the knowledge is captured accurately, it is sometimes either lost, or only a small fraction of it progresses into the project documents (Fruchter, 2002). Consequently, the knowledge acquired during a construction project may vanish if the project participants are not allowed to reproduce it in impending projects (Robinson et al., 2005; Barlow and Jashapara, 1998). Once knowledge is captured in a project, results and justifications are made explicit in project depositories, (Kamara et al., 2005) which are overlooked by the organisational members. However, if an efficient knowledge capture and recovery strategy is put in place, there can be a movement of knowledge between and within different project life cycles in every construction project phase (Falqi, 2011).

The motive to work together and convey the best value instead of the lowest cost for stakeholders, clients and others participating in the development of built environment assets in the UK are now well recognised (Higham et al., 2015). Innovative methods for procuring a construction project tie the collection of the design, construction and operation stages, which is often executed by a single

organisation (Higham et al., 2015). So, it would be anticipated that it is significant to have an appropriate construction expert bring to the table cost advice at the early stage of the project by adopting an appraisal tool such as whole life costing (WLC). Whole life costing practice is considered as a method that emerged from the energy crisis in the mid-1970s with an economic focus (Steen, 2005) and was originally designed for procurement purposes in the United States Department of Defence (White and Ostwald, 1976) and it is still commonly used in the military sector (Woodward, 1997). However, before the 1970s, most clients, developers and professionals undertaking building procurement made capital investment decisions solely on the basis of capital cost (Boussabaine and Kirkham, 2008). Outside the construction industry, WLC practice was appreciated in some quarters that making decisions solely on capital cost could be folly. They believed that by possibly spending more in capital cost, the long term would realise substantial cost savings when compared with a cheaper alternative (Boussabaine and Kirkham, 2008). While in the mid-1980s attempts was made to adapt WLC to building investments (Bennett and Norman 1987). The practice of whole life costing in the construction industry is now becoming widely recognised amongst practitioners and academics as an alternative approach in building procurement and a valuable method in assessing the economic efficiency of constructed facilities (Kirkham, 2005). Whole life costing (WLC) practice which is the primary focus of this research is regarded as a method used for carrying out an economic appraisal of the whole life costs over a given period of analysis, as defined in the agreed scope (BSI, 2008). It is mostly employed in the decision-making process, for instance, the comparison of several project design alternatives at the pre-construction stages of the construction project (Hunter et al., 2005). It is a practice which aims to appraise the overall design life costs of materials or components that are projected to be elements of a building project's design (Higham et al., 2014). However, a growing number of building firms are employing project enhancement initiatives to enhance their performance and increase their widespread use in construction projects which include the establishment of the Whole Life Costing Forum (Whole Life Costing Forum, 1999) and gathering benchmarking cost and time data for utilisation in whole life costing (El- Haram et al., 2002); the development of standardised whole life costing methodology, e.g. the ISO 15686-5 and the UK whole life costing supplements to it (BSI, 2008a). Despite the development and implementation of several project initiatives as reflected by Swaffield and McDonald, (2008), whole life costing is still crippled. This study therefore primarily seeks to investigate, develop and improve initiatives that would support the capture and recovery of whole life costing knowledge.

A practical method for managing captured knowledge hinges on the technologies and mechanism that promote the alteration of explicit knowledge into a tacit knowledge format or that changes tacit knowledge into explicit knowledge (McComb, 2007). Model construction and good practice articulation or lessons learnt are a couple of illustrations of mechanisms which facilitate the transformation of explicit knowledge to tacit knowledge, while the mechanisms that promote the

alteration of tacit knowledge to explicit knowledge are; on the job training, learning by doing, face to face meeting and learning by observation (Becerra-Fernandez and Sabherwal, 2006).

The distinctiveness of a project happens to be a major problem linked to KM deployment in construction project (Falqi, 2011). Without a doubt, each construction project has a distinctive feature which is shaped by some distinctive set of characteristics such as project specification, site, resources, project team conditions, culture and environment (Egbu et al., 1999). However, the distinctive nature of a construction project does not limit knowledge capture and recovery in the project because similar construction processes, team structure, skills and tools utilised in project development are unique characteristics as well (Hughes, 1991; Kamara et al., 2003). Managing knowledge in a sector where work is often repeated is more advantageous than in areas where it is hard or not repeated at all (Falqi, 2011).

It is evident that whole life costing techniques can inform the project team with the detailed knowledge required to make productive future investments and budgetary decisions which can enhance whole life costing performance in building projects (Akinrata, 2016; Oduyemi et al., 2014). No doubt the numerous attempts have been made by governments worldwide to improve the performance of the building sector (Mohd Zin, 2014). The initiative is to make fundamental alterations to how business can be conducted to help success in a new and more demanding business environment (Mohd Zin, 2014). One of the initiatives to enhance construction project performance is the manner in which knowledge is managed within organisations. The emphasis of this research is therefore on how knowledge is captured and recovered in whole life costing in a building project. There is an absence of studies which investigate the present practice of KM in whole life costing practice in the UK building sector. Although, a few studies have highlighted how a significant number of the UK construction industries conduct the practices of KM in whole life costing informally. Cases such as explicit knowledge in the form of whole life costing standardised methodologies, guidelines of manuals giving a step-by-step process on how whole life costing analysis and planning now abound (BSI, 2008). Other methods in use are; community of practice formation known as the whole life costing forum (Whole life costing Forum, 1999) which is currently no longer in use; the gathering of benchmarking cost and time information for use in whole life costing (El-Haram et al., 2002); construction of a framework document and input tool which gives a cost professional adequate knowledge to produce a whole life costing analysis with minimum effort (Hunter et al., 2005). Nevertheless, a significant amount of knowledge is captured in many construction firms which nobody uses which results in information overload (Wenger, 2000). According to (Liston et al., 2000), the overload of information is a key challenge when adopting KM in the construction sector. Consequently, the random capture of knowledge is insufficient. Knowledge must be refined and the right strategies and tools ought to be chosen to assist project members in recovering what they require speedily and efficiently. An effective

strategy for recovering knowledge can help individuals to comprehend their knowledge resources and locate necessary knowledge quickly (Falqi, 2011).

At present, there is no structured way or practice of knowledge capture and recovery in whole life costing practice. It is argued that the lack of knowledge capture and recovery approach in the building sector hinder the continuous improvement of efforts in this direction (Falqi, 2011). Prior research has also informed that there is a shortage of empirical study on knowledge capture and recovery models for construction firms, resulting in the endless necessity for such models to be developed and tested (Falqi, 2011; Egbu, 2004). So, there is a need to design a comprehensible knowledge capture and recovery framework in whole life costing practice. In the light of a lack of appropriately structured guidelines to guide construction firms on the problems of knowledge capture and recovery, this research proposes to fill the gap by constructing and authenticating a framework for knowledge capture and recovery in whole life costing in the construction industry.

1.3 Need for Change

Egan (1998: p3) painted the picture clearly by stating that *"...a thriving construction industry is vital to us all. We all benefit from high-quality housing, hospitals or transport infrastructure that is efficiently constructed. At its best, the UK construction industry displays excellence. However, there is no doubt that significant enhancements in quality and efficiency are possible. Indeed, they are vital if the sector is to satisfy all its clients and gain the benefits of becoming a world leader..."*

The above pronouncement reveals the necessity for revolution and continuous enhancement in the building sector. The construction sector is vital, due to its massive production and wholly because of its economic worth (Mohd Zin, 2014). The construction sector output is an essential and critical aspect of national production, which accounts for a substantial amount in the Gross Domestic Product (GDP) of both advanced and underdeveloped countries (Crosthwaite, 2000; Tse and Ganesan 1997). Hillebrandt, (2000) states that the value added by the construction sector is in the range of 7% to 10% for highly advanced economies and around 3% to 6% for poor economies. As a result, there is increasing public concern about the legislative requirements for sustainable construction as it is connected to the need to conserve resources (Pasquire and Swaffield, 2002). Regarding sustainability, it is evident that the utilisation of whole life costing can assist at an early project stage, the environmental/economic aspects of a proposed building project design (Caplehorn, 2012).

Knowledge in today's world is not only an essential economic resource (Drucker 1995) but also an organisation's most competitive advantage (Davenport and Prusak, 1997). In the knowledge-based theory of a firm as put forward by Grant (1996), it was suggested that knowledge can be considered as a vital and most crucial asset of an organisation. Rezgui et al., (2010) supported the view by pointing out that construction firms are a knowledge-based organisation and their every-day operation is heavily dependent on the knowledge, ideas, skills and experience of the construction workers, which

come from various sources including documents, other experienced individuals and electronic media. This abundance of knowledge assists in conveying construction projects as efficiently as possible (Mohd Zin, 2014). Although the building sector is very knowledge-intensive as Hari et al., (2005) observed, Rezgui et al., (2010) contended that the knowledge of the project workers is not utilised efficiently in many cases. Moreover, despite several efforts being put forward to enhance the management of construction, and a significant number of systems and tools created to aid successful project conveyance, the record of construction project implementation is poor (Ogunlana and Promkuntong, 1996; Assaf et al., 1995). Nevertheless, an exceptional level of demand for improvement has been experienced by the construction sector in the last two decades (Falqi, 2011). The call for change as proposed by Egan (1998) and Latham (1994) in their reports which critiqued the performance of the industry and called for improvement. The absence of capturing best practice from the previous projects was considered as a major obstacle that needs to be tackled so as to be more cost efficient and performance-oriented. The Egan (2004) report deals with the practice of KM and stresses the significance of the capture of a lesson learned and a deeply rooted learning culture. Response from the government regarding the report from Egan in ODPM, (2004) reveals the assistance of KM practice utilisation in the construction sector and the government's readiness to assist the present programmes with further development and learning programmes. In a report by Pearce (CRISP, 2003) emphasis was placed on the significance of a knowledgeable and well-trained workforce and staying up to date with the technological revolution. A publication titled A strategy for the future by Constructing Excellence (2004) clearly underlined the importance of KM in the management of construction and also recognised the need for the deployment of activity-based programmes to ensure that best practice of KM is addressed and called for continuous improvement through best practice exchange which would help improve the performance of the construction industry.

1.4 Problem Statement

The UK construction sector is working in a progressively uncertain business setting, depicted by growing competitiveness, resources shortage, and request for value for money by its partners and the sustainability requirement (Swaffield and McDonald, 2008). The construction industry has wide-ranging economic and environmental ramifications: it is responsible for half of all CO_2 discharges, as well as half of water utilisation, a third of landfill waste and one-fourth of raw material used in the UK (BERR, 2008). As a result, there is growing public awareness on the legislation for sustainable construction, and it is significant that the sector is greatly appreciated for better value, rather than lowest price. This must be emphasised at the initial stage of the project appraisal of projected construction projects (Wolstenholme et al., 2009; Pasquire and Swaffield, 2002). Therefore, Treasury Guidance (2003; 2011), demands value for money to be evaluated in public projects through the utilisation of whole life costing to guarantee that the completed project meets the standard of the projects end-users.

Hence, there has been a move from addressing buildings "as built" to "in operation": that is as it should be constructed (Kirkham, 2014; Clift, 2003). Different life cycle procedures are utilised to evaluate asset performance or the whole life cycle, from start to finish (Pelzeter, 2007). Whole life costing (WLC) has been recognised in principle and practice by experts and researchers as an economic appraisal tool which assesses the cost of an asset, or its parts for the duration of its lifespan while satisfying its performance necessities (BSI, 2008a; Swaffield and McDonald, 2008). Whole life costing techniques include acquiring, maintaining, operating and the disposing cost of an asset (BSI, 2008b; Swaffield and McDonald, 2008). The long-held idea that the cost being used of constructed assets can be several times higher than the initial capital cost is ever more relevant today with increasing use of private finance initiatives (PFI) and private-public partnerships (PPP) (Flanagan and Jewel, 2005). Whole life costing would appear to be necessity for these projects (Swaffield and MacDonald, 2008), which is adopted to assess the construction asset, its component parts, or materials based on their initial and consequential cost, to achieve better value for money at the pre-construction, construction and occupancy stages (Davis Langdon, 2007; OGC, 2007).

Regardless of the benefits of implementing whole life costing and its adoption as part of procurement in the construction industry, whole life costing is not broadly embraced, and its utilisation in the building sector has been crippled (Akinrata, 2016; Oduyemi et al., 2014; Olubodun et al., 2010; Davis Langdon, 2007; Christenen et al., 2005). The reasons for the obstacles to its adoption as published in a report by National Audit Office on “Improving Public Services through better construction” (NAO, 2005) are mainly due to the fact that clients are ill-informed about the benefits of the practice which can result to subjective decision-making; the lack of tangible know-how skills and knowledge by cost experts in carrying out whole life costing in a construction project, i.e. many establishments require experts with the training and experience of this. This situation is compounded by the absence of available data on whole life costing from important projects. The time required for data collection and the analysis may leave inadequate time for essential dialogue with the decision-maker and the re-run of alternative investment decisions (Ferry and Brandon 1991, Bull, 1993, Flanagan et al., 1989, Ashworth 1996).

Several studies have been carried out in the course of adopting the whole life costing in the building sector. For example, whole life costing utilisation by contractor surveyors on PFI projects (Swaffield and McDonald, 2010); appraising the level of utilisation of whole life costing in the UK construction industry (Opoku, 2013; Olubodun et al., 2010); the usage in real estate in Germany (Pelzeter, 2006). The findings of these studies reveal that there is a general appreciation of the advantages of whole life costing usage, yet numerous barriers cripple its greater application. Thus, whole life costing is either adopted in a simplified format or not accepted at all in the construction industry (Swaffield and McDonald, 2008). As a result, there has been an increasing number of building firm applying project improvement initiatives to enhance performance (Carrilo and Chinowsky, 2006). Their central

objectives are to convey to the building project the necessary quality more quickly (CIRIA, 2001), preventing 're-inventing the wheel' (Holroyd, 1991), and enhancing project performance (Wong and Aspinwall, 2006).

Due to the complex nature of undertaking whole life costing practice in a construction project (Olubodun et al., 2010), many building firms are confronted with the challenge of knowledge overload and the growing complexity of project activities (Sullivan, 2009). An enamours amount of knowledge can be disseminated all over the firm (Wen-Bing, 2011), making it difficult for the right knowledge to be captured and recovered, and as well possibly having redundant, irrelevant or unutilised knowledge when captured (Zack, 1999). Capturing and recovering knowledge in building firms can prevent re-invention of the wheel, facilitate innovation; and lead increased agility, efficiency, flexibility, quality, learning, better decision making, better teamwork and supply chain integration, improved project performance, capture best practice which can be used in future projects, higher client satisfaction, and organisational growth (Mohd, 2014; Falqi, 2011; Hari et al., 2004; Kamara et al., 2003).

There is no point wasting time and resources in re-inventing current best practice in the construction projects (Egan, 2004), especially when the various obstacles have averted the capture of existing practice required from projects and guaranteed it easy recovery (Court et al., 2007). The issue focuses on the gap between the time of knowledge capture and the learning event, the lack of project workers and the concluding planning of the project knowledge which all inhibit efficient capture and recovery of required knowledge (Checkland and Holwell, 1998). Prior investigations have attempted to handle these issues to ensure that a radical solution is created. However, they have not tried to enhance the existing circumstances of project KM, and there has also been an absence of studies that mainly address KM in whole life costing practice.

Falqi, (2011) categorised the approaches for project knowledge capture in order of the time they are undertaken; (1) post project based, (2) stage based, (3) and activities based approaches. The post project-based strategy (e.g. post project and execution review) is efficient in showcasing the lesson learned and experience from a broad perspective that is seen from an entire project. Furthermore, it gives a reasonable chance to reviewers to judge project performance after a product (e.g. building) has been conveyed and occupied. However, because of the time it takes to conduct an audit (usually two years after the project), a significant amount of project knowledge may be lost (Kamara et al. 2003; Fruchter, 2002). There may be a threat that relevant individuals might have moved to different projects (Kasvi et al. 2003; Orange et al., 1999).

Stage-based technique (e.g. PR and project audit) of project knowledge capture partially solves issues linked to the lack of appropriate individuals specified above. However, in practice, some parties or project individuals are included in a part of a stage, and after that, they leave the project (Kasvi et al. 2003). The time between the start and finish of a stage may be extended to the point that part of the

knowledge would be lost, especially in complex projects where an enormous amount of learning event and activities can occur (Falqi, 2011).

Many efforts have been made in resolving difficulties related to the post project based and stage - based methods. These efforts set up what is known as the activity based approach. An activity-based KM structure was constructed by Tserng and Lin (2004) for contractual workers during the construction stage, and Kamara et al., (2005) designed a conceptual model for the purpose of live capture project knowledge which can be the re-use of project knowledge which depends on capturing learning straightforwardly when a learning event is detected (Falqi, 2011). It is asserted that these concepts can solve all known issues if two of them depend on capturing knowledge immediately after the learning event occurs or after each activity in a project has been undertaken. Nonetheless, visualising the number of activities or the number of potential learning events in a project may prompt consideration of a vast number of activities and even more learning events. Applying any of the above approaches may be very demanding and may affect the project activities.

In a situation where knowledge is captured after each event, an allocated time may be available for capture of knowledge, as knowledge from events should be known in the project schedule (Kamara et al. (2005) cited in Falqi, (2011). However, Kamara et al., (2005) who constructed this strategy did not take into account how it would ensure the contribution from project members to the capture of knowledge. Kamara et al., (2005) acknowledged that a knowledge file from projects ought to be agreed on before it is set up at the early project stage, with all participants contributing to its compilation. It is hard (if not impossible) to identify the "when and where" of learning occurrence. As a result, there will be no set time for knowledge capture, and thus knowledge capture using this system may negatively affect project activities. This approach sets up an essential answer to the issue by adding new challenging tasks to the development processes of the construction project. The absence of time formally put aside for the learning process happens to be a serious issue because of the pressure of the organisational environment and construction programme (Boyd and Robson, 1996). Construction projects are complex and include additional tasks which make it more demanding and complex. Subsequent available enhancing processes or methods, (for example, a project review) may save time and effort in a construction project.

The widespread use of the project review (PR) method for the purpose of capturing knowledge has made the method gain popularity among research scholars and construction practitioners (Falqi, 2011; Tan et al. 2004; Winch and Carr, 2001; Orange et al., 1999). Despite its popularity and suitability, the PR issues are still encountered in the post-project based and stage-based approach. However, it has been argued by Schindler and Eppler, (2003), that the capture of knowledge is not the reason why PR is used in the project. Rather it is employed with the aim of project performance tracking (CIOB, 1998). However, PR is practically acknowledged in order for it to be adopted effectively in firms, so it is vital that is conducted by an external party (Schindler and Eppler, 2003; OGC, 2003b and Prencipe

and Tell, 2001) who is not linked to the project. The knowledge gathered from the PR sessions may not be appreciated by the external party, as much as the project members.

Most studies either investigate the capture of knowledge alone (Suresh and Egbu 2006) or at least with knowledge-use (Udeaja et al. 2008). This shows an absence of research that attempts to investigate both capture and recovery for usage in the context of whole life costing practice. The capture and recovery of whole life costing knowledge can influence the organisation's performance in a positive direction. Thus, the study sets out to design a knowledge framework for the capture and recovery of knowledge in whole life costing practice in the building sector. This approach will assist construction firms to spot problems practically and also make a positive contribution to the company's performance.

1.5 Research Aim and Objectives

The primary aim of this study is to develop a conceptual framework that supports the capture and recovery of knowledge in whole life costing practice in the construction industry. Precisely, the study is intended to achieve the following objectives:

1. To conduct the review of literature and document KM practice in construction and identifying the diverse KM tools and deployed in the construction industry
2. To conduct a literature review around whole life costing practice alongside exploring the use of KM in the construction sector and its applicability.
3. To explore the existing KM practices by defining the tools and techniques commonly used and their efficiency in capturing knowledge from whole life costing practice, the capacity of recovery, and the existing practice of PR.
4. To explore and uncover the details common in advanced approaches deployed in knowledge capture and recovery in the course of undertaking whole life costing practice in construction projects.
5. To utilise the findings gathered from objective 3 and 4 to develop a whole life costing knowledge capture and recovery framework (WLCKCR).
6. To validate the framework through academic and construction expert's evaluation

1.6 Research Aim and Objectives and Related Research Propositions

The research aim and objectives above, a set of research propositions were formulated to guide the research as shown in Table 1.1 and 1.2.

Table 1.1: Research proposition

Proposition 1 (P1)	How is KM practised in the construction industry? What are the various KM tools and techniques implemented in whole life costing practice and the construction industry? How is the existing method of PR practised?
Proposition 2 (P2)	What research has been carried out previously in discovering the elements of KM available and practised in whole life costing practice?
Proposition 3 (P3)	What are the KM techniques and tools available in construction organisations and how efficient are they?
Proposition 4 (P4)	How is the capture and recovery of knowledge in whole life costing practice undertaken within the selected construction organisation?
Proposition 5 (P5)	How does one design a conceptual framework for knowledge capture and recovery in whole life costing practice?
Proposition 6 (P6)	How suitable and efficient the newly developed framework?

***key: P**= Proposition

Table 1.2: Link between the research propositions, objectives and adopted methodology

Research Proposition	Research Objectives	Adopted Methodology
(P1): How is KM practised in the building sector? What are the various KM tools and techniques implemented in whole life costing practice and the construction industry? How is the existing method of project review practised?	**(O1):** To conduct the review of literature and document KM practice in construction of projects and identify the diverse KM tools used in the construction industry	Literature review
(P2): What research has been carried out previously in discovering the elements of KM available and practised in whole life costing and the construction industry?	**O2):** To conduct a literature review around whole life costing practice alongside exploring the use of KM in the building sector and whole life costing practice	Literature review
(P3): What are the KM techniques and tools available in construction organisations and how efficient are they?	**O3):** To explore the existing KM practices by defining the tools and techniques commonly used and their efficiency in capturing knowledge from WLC practice, the capacity of recovery, and the existing practice of PR.	Semi-structured interview
(P4): How is knowledge captured and recovered in whole life costing practice and construction projects within the care study organisations?	**O4):** To explore and uncover the details common in advanced approaches deployed in knowledge capture and recovery in the course of undertaking whole life costing practice in construction projects	Semi-structured interview
(P5): How to build a whole life costing framework for knowledge capture and recovery	**(O5)**: To utilise the findings gathered from objective 3 and 4 to develop a knowledge capture and recovery in whole life costing practice (WLCKCR)	Content analysis
(P6): How suitable and efficient is the newly developed framework to the case study organisations?	**(O6):** To validate the framework through academic and construction experts	Questionnaire

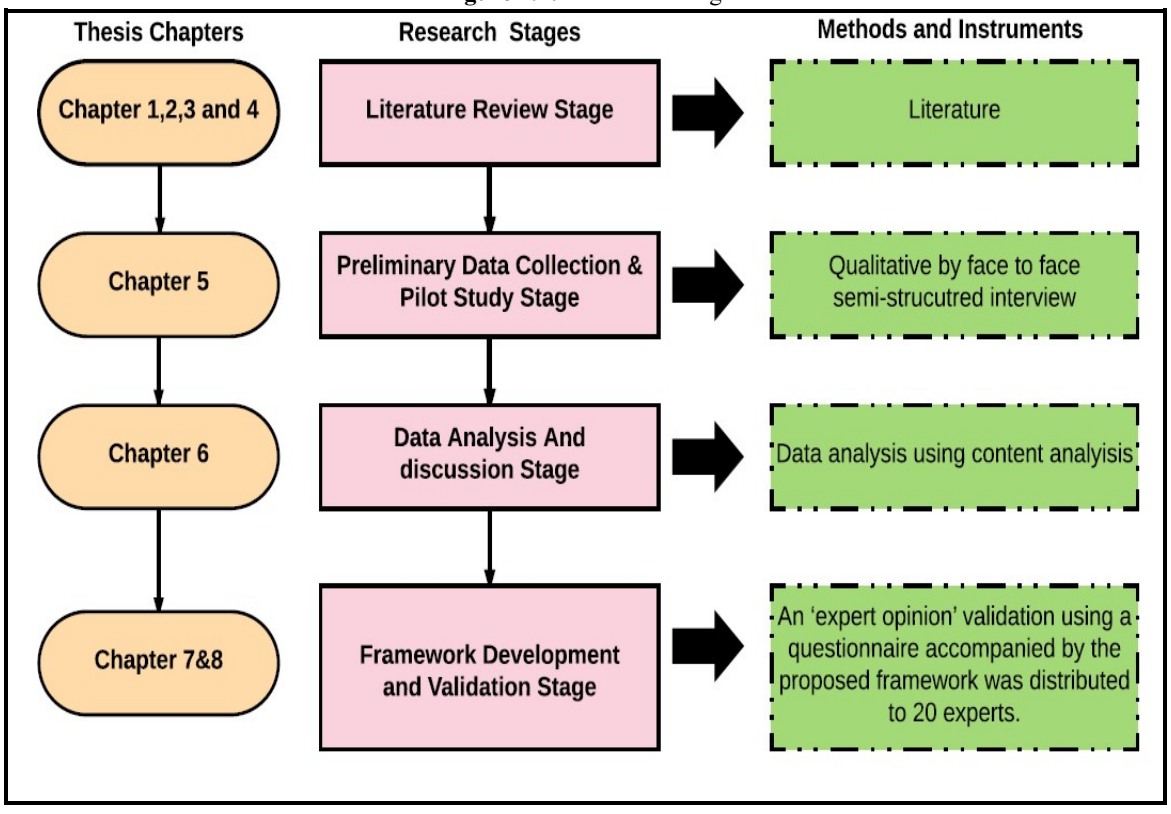
***Key: P**= Proposition, **O**=Objective

1.7 Research Design

The research method is a fundamental prerequisite for successful research. The most essential research methods and the most commonly used in scientific research are the theoretical and practical approaches; although, there are many other scientific methods (Remenyi, 1996). The principal step for the success of research is to choose the appropriate methodology, which in turn depends on the aims of the research and proposition that are to be answered. It is a guide to the researcher to design a suitable approach to gather data and to help analyse this data. Thus, the research is based on qualitative and quantitative techniques.

This research has been undertaken on the basis of developing a conceptual framework for knowledge capture and recovery in whole life costing in construction project. In addition, theoretical approaches are included to review previous research further to practical approaches that are concerned with field work to collect information and data through interviews. The research programme can be classified into four basic stages as seen in Figure 1.1.

Figure 1.1: Research Design



1.8 The Thesis Structure

The thesis consists of eight chapters, as shown in Figure 1.1. A summary of each chapter is summarised as follows:

Chapter 1: Research overview: Chapter one presents the topic and provides a background to the research alongside the problem statement of the research. It also outlines the research aim and objectives as well as the research proposition and their relationship. Finally, the chapter explains the research design and the layout of the thesis.

Chapter 2: A literature review on KM perspectives, tools and techniques: The chapter examines the theoretical fundamentals of knowledge and knowledge management. Firstly, the critical viewpoints, techniques and tools of KM are highlighted and discussed. Secondly, the theories of knowledge capture and recovery in project-based setting and the construction sector considered.

Chapter 3: A literature review on WLC practice: The chapter firstly reviews whole life costing practice alongside it processes. Secondly, it presents a summary of the energies that have been packed in the models of the construction management processes. Thirdly, describing the existing situation of KM practice in the UK construction sector, and finally, present the key viewpoints to KM in whole life costing in the construction industry.

Chapter 4: Research methodology: This chapter commences by examining the different research philosophies and methodologies that are available and then selects a method for this investigation. The chapter also presents the research design and stages of data collection and clarifies the methodologies utilised in obtaining and analysing that data.

Chapter 5: Interview analysis: This chapter presents and discusses the results achieved from the pilot and main interviews on existing KM practice, alongside the KM techniques and approaches of knowledge capture and recovery in whole life costing and construction of knowledge in advanced practice.

Chapter 6: Framework development: The chapter outlines the formulation of a conceptual framework based on the findings gathered from the pilot and main interviews.

Chapter 7: Validation of a proposed knowledge capture and recovery framework: In this chapter, the validation results gathered from construction and academic experts using questionnaire survey. A few recommendations from the academic and construction experts has been put forward for further research in order to refine the proposed framework are also discussed in this chapter.

Chapter 8: Conclusions and recommendations: The output of the whole research thesis will be recapitulated in this chapter alongside the study findings regarding the study's main aim, objectives and research proposition. It outlines the research limitations. Finally, it concludes with the

presentations of highlights from the research findings and offers recommendations for future studies in the aspect of knowledge capture and recovery.

CHAPTER 2 : LITERATURE REVIEW

"*If knowledge is not put into practice, it does not benefit one.*" ― Muhammad Tahir-ul-Qadri

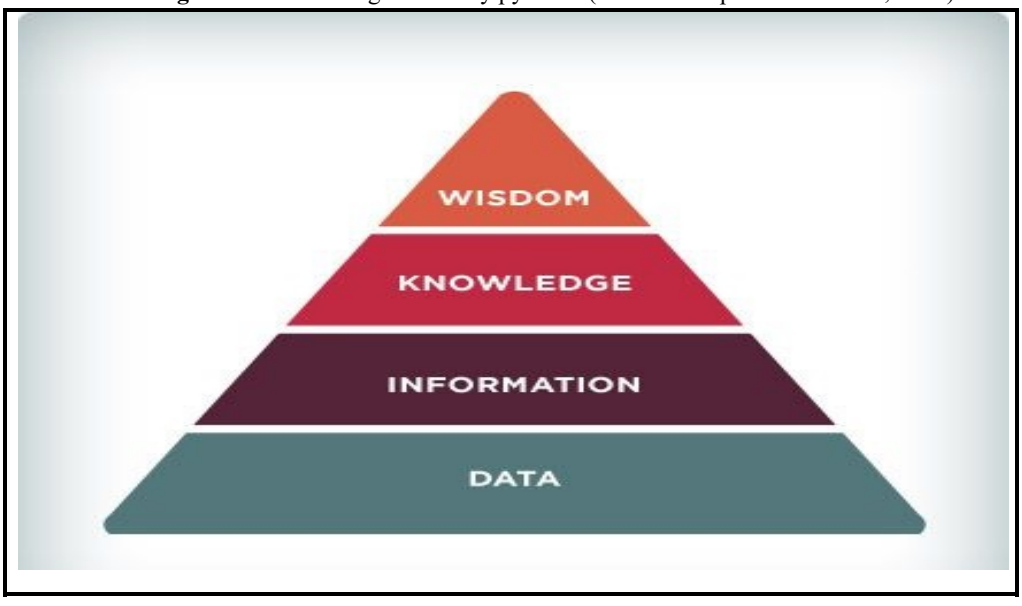
2.1 Introduction

The purpose of this chapter is to provide an in-depth review of knowledge and knowledge management definitions and looking at its tacit and explicit dimensions. It presents the drivers for KM alongside different knowledge dimensions. The chapter further highlights and discusses the major perspectives of KM documented in the literature. The different KM processes, IT tools and techniques are presented.

2.2 Definition of Fundamental Concepts

It is evident in the literature that there is mounting concern regarding the misconception on the use of the terms data, information, and knowledge and wisdom in the KM discipline which are difficult to comprehend (Kalkan, 2008). This misunderstanding arises from interchangeable use of the terms data, information and knowledge to mean the same thing (Melkas & Harmaakorpi, 2008). In order to understand what constitutes KM, it is necessary for one to have a deep understanding of the meaning of knowledge and how it is generated. The knowledge concept will be defined, separated or differentiated and illustrated in this section as well as considering the hierarchical connection between them. In this regard, it is beneficial that consideration is given to the following knowledge hierarchy as shown in Figure 2.1.

Figure 2.1: Knowledge hierarchy pyramid (**Source:** adapted from Tobin, 1996)



The hierarchy of knowledge is often utilised when conceptualising knowledge. The hierarchy epitomises the typical conception of knowledge growth which transforms data into information and

information is transformed into knowledge, which finally advances into wisdom (Hick et al., 2007; Tobin, 1996). As shown in Figure 2.1, each pyramid segment is reliant on the segment below it.

2.2.1 Data

The first phase of the hierarchy is data, which refers to "… a set of discrete, objective facts about events" (Davernport and Prusak, 1998, p. 2) that have not been organised and processed. Within the organisational context, data or facts in their basic form carry no meaning and have little value for managers in an organisation unless one understands the context in which the data were collected. Most organisations capture significant amounts of data in highly structured databases. Business data is valuable if it can be processed properly, including analysing, synthesising and then transforming it into information and knowledge.

2.2.2 Information

The second phase of the hierarchy is information. When data is processed and structured it becomes information. Unlike data, information carries meaning, purpose and relevance to the individual (Ong, 2003). Information can thus be explained as data that has a function and significance that has been placed in context (Hick et al., 2007). The core value of building activity around information is managing the content in a way that makes it easily accessible, reusable and such that users can learn from experiences so that mistakes are not repeated and work is not duplicated (Mohd, 2014). So, within the context of an organisation, this organised data is advantageous with the intent of analysing and solving problems.

2.2.3 Knowledge

Knowledge is the third hierarchy segment on the pyramid, which is reliant on information. Knowledge comes into existence when a person obtained information with understanding and applied it in context. Knowledge emerges from information when the values and beliefs of people are incorporated for the purpose of comparison, experiences, making decisions, judgements and communication (Davenport and Prusak, 1998). Hence, one could term knowledge to be applied information, which refers to the result of processed information (Minnar and Bekker, 2005, p.106). Knowledge has a superior meaning, as it is the product of an expert's work experience. Therefore, it requires a higher understanding when equated with information (Lehaney et al., 2004). The existence of knowledge is because of societal dealings between organisations and individuals. Hick et al., (2007) suggested that knowledge has to be contextualised mixed with a comprehension of how to use it, and if it is not contextualised, it will be regarded as mere information.

2.2.4 Wisdom

The fourth phase of the hierarchy constitutes wisdom. Wisdom, according to Lundvall and Nielsen (2007), is assumed to create a better understanding and ethical basis for action. It is sometimes added to the top of the data-information-knowledge hierarchy (Ackoff, 1989), but its appearance is less

widespread in the literature. From the discussion above, it can be inferred that knowledge is fundamentally different from data, information and wisdom. Data, information, knowledge and wisdom in combination are essential to organisations. As data and information are carriers of knowledge, it seems appropriate to regard knowledge as a major production factor for organisations (Zeleny, 1989). According to Boersma and Stegwee, (1996), the availability of data and information does not necessarily alter the organisation's behaviour or competitiveness. The knowledge needed to interpret the information and to act upon it is the key to organisational success (Boersma and Stegwee, 1996). For this reason, it has to be managed.

2.2.5 Knowledge Definition

Despite the discrepancy between the terms that form the knowledge pyramid in Figure 2.1, several scholars have been able to establish a definition of knowledge. According to De Long and Fahey, (2000), the outcome of people's reflection and experience can be termed as knowledge. While Alavi and Leidner, (2001), define knowledge as the process of human reasoning which brings about an influx of new stimuli. For Van der Spek and Spiljkeet (1997), knowledge is a whole set of procedures, experiences, and insights which are perceived to be genuine and correct which then direct the behaviour, thought and communication of individuals. While, Bhatt (2001), considers knowledge as meaningful information. Knowledge can be regarded as a mix of well-organised data which can be assimilated with procedures, rules set, work learning through practising, and experience. Apparently, knowledge is meaningful evolving from the human mind. Therefore, the knowledge that is not contextualised is meaningless and can be classed as information. A more distinct clarification by Davenport and Prusak (1998) that defines knowledge definition as:

> "*A fluid mix of framed experiences, values, contextual information and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowers. In many organisations today, the knowledge concept is often embedded not only in documents or repositories but also in organisational routines, processes, practices, and norms" (p.5)*

A theory proposition for describing organisational knowledge creation by Nonaka and Takeuchi (1995 p.21) describe knowledge as "justified true belief" to mirror the knowledge context which exists.

The definition of knowledge suggested by Probst et al., (2000 p. 24) will be adopted in this study which states that:

> *"...knowledge is the whole body of reasoning and skill which individuals utilise in problem-solving. It includes both theories and practical ways of doing things, standard rules and instruction for action. Based on data and information but unlike these, it is always bound to (a) person. Structured by individuals and epitomises their beliefs about causal relationships".*

This knowledge definition adopted is reliant on the fact that it is in agreement with the definition presented by many writers (Bhatt, 2001; Van der Spek and Spiljkeet, 1997; Nonaka and Takeuchi, 1995). **Diverse types of knowledge** (Source: **adapted from Alavi and Leidner, 2001)**

Table 2.1: Diverse types of knowledge

Author	Knowledge Classification	Definition
Alavi & Leidner (2001); DeLong & Fahey (2000)	Individual	Created by and inherent in the individual
	Social	Created by and inherent in collective actions of a group
Hislop (2005); McKenzie & Van WinKelen (2004); Alavi & Leidner (2001); Nonaka & Takeuchi, (1995)	Tacit	Knowledge is rooted in actions, experience, and involvement in specific context
	Cognitive tacit	Mental models
	Technical tacit	Know-how applicable to specific work
	Explicit	Articulated, generalised knowledge
Hansen et al (1999)	Codified	Available in written documents and manuals, procedures
	Non-codified	Acquired through experience
McJenzie & Van Winkelen (2004); Alavi & Leidner (2001); Zack (1999)	Declarative	Know-about
	Procedural	Know-how
	Causal	Know-why
	Conditional	Know-when
	Relational	Know-with
McJenzie & Van Winkelen (2004); Blackler (1995	Endbrain	Conceptual skills and abilities
	Embodied	Acquired by doing
	Encultured	Acquired through socialisation
	Embedded	Organisational routine
	Encoded	Sign and symbols

*(Adapted from Alavi and Leidner, 2001)

Knowledge is viewed from five distinct classifications by Zack (1999): declarative knowledge (know-about), procedural knowledge (know-how), causal knowledge (know-why), conditional knowledge (know when) and relational knowledge (know-with). The knowledge framework by Blackler's (1995) avoided the inconsistent character of knowledge (Snowden, 2003) by deploying new conventional thought regarding the location of the knowledge (i.e. knowledge that is embedded in individual brains, routine symbols and dialogue). Blackler, (1995) recommends the five-diverse classification of knowledge: "embrained" (obtained through conceptual skills and abilities); "embodied" (achieved by doing); "encultured" (achieved by socialisation); "embedded" (acquired from routines in organisations) and "encoded" (acquired from sign and symbols). Two knowledge classifications were suggested by Hensen et al. (1999): codified (obtainable from manuals and inscribed reports) and non-codified (obtainable via work experience).

Three kinds of project knowledge were identified within the construction project context by Kasvi et al., (2003):

- **Technical knowledge**: This has to do with the product, its components and technologies.
- **Procedural knowledge**: This has to do with the production and product utilisation and actions in a project.
- **Organisational knowledge**: This aspect deals with collaboration and communication.

Another broad perspective suggested by Mead, (1997), that construction project knowledge can be classed into four general categories: design, financial information, project and management. Tserng and Lin (2004) divided project knowledge, based on the nature of knowledge, into tacit and explicit knowledge. Lin et al., (2005) describes tacit knowledge as experience and expertise embedded in the heads of the construction professionals, the culture of the firm, from lessons learned and know-how, and other abstract sources. Explicit knowledge refers to documented material such as cost reports, project information, specifications, design drawings, risk analysis results, journals, articles, books, website pages, databases, intranets, notes, emails, graphic representations, or audio and visual materials and other information that is collected, stored, and archived, in paper or electronic format (Abu Bakar et al., 2016). On the other hand, Lin et al., (2005) describe tacit knowledge as experience and expertise embedded in the heads of the construction professionals, the culture of the firm, from lessons learned and know-how, and other abstract sources. In some way, as long as a similar idea of explicit and tacit knowledge. Nevertheless, other terms were used as substitutes such as team contract and project plan:

- **Project plan**: This is regarded as a repository for hard knowledge project which comprises project activities, definition, and results
- **Team contract**: this consists of the knowledge from an organisation, such as lesson capitalisation and experience

There is an absence of studies which explore the manner in which knowledge is classified in the knowledge repository. A study by Millie Kwan and Balasubramanian, (2003) demonstrated that the majority of the available knowledge repositories are characterised by the area of discipline, such as risk, cost planning and procurement. In another project knowledge classification by Tserng and Lin, (2004), it is based on project activities.

2.3 Knowledge Management: Definition and Description

Knowledge management was introduced in the 1990s to assist organisations create, share, and utilise knowledge systematically (Abu Bakar et al., 2016). KM could refer to different things to different people, and no single definition of KM is universally accepted (Abu Bakar et al., 2016). There is a continuous pursuit amongst researchers to find a precise meaning of knowledge management which has resulted in the absence of agreement on the definition of knowledge management (Mohd Zin, 2014; Haggie and Kingston, 2003). As stated by Ives et al., (1998) who described knowledge

management as a developing practice, there are numerous variations of defining knowledge management and how it could be utilised effectively. KM is viewed as a tool that has the capabilities of translating and employing explicit and tacit knowledge so it can be beneficial to projects and the organisation at large. There is a need for organisations to have a better comprehension of the roles of KM in order to attain a first-class rating (Abu Bakar et al., 2016). The utilisation of KM in an organisation is deemed a vital asset for the development of the organisation (Dixon, 2004; Pentland, 1995).

Many writers such as (Pathirage et al., 2007; Stewart, 2007; Yahya and Goh, 2002; Barrett and Sexton, 1999) in the field of KM are of the view that the complexity following the KM definition of knowledge management is to some extent attributed to the problem in identifying knowledge itself. For this reason, defining KM is complicated, as a different perspective of KM can yield different meanings and dimensions (Yahya and Goh, 2002). The different definitions below give an example of the multiple perspectives on KM drawn from the literature.

A definition by Webb, (1998) views KM as the identification, active management and optimisation, of intellectual assets that enhance productivity, creates value, increases gain and sustain a competitive edge. Yang (2007) also defined it as the process of identifying or creating, assimilating, and applying knowledge from an organisation to exploit new opportunities and boost performance. Gold et al., (2001) define KM as structured coordination to manage knowledge effectively. KM is a subject that aims to enhance individual and organisational performance by maintaining and leveraging the present and future value of knowledge assets (Newman & Conrad, 2000). Any practice or process of creating, acquiring, capturing, sharing and using knowledge anywhere it resides has the aim of improving organisational learning and performance (Scarborough et al., 1999). KM is a method that adds or creates value by actively leveraging the know-how, experience, and judgement resident internally, in many cases, in an organisation externally (Ruggles, 1998). KM is a process of capturing an organisation's collective expertise wherever it resides in databases, on paper or embedded in the heads of individuals and distributing it to wherever it can assist generate the biggest payoff (Hibbard, 1997). KM is a systematic, explicit, and deliberate building, renewal, and application of knowledge to maximise an enterprise's knowledge-related effectiveness and returns from its knowledge assets (Wiig, 1997).

The various definitions of KM documented in the literature are a result the various inclinations of scholars on the subject matter of knowledge management (Carrillo, 2004; Egbu, 2004). However, a critical review of literature uncovers that some KM definitions concentrate on the goal (objective) of utilizing knowledge such as "value creation" (Ruggles, 1998) and "to accomplish the purpose of the organisation" (Mackintosh, 1996), in contrast to a process approach (Scarborough et al., 1999).

The definition by Hibbard, (1997) and Wiig, (1997) is mainly about making collective organisational information and experience available to the individual, and the project team to utilise in projects, encourage collaboration and empower project individuals to improve the way their work is carried out continuously. KM can be viewed as a discipline that can be integrated with the aim of improving individual and organisational performance while maintaining and leveraging the present and future value of knowledge assets of an organisation (Newman and Conrad, 2000). It underlines the significance of integrating individual and collective knowledge in considering what KM means.

Many scholars in the discipline of KM have concentrated on specific activities and processes within KM (Scarborough et al., 1999; Quintas et al., 1997). An example, is the introduction of KM by Scarborough et al., (1999: P.1) as "*Any practice or process of creating, acquiring, capturing, sharing and using knowledge anywhere it resides, with the aim to improve organisational learning and performance".* The definition by Quintas et al., (1997) views KM as a process of contentious management of all kinds of knowledge in order to meet present and future requirements, to identify and exploit current and acquired knowledge assets and build new prospects.

Although several definitions of KM are used by scholars in the KM discipline, they concur that a KM definition uncovers a fundamental aspect of how KM activities or strategies should be structured in order to manage the processes of knowledge or enhance KM related activities within organisations. This implies the aim and approaches of KM ought to reflect those of the organisation (Kim et al., 2003). Remembering that, an operational definition has been constructed for this study. It is proposed that *"KM can be defined as a combination of different processes, supportive procedures, technologies and the discipline of research required to bring about an environment that is sustainable, allowing knowledge to be distinguished and exploited for performance improvement of an organisation".*

2.4 Knowledge Management Drivers

Knowledge management acts as a key enabler and primary managerial component for successful organisations (Flaqi, 2011). According to Drucker, (2011), knowledge is a major cost centre and a central capital which is an essential resource for an economy. Flaqi, (2011) and DiMattia and Oder, (1997) ascribe the growing consideration given to KM to two major moves: innovative advancement and economising (laying-off). Laying-off refers to reducing the number of workers for the sake of profit increment (Flaqi, 2011). When workers are made redundant, the organisations become short of some knowledge (knowledge waste).

Rapid developing attentiveness to the management of knowledge by governments, companies, and academicians, has prompted Sanchez, (2001) to enquire the reason for KM becoming a central concern. Should it turn into a fundamental expertise of a current manager? To answer this question, the following KM drivers were identified by Qunitas, (2005):

- Wealth is being increasingly and demonstrably created from intangible assets and knowledge,

- Organisational knowledge focuses more on individuals,
- The increasing change in innovation, business markets, and competition, making continuous learning importance are embedded in KM,
- Innovation is acknowledged as crucial to competitiveness, and is dependent on creating and applying knowledge and
- The restrictions of ICT, and potentials of communications and knowledge technologies

Other reasons for justifying the need for KM as put forward by Jennex, (2008):

> "*KM is necessary because organisations need a formal strategy in identifying, capturing, storing and recovering knowledge. KM processes are required to assist organisations to deal with the shift in storage strategy. KM is necessary to support organisation deal with the transience of knowledge workers. KM processes are required to help organisations manage a glut of knowledge. Ultimately, knowledge management is needed to help organisations to make sense of what they know, to know what they know, and to effectively use what they know"* (p.4).

In research conducted by Wijnhoven, (2006) three sources that enrich and nourish KM practice are;

- Academics and suppliers of information technology in the KM discipline have designed frameworks/models which support the creation and reuse of knowledge.
- Experts, organisations and academics have also perceived the need for an educationally challenging profession and for using the opportunities of a progressively highly educated workforce in modern societies.
- Intellectual capabilities have been considered the best source for maintaining a competitive edge in a global economy.

In summary, "the need for sharing knowledge has not changed, however the working environment has" (BSI 2003). Moreover, the future may witness more need for knowledge management as rapid change is expected to continue in working environments.

2.5 Knowledge Management Processes

KM processes comprise sets of approaches and activities employed in managing or structuring knowledge (Falqi, 2011). It is contended that they can naturally occur independently in an organisation without the existence of any formal strategy of managing knowledge (Supyuenyong et al., 2009). The literature contains several descriptions of the activities and processes of KM (Lytras et al., 2002; Egbu et al., 2001; Scarbrough et al., 1999; Van Burren, 1999), no one seems to have gained a consensus yet. However, amongst the best known are those of Wiig, (1993); van der Spek & Spijkervet, (1995);

Holsapple & Joshi, (2000) and Egbu et al., (2001). Each of these presents a slightly different focus within the process viewpoint.

These processes are epitomised adopting different terminology by the various scholars. The term knowledge creation is often interchanged with knowledge acquisition, while some writers view knowledge application as knowledge use or knowledge exploitation (Umar, 2016). For the purpose of the research, only the processes of knowledge capture and recovery are underlined while the maintenance of knowledge is highlighted. There are many other descriptions of the KM process with either similar or different viewpoints. For the purposes of this study, a similar view to that of Tserng and Lin (2004) was adopted. The five primary processes of KM mentioned by Tserng and Lin (2004) are the base on which this study is driven.

2.5.1 Knowledge Creation

Knowledge creation refers to the process by which knowledge objects are improved with specific metadata so it can be reused (Lytras et al., 2002). It is the ability of a strategic organisation to originate and bring into existence new knowledge repeatedly and continuously in a circular process with no ultimate end (Egbu et al., 2001; Storey and Quintas, 2001). The creation of knowledge has to do with the discovery and generation of new knowledge which consists of activities such as gaining, combining, and adapting existing knowledge. Adding value to knowledge gives room for knowledge object exploitation via learning processes. An organisation cannot by itself create knowledge. Therefore, the creation of knowledge in organisations should be considered as a process where the created knowledge is strengthened and crystallised and used as part of the knowledge network of the organisation (Takeuchi and Nonaka, 1998).

The processes of conveying a building project can be considered as part of product advancement. As product advancement is described by Rozenfeld and Eversheim, (2002) as a vital process of creating knowledge. Creating knowledge involves developing, enhancing or modifying existing content, or creating new content, within the organisation's body of knowledge (Pentland, 1995). Nonaka and Tekeuch, (1995), expressed that the new knowledge created could either be tacit or explicit which is developed through the means of interacting with groups and individuals within given organisations. This highlights how important collaboration between members of a team can be on a construction project for new knowledge creation. Nevertheless, the need for specific context has been emphasised by Suchman (1987), if knowledge is to be created. Moreover, interaction and collaboration between and amongst the members of the project team is not just necessary but also takes place over the project span. However, the space of developing relationships can be virtual or physical (Nonaka and Takeuchi 1995). In the context of a construction project; emails, groupware, electronic forums can be grouped as virtual spaces (Falqi, 2011). As reported by Horvath et al. (1996), who considered the project team as fertile ground for the creation of knowledge because there is an established interaction and links between external parties and the project team members involved in the project.

Every construction project bring to the table a substantial amount of newly created knowledge which is embedded in the heads of project members which has not yet been captured and converted into explicit knowledge for future use (Falqi, 2011). Regarding both communication technology (ICT) and information, it was uncovered by Berente et al., (2010) that projects which involve joint ICT tools ingrained in practice are conceivably going to entail not as much regular physical contact throughout the knowledge creation process hence, a significant amount of information pooling.

2.5.2 Knowledge Capture

Egan (2004) argues that there is no point wasting money and time in reinventing the wheel of current best practice in construction projects. Construction projects are viewed as being extremely knowledge intensive (Hari et al., 2005; Woo et al., 2004), and knowledge creation still occurs. The new knowledge created is embedded in the heads of project members. Acknowledging that organisations members participating in the project are carriers of the new knowledge, it is vital that they are encouraged and inspired to capture the knowledge.

There is a difference between the term knowledge capture and knowledge access. Becerra-Fernandez and Sabherwal define knowledge capture, (2006: p. 235) "*as the process of eliciting knowledge that exists within people, artefacts, or organisational entities, and showcasing it electronically in the form of a knowledge-based system for later reuse or recovered".* Knowledge access, on the other hand, involves permitting approved individuals to read, keep up to date, transfer and copy the knowledge that has already been codified appropriately and swiftly (Schwartz, 2006). Furthermore, knowledge recovery recalls previous experiences that are relevant in order to enhance the way decisions are made (Niu et al. 2009). Effectively applying strategies for capturing knowledge can be regarded as *"turning individual knowledge into corporate knowledge that can extensively be shared and legitimately adopted throughout the firm in order to have a competitive edge"*(Hari et al., 2005: p. 535-36).

Practically, the knowledge that is newly captured is restricted to formal knowledge (e.g. documents). Informal knowledge, for instance, the interaction between members in the project or justifications behind choices or decisions, is often misplaced. A successful KM approach is dependent on technologies and mechanisms that assist the conversion of tacit knowledge into explicit knowledge or explicit knowledge conversion to tacit knowledge and stored in the form of rules, procedures and instructions Falqi, (2011).

It is evident in the body of literature that most knowledge in an organisation is embedded in processes, routines, IT and that which also remains in the heads of members of an organisation can hardly be replicated as tacit knowledge captured without losing some of its content. The explicit side of knowledge can only be captured by knowledge repositories (Falqi, 2011). Therefore, some portion of project knowledge can be captured and utilised successfully and more efficiently. Nevertheless, in order for the approach to knowledge capture to be effective, the exercise of knowledge capture is not

to be carried out once. It should be an exercise that requires being invested in, and it needs to be considered continuously over a considerable time frame (Hari et al. 2005). According to Zack, (1991), explicit KM uses primary resources:

- Explicit knowledge repositories;
- Factories for gathering, filtering, managing, and distributing that knowledge;
- The role of the organisation is to carry out and manage the filtering process; and
- IT to support those processes and repositories.

It is evident in the literature of KM discipline that a number of appropriate methods and techniques abound for knowledge capture in the construction of projects. These include post project review (Tan et al., 2005; Orange et al. 1999), CoP (Anumba et al., 2005a), storytelling, manuals and information system tools (Shapiro, 1999).

Literature has documented several perspectives on the processes of knowledge capture (Falqi, 2011). Phillips-Wren and Jain, (2005) have identified five knowledge capturing processes: identification, conceptualization, formalisation, implementation and testing. Another congruous perspective by Hari et al., (2005) is the seven knowledge capturing processes identified which include: recognise, examine, implement, filter, bank, disseminate and update knowledge. Nevertheless, the two knowledge capturing process approaches which interfere with the other processes of KM are knowledge dissemination and application. Dissimilar approaches viewed and suggested by Gruber and Russell, (1991) in knowledge capture are eliciting, recording, and organising knowledge in the project. Though this approach differentiates between knowledge capture and the processes of KM. It does ignore the processes of identifying the desired knowledge which is considered a vital part of knowledge capture (Falqi, 2011).

2.5.3 Knowledge Codification

Knowledge codification is perceived to be one of the most significant and challenging methods in KM discipline. According to April et al., (2004: p91) knowledge codification refers to *"the process of knowledge transformation into an applicable and accessible format".* It is considered a way of getting knowledge into "several forms that can be leveraged and transferred" (Ruggles, 1997b: p 6). The required information for designing a project knowledge map is often in existence in firms, but it is usually in an undocumented and fragmented form (Falqi, 2011). Every worker in the company has a little piece of the map in their head (Davenport and Prusak, 1997). In the construction project context, the purpose for codifying knowledge has to do with presenting the knowledge in an accessible form to every individual of the project team so that it can be utilised when required. Every piece of knowledge can be codified. However, it is vital to underline the relevant knowledge for codification because codifying any and every kind of knowledge could result in information overload which can make knowledge recovery difficult. Simon, (1978: p.13) stated that: *"In a world where attention is a*

significant scarce resource, information may be an expensive luxury, for it may turn our attention from what is important to what is unimportant".

2.5.4 Knowledge Dissemination and Sharing

According to Alavi & Leidner, (2001), another form of passing on knowledge is by sharing. Knowledge sharing from the creator of the knowledge is usually placed in the knowledge repository of an organisation from where it can be disseminated. Placing acquired and documented experience into an organisational repository is an example of knowledge sharing (King et al., 2008). Knowledge sharing refers to the activities involving knowledge dissemination and distribution via specific media. It can occur at various levels such as; individual level, groups, organisations or inter-organisational level and the connections between them are reciprocal. Knowledge sharing can happen explicitly or implicitly (Argote & Ingram, 2000). Knowledge sharing occurs explicitly when, for example, a unit communicates with another unit about a practice that has been found to improve performance. Knowledge sharing can also occur implicitly without the recipient unit being able to articulate the knowledge it has attained. Seventy to eighty percent (70% - 80%) of knowledge available in organisations is transferred through a network of people whereby chatting, conversations, luncheons and other means are used (Davenport & Prusak, 1998). Apprenticeship and tutoring also serve a great purpose in sharing (Nonaka & Takeuchi, 1995).

2.5.5 Knowledge Recovery

For more than 3000 years, Information has been structured for future recovery and use (Falqi, 2011). An example of information structuring for future recovery and use is the table of content of a textbook or a report (Baeza-Yates and Ribeiro-Neto, 1999). After the creation, capture and storage of knowledge, it will be made accessible for project members to utilise while involved in a project. The ideas that are:

- Non-codification of organisational knowledge (Polanyi, 1966),
- Lessons learnt in the course of the project are often overlooked by the project team members (Darr et al.,1995), and
- Knowledge is regarded as a vital resource that enables an organisation to gain a competitive edge as Etzioni, (1964) pointed out. This has prompted many firms to capture relevant knowledge so it can be recovered when needed.

An effective approach for knowledge recovery can assist in a better comprehension of knowledge assets and enable members within the organisation to quickly locate the knowledge required (Falqi, 2011). Several tools have been designed for the enhancement of a knowledge recovery approach. These tools comprise expertise or user profile document classification also known as automatic clustering, and search engines (Geo and Kokossis, 2004). It can be argued that the two main approaches to knowledge recovery are navigating and searching (Rollett, 2012). Nevertheless, the success of the two approaches is solely dependent on the knowledge structure and classification.

2.6 Knowledge Base

In the construction industry of today, many construction organisations are practising knowledge capture, but are constrained in their dealing with the archives of paper documents (Falqi, 2011). Organisations that utilise information technology (IT) in capturing knowledge digitally are employing folders and documents, which make it hard to navigate and explore (Fruchter & Demian, 2005). The absence of a suitable framework is one of the major obstacles to the effective implementation of KM initiative in construction projects (Ajmal et al., 2010). The management of the project and organisational memories can be improved by effective utilisation of information technologies (Alavi & Leidner, 2001). The reason behind the design and implementation project base system in an organisation is to store the project knowledge captured so that project team members can recover it during the span of the project. The project based system is faced with the dilemma of having the capacity to collect the created knowledge in an on-going project process, sorting out and storing such learning, and after that distributing it to individuals from the project who may find it beneficial (Grant, 2000). It is important to consider two issues when utilising the project based system these are; a knowledge bank which can only be utilised to capture the aspect of explicit knowledge (Falqi, 2011). Therefore, some part of knowledge from the project can be captured effectively and utilised adequately. Nevertheless, the human head still retains a large part of this knowledge. The second issue is that an enormous amount of knowledge is captured by organisations which no one takes a look at (Wenger, 2000).

Ontology viewed as the specification of discourse in a shared vocabulary form is considered another factor that can influence the implementation of an effective knowledge-based system. It gives a structure to the way the knowledge based system is to be developed. At the peak level, the knowledge base components are determined by ontology and regulate the models in a specific component at the lower level (O'leary, 1999). A knowledge-based system consists of several components such as yellow pages (Davenport et al., 1999), which provides details regarding members in the firm and their area of expertise and contact details. File management is another knowledge base system component (Bowman, 2002), which assists in sorting and storing knowledge online (Falqi, 2011). Another tool identified by Alavi and Leidner, (2001) is the online discussion board which assist in knowledge sharing, disseminating and capturing. Messaging (email) clients are likewise viewed as a tool in the KM discipline which can be used for communication and storage of project correspondence (Woo et al., 2004).

2.7 Cultural and Organisational Influence

It evident that social interaction can result in the creation of knowledge (Alavi and Leidner, 2001) and has prompted several pieces of research to be conducted into the cultural and organisational impact as they are seen to be influential in the successful implementation of KM. The social capital of KM is

emphasised in this study as it is acknowledged as "goodwill that is engendered by the fabric of social relations, and that can be mobilised to facilitate action" (Adler and Kwon, 2002: p.17).

- To enhance social capital, three crucial indicators were suggested by Davenport et al., (1999) namely;
- Individuals must have a positive orientation to knowledge
- Individuals should not be reluctant to share knowledge and
- The KM project should suit with the present culture

A study conducted by Styhre et al., (2004) regarding learning capabilities demonstrates that in a construction project context, organisational learning is dependent on face-to-face interaction, learning by doing rather than formal and technical systems and community of practice. The emphasis should be concentrated on the management and the project team who are carriers of the knowledge from projects (Kamara et al., 2002). Due to the fact that the carriers of knowledge are one of the two primary essentials of KM, it is vital that they are motivated to share project knowledge (Bresnen et al., 2003). Extrinsic and intrinsic motivational factors are expressed in a study by Jone et al., (2011) which can positively provoke positive behaviour towards sharing knowledge, nonetheless intrinsic motivational factors were found to be more influential.

Implementing KM effectively is also dependent on various factors such as, leadership (Ajmal et al. 2009; Egbu et al., 2001b), culture (Lindner and Wald, 2011; Ajmal et al., 2009; Egbu et al., 2001b), people, the structure of the organisation, the environment (Egbu et al. 2001b), technology, and finance (Egbu et al., 2005), as well as incentives (Ajmal et al., 2010), processes, practice and social patterns, that outline the value of executing a community-based approach (Bresnen et al., 2003). However, the support from management and the right culture are identified as the key factors influencing the processes of knowledge capture, knowledge dissemination and knowledge recovery in a project setting (Suresh and Egbu, 2006). Managing knowledge in the project is not an easy task because it deals with the integration of complex social processes (Egbu et al., 2005).

2.8 Project Review (PR)

A project review (PR) is viewed as a suitable and popular technique utilised in the capturing of knowledge in projects (Tan et al., 2005 and Orange et al., 1999). PR mostly emphasises the project activity assessment (Falqi, 2011). It is carried out after the key phases of a project, where lessons learned are collected at the conclusion of the project. Also, it is conducted only once after the completion of the project. According to Falqi (2011), the process-based method deals with information of how good or how poor the performance is regarding time cost and quality.

Research studies have highlighted four distinct types of PR which are; post project review (PPR), project completion review (PCR) and project post-mortem (PPM) (Falqi, 2011). PR is usually

conducted after the project is completed or sometimes two years afterwards. According to Von Zedtwitz, (2002), PPR allows a systematic performance improvement in subsequent projects through the knowledge capturing process in organisations. The writers documented definition of PPR is "the final formal review during a project that examines any lessons that may be learned and used to the benefit of future projects" (Von Zedtwitz, 2002, p. 256). PPR includes the input from individuals in the project team and external project participants, such as specialists and contractors. PPR is in the form of a survey disseminated to participants in the project and commenced before the project is reviewed, or in some cases, it takes the form of checklists (DIR, 2003; Bolles, 2002; Von Zedtwitz, 2002). The aim of PPR is to collectively evaluate the parts of the project the project participants were involved in and to enable dialogue during a PPR meeting. The primary objective is to serve as a continuous learning tool within the organisation in order to support the organisation's competitive advantage (Von Zedtwitz, 2002). Four main components that are contained in PPR were identified by CIOB, (1998) namely; performance study, project audit, the human resources aspect, cost and time study. Lesson learned are also considered and documented in a lesson learned report.

The review is done by a PR unit outside the organisation or by a group called Project homework (Flaqi, (2011); Garvin, (1993); Gulliver (1987)).

Project evaluation is considered another type of PR which is identified as an on-going check of how well the project is performing. These reviews are done at key decision points and major gateways. The performance shown in the project evaluation falls within the project team and the facility being developed concerning the needed advantages (OGC 2003a). The aim of the project evaluation in the PPR is to obtain project knowledge to enhance future project performance. The method is normally carried out through close and personal meetings which are then codified in the form of a report.

The third kind of PR is the post-implementation review (PIR). Organisations are beginning to recognise the growing importance of the knowledge attained during project execution due to the competitive edge it provides (Brady and Davies, 2004). By learning from prior experiences, organisations can spot and correct errors made previously (Torres and Gati, 2011; Argyris, 1977). The motive for carrying out PIR is to evaluate the quality of the project execution product.

In contrast, scholars, such as OGC, (2003a) and Frigenti and Comninos (2002), pinpointed that PIR is initiated with the aim of recognising lessons learned from the project experience alongside measuring the performance quality of the project. Westland (2007) in agreement with (OGC, 2003; Friganti and Comninos, 2002) identified the content of PIR documents which includes:

- An evaluation of the project's performance against its pre-determined objectives, scope, deliverables, schedule, expense and resource targets identified during project initiation and planning phases;

- An analysis of project accomplishments and failure and lessons learned and recommendation for future projects.

The PIR is initiated only at the end of the project closure phase, once the project closure report has been approved and all project closure activities completed (Westland, 2007).

The fourth type of PR is the after-action review (AAR) which was initially designed to deal with learning by the US Army in the 1970s (Falqi, 2011). The purpose of its adoption was to stimulate knowledge from combat drills workout (Sheehan et al., 2005). AAR is carried out over the span of the project after each decision stage, in the form of discussion. A facilitator ought to be appointed to complete these reviews and all individuals from the project team ought to contribute to the debate. The discussion covers the responses to inquiries, for example, what is supposed to happen? What happened? Why were there differences? What is more, would one be able to gain from this experience? The codification of this review is done in the form of flip charts (Schindler and Eppler, 2003; Ozorhon et al., 2005). A study conducted by Schindler & Eppler, (2003) differentiated four types of interview methods in projects. Table 2.3 indicates a comprehensive practice of those techniques.

Another study by Orange et al. (1999) identified two major categories for project processes review as follows:

Programmed Review

- Post completion, leading to a review where the scope encompasses the construction project as a whole.
- Stage completion, scoped for a particular stage of the construction process.
- Time based (e.g. period end, monthly)

Non-programmed Review

- Issue resolution, necessitating a review to address a particular problem of high priority, for example, running late or over budget or, perhaps, a technical difficulty.
- Innovation, where a team has been innovative, either in process or use of materials, this experience should not be lost.

Table 2.2: Process-based method to learn from experience (**Source:** Adapted from Schindler and Eppler, 2003)

Parameters	Method			
	Project Review/Project Audit	**Post control**	**Post-Project Appraisal**	**After Action Review**
Time of execution	After project completion or in the course of the project during individual project phases	Exclusively at project 's end	Approximately two years after project completion	During work process
Carried out by	Review: moderators respectively Auditor Audit: project-external people	Project manager	External post-project appraisal unit (a manager and four assistants), project homework group	Facilitator
Participants	Project team and third parties that are involved in the project	Project manager (inclusion of project team not neglected)	Project team and third parties that are involved in the project	Project team
Purpose	Status classification, early recognition of possible hazards, team-internal focus	Serves as delimitation/in addition to a more formal project end that focuses on the sole improvement of future projects goal conformity	Learning from mistakes, knowledge transfer to third parties	Learning from mistakes, knowledge transfer inside the team
Benefits	Improvement of team discipline, prevention of weak points and validation of strategies	Result is a formal document, which considers the ranges of aims of the project, quantitative goals, milestones, checkpoints and budget goals and contains an evaluation of the project result as well as a recommendation for future improvements	Best practice generation for large- scale projects, improvement of forecasts and proposals	Immediate reflection of the own doings to improve future actions
Interaction mode	Face to face meetings	Non-cooperative form of recording experiences, analysis of existing project status reports, milestones, checkpoints and budget targets are being compared in order	Document analysis, face-to-face-meetings	Cooperative team meeting
Codification	Partly in reports, usually no predefined circulation with knowledge transfer as a primary goal (excluding predefined distribution lists)	Partly in reports, usually no predefined circulation with knowledge transfer as a primary purpose (excluding predefined distribution lists)	Booklets as well as personalised	Flip charts

2.9 KM Tools and Techniques

KM tools and techniques form part of KM which is used alongside strategies, processes and methodologies (Liebowitz, 1999). KM is supported by several tools that assist in the facilitation of KM implementation. Such tools include external knowledge sources, knowledge recording/codification, training, research collaboration, PR, discussion group, knowledge manager, knowledge team, apprenticeship, mentoring, storyboards (Tan et al. 2005). This study does not try to cover each of the KM tools and techniques in detail due to an extensive amount existing in diverse KM sub-processes (Tsui, 2002; Al-Ghassani, 2002; Rezgui, 2001; Gallupe, 2001; Laudon and Laudon, 2000; Wensley, 2000; Jackson, 1998; Ruggles, 1997). The following section discusses the KM tools and techniques related and vital to knowledge capture and recovery.

2.10 Communities of Practice (CoP)

Communities of practice (CoP) refers to a group of individuals with a common interest that, while they may work for different business units (Carrillo, 2004), provide an environment where common sense can be achieved (Hasanali et al., 2002; Wenger, 1998; Argyris et al., 1985). CoP comprises individuals coming together informally bound together by shared expertise and a passion for a joint enterprise (Wenger & Snyder, 2000). In modern society, CoP has gain popularity online in the form of online forums, blog, Facebook (Falqi, 2011).

2.11 Mentoring

Mentoring is considered beneficial to organisations because it allows the transfer of knowledge from experts to protégée, particularly, tacit knowledge transfer which is hard to transfer (Swap et al., 2001). Mentoring assists in cross-departmental communication and organisational learning (Singh et al., 2002; Merono-Cerdan et al., 2007).

2.12 Apprenticeship

Apprenticeship means “young trainees working alongside the old master craftsmen, in so doing obtaining technical skills through imitation, observation and practice (Nonaka et al. 1996 p: 205). Since the evolution of KM, apprenticeship is considered a technique for tacit knowledge transfer. According to a pioneering scholar on tacit knowledge, Polanyi (1966) pinpointed that experts cannot fully explicate tacit knowledge but rather, can only be moved by long apprenticeship. The picture becomes clearer of the importance of apprenticeship when it comes to tacit knowledge transfer. Apprenticeship is suggested as a technique of socialisation in which tacit knowledge can be transferred from one individual to another (Nonaka and Takeuchi, 1995).

2.13 KM Systems (KMS)

KM systems (KMS) are considered IT-based systems developed to improve and support KM processes in an organisation alongside supporting knowledge creation and integration into the business (Alavi and Leidner, 2001). It has been debated and documented in the literature regarding the role information technology plays in the management of knowledge initiatives following the KM research being held responsible for focusing on the aspect of technology in KM (Mohamed and Mohamed, 2008). It was resolved that KM is not just about IT but that IT can be an enabler in an organisation to accomplish effective KM (Tyndale, 2002). Technology is considered the most critical factor in effective KM strategy (Chong et al., 2005), although there are other factors such as leadership, culture, etc. for a successful KM strategy. Merono-Cerdan et al., (2007) suggests that technology is vital in successful KM strategy, but its aim is to provide tools that assist humans in sharing knowledge and facilitating other KM processes. There are several KM tools such as custom-designed software, such as a portal/content management system, electronic file manager, groupware, project extranet, expert directory, website and email. The following section will discuss the tools related to this research. There are three kinds of system network that the electronic system is built on: the intranet, extranet and the Internet (Flaqi, 2011).

2.13.1 Intranet

The intranet is a private internet-based network system utilised in knowledge sharing (Gallupe, 1998). It is further described by Tyndale, (2002) as an organisation's extensive information circulation system that enables workers to have admittance to organisational software, documents, scheduling, etc. Content can include but is not restricted to directories, calendars, organisation newsletters and policies.

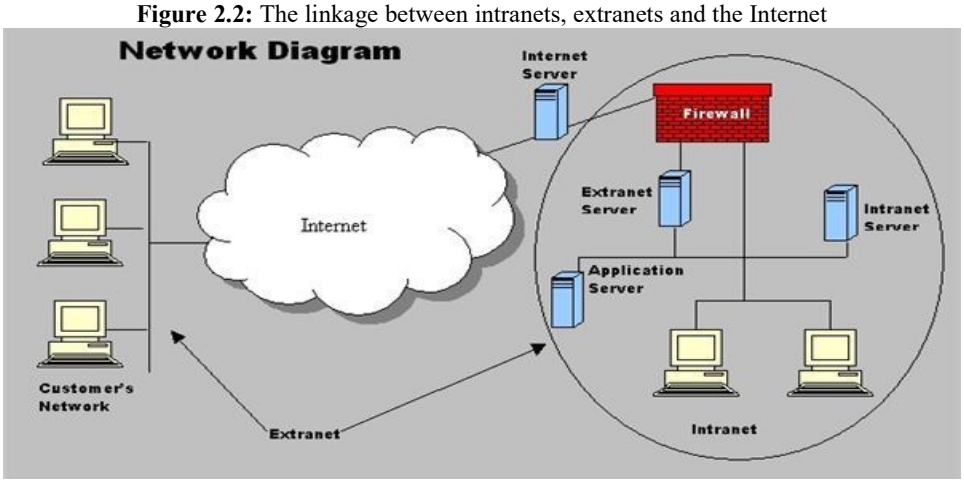
2.13.2 Extranet

A project extranet is a network connecting the several parties or organisations to a construction project for the purpose of exchanging and storing project information/knowledge digitally (Hamilton, 2005). Extranet gives admittance to both external parties and organisational members, but only certain parts of the system are allowed access to external parties (Flaqi, 2011).

2.13.3 Internet

The internet is sometimes utilised as a tool for creativity, flexibility, and freedom to create and evolve, freedom of information, freedom of expression, and the free flow of information (Liddicoat and Doria, 2012). The Internet is an interconnection of a variety of networks, all of which utilises sharable programmes, files and databases (Hura and Singhal, 2001). It is always considered to be a wide area network (WAN), and it connects millions of people around the world via their computer systems (Lathrop 1999). Also provides a suitable platform for information sharing amongst people worldwide (Flaqi, 2011).

Figure 2.2: The linkage between intranets, extranets and the Internet



Source: Adapted from Chaffey et al., (2009)

2.13.4 Electronic Discussion Board

Online discussion sites are considered the most popular producers of scripts for a discussion board (vBulletin Solutions, 2009). Discussion boards are sometimes referred to as online discussion site, discussion message or forum (Flaqi, 2011). Discussion board may contain several categories, comprising posts from individuals, threads, and forums (vBulletin Solutions, 2009). Many organisations utilise discussion boards as a tool for sharing knowledge (Honebein, 1997). It allows ideas, comments and questions to be posted by members. The post is then considered by other members, and gets responded to over time with their thoughts and remarks (Flaqi, 2011). Discussion boards provide the context for the original digital groups because of its historical value (Zaphiris and Ang 2009) and have been considered by several scholars as a virtual CoP (Kimble et al., 2008; Ardichvili et al., 2006; Sharratt and Usoro, 2003).

2.13.5 Expert Directory

Expert directory can be considered as validated and managed directory which points to persons officially recognised as professional in a specific knowledge discipline (Gaallier and Leidner, 2014). Expert directory does not necessarily contain knowledge but rather assists the user in locating professionals from whom he or she can acquire knowledge. An active expert directory was found to incorporate individual details such as individual skills, experience, knowledge and expertise (McNabb, 2006). A robust expert directory can assist users in locating the right person to contact for guidance and best practice (Anumba et al., 2005a). Considering that 80 per cent of organisational knowledge is tacit knowledge which is embedded in the heads of individuals (Wah, 1999; Grant, 1996), access to carriers of this knowledge is very important because it saves time and effort (Flaqi, 2011). The use of expert directory as highlighted by Gamble and Blackwell (2001) includes;

- It helps users develop awareness of the knowledge background of others in the organisation

- It plays a role in the creation of a competent internal labour market. Making it easier for a project team to be assembled more efficiently
- It acts as a vital communication tool, by providing the type of social network that occurs in a face to face environment and
- It increases awareness of what is happening by uncovering which departments and groups people belong to and which project task/ activities they are associated with.

2.14 Summary

This chapter presents an extensive review of the perspectives of knowledge and KM alongside the roles of technology, and the available tools and techniques were also emphasised. This chapter also described the different KM process and emphasised the importance of capturing and recovery of knowledge in an organisational context. This elaboration provides a further foundation and direction for the study of knowledge capture and recovery in construction organisations.

From the discussions throughout the chapter, the following conclusions can be made:

- Knowledge capture, recovery and sharing have a major role to play in improving performance in an organisation.
- A variety of KM tools and resources may support knowledge capture and recovery, such as communities of practice, PR, mentoring, etc.
- The utilisation of IT is also a significant factor as it can facilitate communication even between geographically distant parties.

Diverse type KM tools can be utilised in construction. For example, live discussion, e-forum, file manager, live discussion, content management system and instant messaging system. The KM tools can be employed in the diverse network system. It can be employed on the extranet or intranet which aid the involvement of other project parties.

CHAPTER 3 : Whole Life Costing Practice - A Review

"The ultimate goal of humanity is knowledge." ― Abhijit Naskar

3.1 Introduction

This chapter presents the reviews of whole life costing practice in the construction sector. First, it looks at the various definitions, its benefits and uses. Secondly, it looks at the processes of WLC and how knowledge management in WLC practice can be beneficial in the capture and recovery of knowledge when employing WLC in a construction project.

3.2 Definitions of Whole Life Costing (WLC)

The term whole life costing (WLC), which has been published in literature since the mid-60s refers to a technique used for estimating the sum of all costs of the equipment incurred to its consumer from purchase to salvage; meaning that from the consumer's perspective, the whole of the equipment includes both its purchase and total cost of ownership Dhillon, (2013). Numerous definitions of whole have been established in the WLC field. According to BSI, (2008) defines WLC as the: "methodology for the systematic economic appraisal of life cycle costs over a period of analysis, as defined in the agreed scope". Whole life costing, in turn, is defined as the "cost of an asset, or its parts throughout its life cycle, while fulfilling the performance requirements". Ferry and Flanagan, (1991) define described the WLC method as putting the estimated capital, maintenance, operating and replacement costs into a comparable form and bringing them into a single figure which allows for the fact that these items of expenditure will take place at different stages within the time-scale.

Norman, (1993) defined whole life costing as the process of economic analysis that takes into account the total investment cost in and ownership, operation and subsequent disposal of a product or system to which the whole life costing method is being applied. This process takes the functional requirements and operational constraints that apply to the system or product and translates these into a common cost measurement known as whole life costing. Also, Kishk et al., (2003) define whole life costing as a tool which "includes the systematic consideration of all costs and revenues associated with the acquisition, use and maintenance and disposal of an asset".

The main point drawn from the definitions above is that the practice of whole life costing helps one to handle both present and future situations and seek to connect the two as a basis for decision-making.

The Norwegian Standard (2000) defines WLC as a tool that puts together the original costs and costs incurred throughout the whole asset lifespan. Primarily in the UK and Canada, the term whole life costing (WLC) is preferred. From the above definition published by BSI (2008) whole life costing is deemed to have a broader scope than whole life costing emphasising particularly an economic life span as it more often than not considers the whole span of the asset as well as non-construction costs such as finance, business costs, incomes from sales/disposals, etc. and also external social/environmental costs and benefits. However, the term whole life costing is a hybrid of many other terms which were used interchangeably to describe this form of cost appraisal such as

terotechnology, cost-in-use and life cycle costing, whole life costing, through life costing (Langston, 1993). However, to prevent confusion, this research will adopt the term "whole life costing"

3.3 The Purpose and Benefit of Whole Life Costing

In the 70s during the energy crisis in America, whole life costing was adopted with the aim of evaluating and comparing energy design options in commercial buildings (Harris and Fitzgerald, 2017). Currently, the highway management and engineering industry are utilising whole life costing to evaluate traffic engineering, bridge construction and highway materials and methods for the best financial alternatives (Di Mino et al., 2014; Kshirsagar et al., 2010; Liu et al., 2015). In the building industry, whole life costing is still principally associated with energy management (Cole and Sterner, 2000) rather than whole building or building system analysis. However, whole life costing is said to centre mainly on capital or fixed assets (Ellram, 1995). On the other hand, Asiedu and Gu, (1998) state that whole life costing can be adopted for all sorts of products: The nature of the analysis and the purpose, however, is dependent on the product. Whole life costing technique was firstly developed for the purpose of procurement, i.e. to be used from a client's perspective. Many of the well-known whole life costing approaches are anticipated to be adopted to support design decision making, but from the client's point of view (Fabrycky and Blanchard, 1991; Woodward, 1997). While from a manufacturer's point of view, Dunk (2004) presents motivational factors for using whole life costing: manufacturers with a strong customer-focus may recognise whole life costing as a customer service resulting in competitive advantage. Nevertheless, the ability of a manufacturer to perform whole life costing is affected by the quality of information available. In the context of the building industry, Kirk and Dell'Isola (2003) emphasise that whole life costing is a technique that can be used in the early evaluation stage of a construction project which aim to determine the total cost for a project by analysing all materials, components, energy and other related costs including maintenance throughout the lifespan of a proposed building project. One of the key aspects of carrying out whole life costing analysis is the discounting of future costs to present value; this allows design alternatives comparisons to be made on a level playing field (Cole and Sterner, 2000). Kelly and Hunter, (2009) pointed out that whole life costing can be adopted in a building project to forecast "cash flow of an asset" for budgeting, cost planning, and tendering cost reconciliation purposes. Additionally, whole life costing can also be adopted to assist design option evaluation studies and to assess present and likely future maintenance costs.

Stakeholders involved in the procurement of construction projects are beginning to appreciate the benefit of adopting WLC in projects. However, a publication by Treasury Guidance (2003) updated in 2011, calls for the value of money evaluation of public projects to be conveyed through the utilisation of WLC for finished built environment projects to meet the project requirements of the end-users.

In the context of sustainability, it can be viewed that whole life costing adoption can assist to appraise, at an early stage of a project, the economic/environmental parts of an anticipated building project

design (Caplehorn, 2012). While acknowledging that the majority of construction professionals are now actively promoting whole life costing as a decision tool for the appraisal of environmental sustainability. Gluch and Baumann (2004); Davis Langdon, (2007) and Tsai et al., (2014) put forward that owing to the tools financial focus such appraisals are often limited to the consideration of buildings energy usage. Given such profound limitations, Haapio and Viitaniemi, (2008) and Ding, (2008) question whole life costing utilisation as a sustainability based tool, putting forward the financial focus of tools such as whole life costing could limit the validity of the sustainability appraisal produced. Nevertheless, Braganca et al., (2010) cited in Higham et al., (2015) pinpoint that when utilised alongside other sustainability evaluation tools, whole life costing plays a vital role in evaluating potential project strategies.

3.4 Management Barriers to Whole Life Costing

Despite the obvious long-term benefits of employing whole life costing in construction projects, its adoption has been relatively slow (Lindholm and Suomala, 2004; Woodward, 1997). Many scholars (Olubodun et al., 2010; Opoku, 2013; Kishk et al., 2003; Sterner, 2000; among others) have tried to identify the areas triggering difficulties in the adoption of whole life costing in the in the construction industry. Some of the reasons behind its low adoption include the lack of tangible evidence and "know-how" skills and knowledge of whole life costing (Olubodun et al., 2010; Langdon, 2007; NAO, 2005) i.e. there is a lack of professionals in many establishments with knowledge and training of whole life costing practice, this situation is compounded by the absence of available data on whole life costing from relevant projects, lack of data collection mechanisms, etc. (Bird, 1987). This proved to be very challenging to those who showed some willingness to employ whole life costing practice in a construction project.

3.5 Implementation Stages of Whole Life Costing

While there are different opinions regarding the sequences in which various whole life costing activities should be used, a report by Kishk et al., (2003) identified the three stages of whole life costing application which consist of whole life costing analysis (WLCA); whole life costing management (WLCM); and whole life costing planning (WLCP).

3.5.1 Whole Life Costing Analysis (WLCA)

In this stage, historical data are collected and analysed on the actual cost of occupying the comparable buildings (Kishk et al., 2003). The main objective is to relate performance data and running cost and provide advice to the project team regarding the running cost of occupied buildings.

3.5.2 Whole Life Costing Management (WLCM)

This stage results from whole life costing analysis. It recognises those areas in which the costs of utilising the building as detailed by whole life costing can be reduced (Kishk et al., 2003). The

objective is to assess and control costs throughout the whole life of the building to obtain the greatest value for the client.

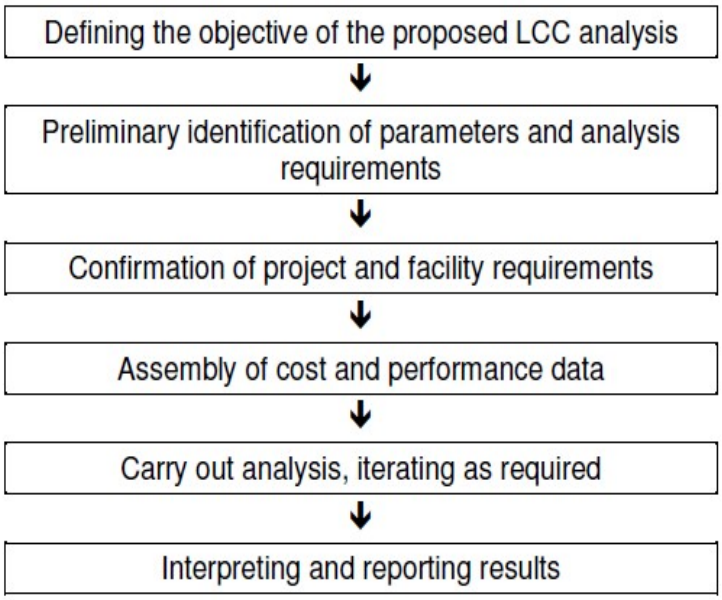
3.5.3 Whole Life Costing Planning (WLCP)

This stage is considered a part of whole life costing management which comprises the forecast of total costs of building, the components of a building, or an individual building component (Kishk et al., 2003). It also comprises planning the timing of work and expenditure on the building, considering the effects performance and quality (Seeley 1996).

3.6 Whole Life Costing Processes

The whole life costing process is administered by the ISO 15686 standards (ISO 15686-5, 2008) as shown in Figure 3.1. Nevertheless, there are several methodologies adopted for whole life costing in construction project (Gundes, 2016). Then in 2006, Davis Langdon Management Consulting was appointed by the European Commission to develop a common methodology for construction projects. The final report was published in 2007 (Davis Langdon, 2007) and the proposed methodology is intended to be compatible with ISO 15686, part 5 (Gundes, 2016).

Figure 3.1: Core processes of whole life costing (**Source:** Adapted from Langdon, 2007)



The purpose of the WLC analysis as defined in the first step in Figure 3.1 will determine the scope and detail of subsequent steps (Langdon, 2007). For a successful implementation of whole life costing in a construction project, the process should be collaboratively undertaken by all key stakeholders in the project.

Step 1: Defining the objective of the proposed analysis: The is the first step of the whole life process which seeks to identify the purpose of undertaking the proposed whole life costing analysis

and gain an understanding of how it can be applied correctly and more efficiently and of the results that are anticipated (Langdon, 2007).

Step 2: Preliminary identification of parameters and analysis requirements: in order to forecast the expected results of the whole life costing analysis in the project, it is vital that the scope of the exercise is identified which includes the stages of the life span of the asset at which it is undertaken, the boundaries of the analysis and whether there are any specific inclusions or exclusions (Langdon, 2007).

Step 3: Confirmation of project and facility requirements: Before undertaking whole life costing analysis in a construction project, it is vital that key features of the asset in question are identified. Where the whole life costing analysis is undertaken in the context of a project to construct, refurbish, adapt or dispose of an asset, it is also vital that the scope and parameters of the project itself be clarified and confirmed (Langdon, 2007).

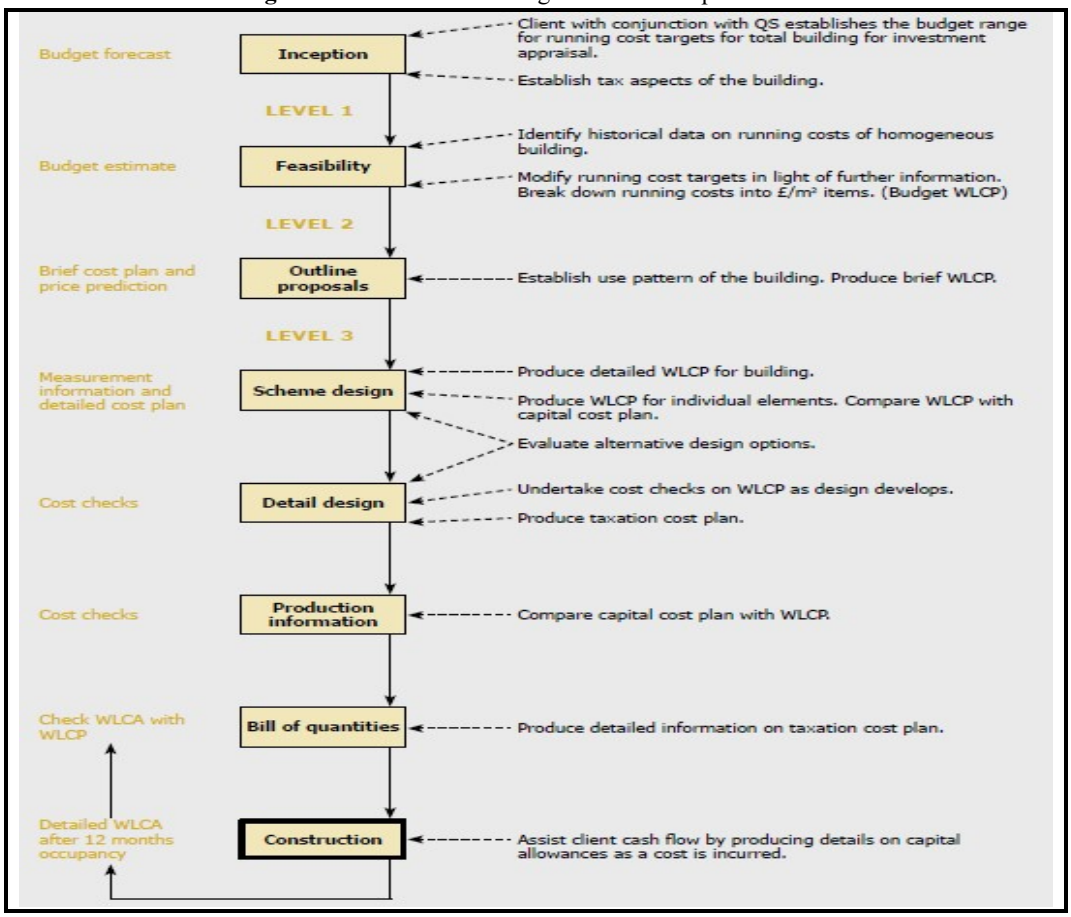
Step 4: Assembly of cost data and performance data: In this step, the user identified and defined the options that are to be considered in the whole life costing analysis: all relevant costs and timescales for each option in preparation for undertaking the analysis (Langdon, 2007).

Step 5: Carry out analysis: At this point, the required economic evaluation is undertaken using data gathered from previous steps. (Langdon, 2007).

Step 6: Interpreting and reporting the results: At this stage, the results gathered from the whole life costing calculation are reviewed and interpreted, identifying the limitations of the cost techniques employed and hence requiring the exercise of professional judgement, also guaranteeing that uncertainties and risks have been adequately addressed (Langdon, 2007).

Langdon, (2007) suggested that when a large number of WLC exercises are undertaken, the utilisation of databases to store data should be considered. These include the list of work items and related costs, cost breakdown structure and period, component service lives, maintenance items, etc. so it can be reused in future exercises. Flanagan and Norman (1983) devised a method of grouping whole life costing activities into a hierarchical structure as illustrated in Figure 3.2. The main point is that as the design develops, the initial WLC plan based on level 1 will be replaced by a detailed plan at level 3. As shown in the figure, this structure fits into the RIBA plan of work with the conventional cost planning sequence on the left-hand side of the figure. The main point is that as the design develops, the initial or budget WLC plan based on level one will be replaced by a detailed plan at level three. As shown in the figure, this structure fits into the RIBA plan of work with the conventional cost planning sequence on the left-hand side of the figure. It should be noted, however, that WLC can be used at any time in the design process (Flanagan and Norman 1983).

Figure 3.2: Whole life costing and the RIBA plan of work



***Source:** Adapted from Flanagan and Norman, (1983) cited in Kishk et al., (2003)

3.7 KM in Construction Organisations

Knowledge is viewed as a valuable asset in the construction industry and has gained recognition and substantial attentions widely in recent years (Rezgui et al., 2010; Graham and Thomas, 2006). If the intention of the construction industry is to reduce waste, enhance profitability and render valuable services to clients, then KM must fully be accepted in the industry Walker (2005). On this subject, some influential research conducted within the construction sector recognises KM as an all-embracing approach which can be utilised by the industry to address its goal (Carrillo et al., 2004; Robinson et al., 2001a, b); the use of KM can enhance the performance needed in the industry and also bring about the much-desired innovation (Egbu et al., 1999; Webb, 1998). Construction organisations have identified KM as a driving force for organisational performance improvement (Schenkel and Teigland, 2008; Hsu, 2008), and as an important way to stay competitive in an unpredictable and competitive market (Egbu et al., 2004). Therefore, the management of knowledge is very crucial to the survival of organisations (Dave and Koskela, 2009; Mohamed et al., 2007; Wong and Aspinwall, 2004 Mohamed and Anumba, 2004). The efficient management of knowledge is crucial for the construction industry, as poor performance and low productivity is widely perceived in the industry, regardless of how important it is to the national economy (Ofori, 2012; Ling and Shan, 2010; Egbu et al., 1999). They

also stated that due to the project base nature of the construction industry, it is vital that lessons learnt be captured and transferred from one project to another.

It is evident that construction firms that have employed KM are earning rewards, even though there are struggles in quantifying them (Anumba, 2009). Other organisations alongside construction firms are collaborating especially as knowledge has increasingly been acknowledged as a source of a competitive edge and a powerful asset for business performance improvement (Robinson et al., 2001b). The need for "innovation and organisational learning" has been identified as improvement initiatives for the construction industry (Anumba, 2009; Wong and Aspinwall, 2004). A few researchers such as (Patel et al., (2000); Carrillo et al., (2000); Kululanga et al. (2002) have conducted reviews which addressed the role of KM and learning as a possible advantage in the construction industry. Certainly, knowledge is vital to innovation and organisational learning and KM strategy should be the foundation for performance improvement in construction firms (Robinson et al., 2001b). From this viewpoint, several construction firms are increasingly concerned about the possible benefits of KM (Chinowsky and Carrillo, 2007; Carrillo et al., 2000) and structuring ways to produce, codify, share and use knowledge effectively in a purposeful manner (Bhatt, 2001; Hansen et al., 1999). It has been emphasised by many scholars such as (Anumba et al. (2005); Omar Sharifuddin Syed-Ikhsan and Rowland (2004a); Davenport et al. (1996)) that products and services in projects and businesses can be executed successfully with suitable KM strategies which give members of an organisation the desired knowledge at the right time. This issue is particularly seen as vital in project-based industries, such as the construction sector, where the successful management of knowledge from projects and organisations can result in the improvement of organisational performance.

A few of the main advantages of KM in the construction industry as identified by (Anumba et al., 2005) consist of the following:

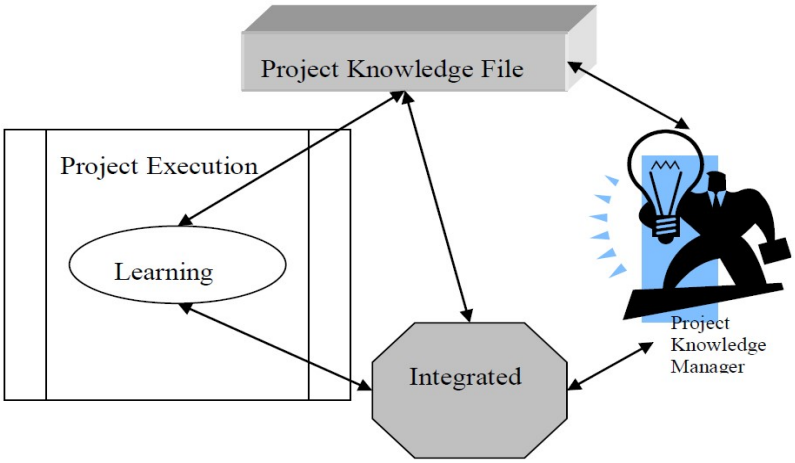
- In an environment where there is an effective management of knowledge innovation is more likely to flourish.
- Performance improvement will result from the pooling of knowledge from the organisation, as employees will be more efficient when using time and other resources and when adopting the most suitable solutions.
- KM is necessary for the enhancement of construction project conveyance, as lessons learned from an existing project can be utilised in future projects, resulting in continuous improvement.
- KM can also make knowledge transfer across a variety of project interfaces to be (discipline, participants, stages, organisations, etc.); to be smooth and with effective management of knowledge; construction companies and project teams can avoid re-inventing the wheel.

- Companies that effectively manage their knowledge are better placed to respond to the needs of their clients quickly and other external factors.
- KM results in enhanced support for the project team in an organisation; especially in the capture of best practice for reuse in future projects.
- The organisation can retain tacit knowledge that would otherwise be lost when the knowledgeable worker retires or leaves
- The efficient management of knowledge in construction firms can enable firms to respond quickly to changes within the company.
- Effective knowledge management minimises risk, because as it improves the knowledge base firms have fewer uncertainties to deal with.

3.8 KM Research in the Construction Industry

It is evident in several publications and conferences that KM has significantly been acknowledged in the construction management academic community. Several KM project initiatives and researches in the construction sector have been carried out that concentrate on diverse parts of KM such as (Udeaja and Kamara, 2010; Anumba, 2009; Udeaja et al., 2008, Egbu, 2006; Jewell and Walker, 2005; Carrillo et al., 2004; Kamara et al., 2002; Robinson et al., 2001a, b, c; Egbu et al., 1999). But only a handful of studies specifically considered the management of project knowledge and the capture and recovery of knowledge. Hari et al., (2005), conducted a study and found that there was an absence of awareness of the benefits of knowledge capture. The study underlined that the application of knowledge capture is reliant on the ideas and concepts of the owners of the organisation. It was also uncovered that structure, culture, people, technology and finance are key factors that influence knowledge capture implementation in organisations. The study concluded that the capture of knowledge in SMEs is a difficult task and called for a comprehensible organised approach to using existing explicit and tacit knowledge within organisations. Another study carried out by Suresh and Egbu, (2006), uncovered factors that influence the capture of knowledge and have suggested that construction firms should apply a holistic and integrated approach to the capture of knowledge. Culture, tools, training, top management, and processes are the core of their strategy in capturing knowledge, were identified to be the basis for an effective application of knowledge capture. A framework for the capture of knowledge was developed by Kamara et al. (2003) (Figure 3.3). In this approach, during the construction project when a learning event takes place, there is a trigger on the integrated workflow system, and this sets in motion a flow of actions to capture the learning at a particular point in time.

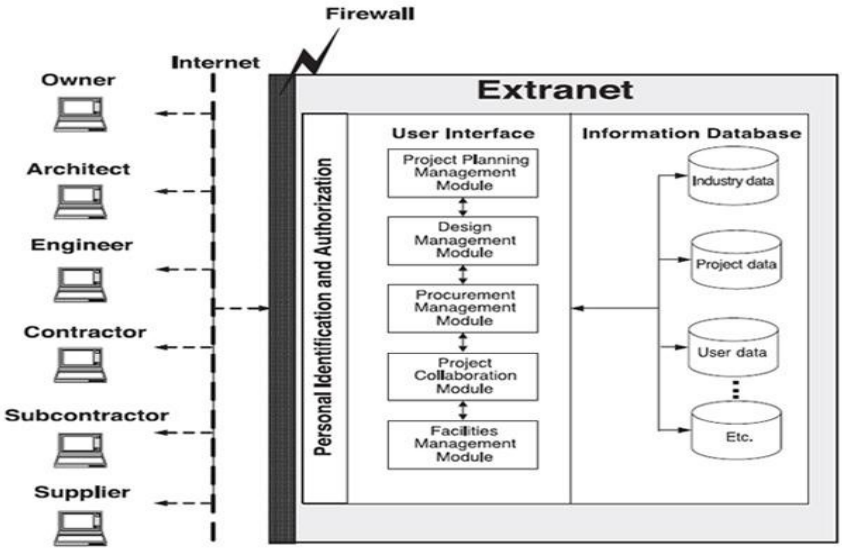
Figure 3.3: Learning event-based knowledge capture system



***Source:** Adapted from Kamara et al., (2003)

Bearing in mind that knowledge is linked to all the parties involved in the project, Nitithamyong and Skibniewski (2004) acknowledged a web-based project management system (WPMS) as a suitable way of capturing knowledge (Figure 3.4). The system is designed using the extranet network, and only the project teams are allowed to access information. Information in the system is transmitted between parties involved in the project and provides a centralised, commonly accessible means of transmitting and storing project information. Information about the project is saved on the server and is available through the Web browser.

Figure 3.4: Functional scheme of WPMS

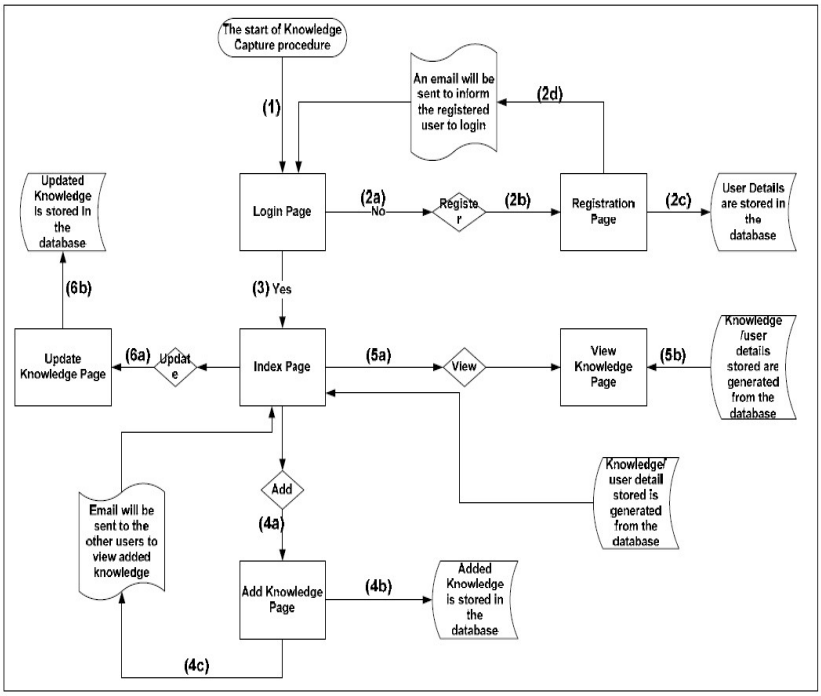


***Source:** Adapted from Nitithamyong and Skibniewski, (2004)

Based on the study conducted by Kamara et al., (2003), a web-based prototype (CAPRI.NET) was developed by Udeaja et al., (2008) for live knowledge capture and reuse in a construction project. It permits project members to file their learning while executing the project in a project knowledge file

(PKF). In this research, the knowledge is not particularly linked to only one party (e.g. project manager), rather, it integrates collective knowledge generated by all firms involved in the project, who will have admittance to the CAPRI.NET system via the internet. Figure 3.5 represents the navigational procedures for users using the CAPRI.NET system. The CAPRI.NET comprises three logical coatings: client side, middle layer and the server side. The client (tier one) sits on the user's desktop and is connected to the server through the intermediate tier (level 2), which in turn is linked to the data server (level three), with access to and control over all types of knowledge and information within the MySQL database. In future, this data server will contain all the databases and links to other data servers. In this study knowledge from projects is reusable; but there are no suggestions about project knowledge type or how it is categorised.

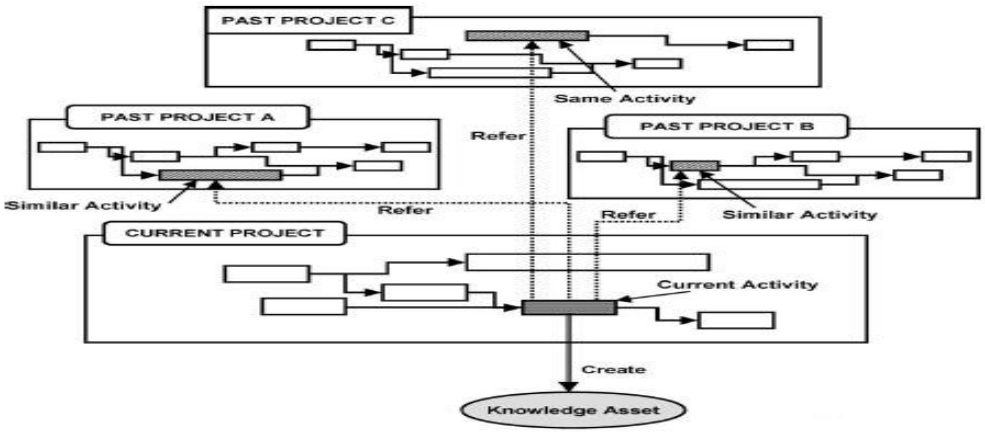
Figure 3.5: Flowchart view of CAPRI.NET approach to knowledge capture and reuse



***Source**: Udeaja et al., (2008)

Linking more to the area of research, a KM concept for use by contractors in construction projects was developed by Tserng and Lin, (2004) (Figure 3.6). This system is based on project planning activities and control from the contractor's perspective. Information and knowledge obtained from the project are classified and deposited as activity units. Knowledge of each project contained in the knowledge asset is saved separately. So, the knowledge obtainable from earlier projects can be recovered by navigating through the knowledge base of previous projects. In this approach, some explicit knowledge and tacit knowledge are considered activities, but some of the information such as project-based information is stored as a non-activity category for the project; hence, knowledge characterised as activities can be used again on impending projects.

Figure 3.6: The concept of KM for construction projects



Source: Tserng and Lin, (2004)

3.9 KM and Whole Life Costing Practice

KM and whole life costing practice are becoming imperative in the performance and sustainability of an organisation, and the connection between the two phenomena is equally becoming very critical and vital for researchers to comprehend. Some significant contributions relating KM to whole lie costing practice can be linked back to the work of Egan (1998), who contended that the whole life costing method of procuring building projects encompasses the introduction and appropriate use of know-how by expert knowledge employees within the context of their work and encourages the capture of experience and lessons learnt so as to improve sustainability and performance in future building procurement. Construction firms are knowledge-based firms (Egbu and Robinson, 2005; Rezgui et al., 2010). Procuring building projects using whole life costing technique is heavily reliant on the knowledge, experience, ideas and skills of workers, which comes from many sources including other individuals, electronic media and documents (Langdon, 2007). In the context of whole life costing process, a range of costing knowledge are generated including both formal knowledge and informal knowledge. The former is mainly embedded in the analysis process, e.g. historical data, calculations, standards etc. (Langdon, 2007), while the latter, predominantly existing in the brains of the WLC project team, and is often referred as experience. Informal WLC knowledge is significantly useful as it drives the reasoning process and provides rich context about how various pieces of WLC data are put into a solution, providing guidance on what kinds of data and information can be reused as well as on how to recuse them. This wealth of knowledge support in the implementation of whole life costing in a construction project as proficiently as possible. Despite how knowledge-intensive construction firms are, it has been contended that the knowledge of their workers is not efficiently utilised (Suresh, 2006; Rezgui et al., 2010). Due to the diversity of knowledge, capabilities and skills of employees that vary across firms, it is significant that they are directed and coordinated efficiently to capture, retrieve and share knowledge so as to improve the performance of the company (Almahamid et al., 2010). In terms

of the capture, recovery and reuse of knowledge, formal knowledge is easier to capture and manage as it relies on standard and accessible data. On the other hand, informal knowledge is more related to personal experience and thus is more difficult to capture and share in particular when a computer is used to complete this task (Qin et al., 2016). In order to capture both of the two kinds of WLC knowledge for effective use, a knowledge representation framework is required to identify how they interact with each other throughout the decision-making process, understand how they can be structured, and develop a representation that allows them to be integrated with the help of KM tools and techniques (Qin et al., 2016).

It is acknowledged that the overall KM processes in the construction sector (construction, architecture and engineering) are categorised by the following:

- Most of the knowledge from construction project resides in the minds of people working within their specific domain (Khalfan et al., 2002); in the whole life costing context, there is a lack of know-how skills by professionals on how to undertake whole life costing practice in a construction project (Olubodun et al., 2010; Langdon, 2007; NAO, 2005), and only a handful of experts acquire in-depth knowledge in undertaking the practice.
- The acquired knowledge is often poorly structured, and there are no well-structured processes in place for the capture, recovery and dissemination of the useful knowledge to other projects (Flaqi, 2011; Khalfan et al., 2002); There is an absence of available data on whole life costing from relevant projects and a lack of data collection mechanisms (Langdon, 2007; NAO, 2005).

In the context of WLC practice, the use of professional judgement is required to ensure that the right decisions are taken when interpreting whole life costing reports (Langdon, 2007), the rationale behind decisions is often not documented or recorded which makes it difficult to track the individuals involved in the decision-making process and who understand the context of making the decision for the purpose of knowledge sharing (Khalfan et al., 2002);

There is a resilient dependence on accrued knowledge by members of the project team, but no formal method of capturing and recovering much of this knowledge (Kamara et al., 2002b);

Given the numerous limitations of KM current practice in construction and hence the sufficient room for improvement. The knowledge management in WLC practice can enhance WLC analysis execution in construction project, as lessons learned from one project can be carried on to future projects, resulting in continuous improvement, provide knowledge that can be used in the operation and maintenance phases of the assets life span (Kamara et al., 2003), tacit knowledge in firms can be retained when valued employees leave, retire or die (Anumba et al., 2005), the client organisation benefits from enriched knowledge regarding the development and construction of their assets. This will contribute to the efficient management of facilities and the commissioning of other projects. In the longer term, clients will benefit from the increased certainty with which construction firms can predict

project outcomes (Kamara et al., 2003). KM can be of benefit to the entire construction industry, where captured experiences are shared by the building supply chain as part of the learning on the main events (e. g. problems, solutions, change orders, etc.) in both the short- and long-term. Short-term in the sense those subsequent phases of a project would be better managed through the capture and reuse of knowledge from previous phases. Long-term because the capabilities of the project team will be increased for better planning of future projects and collaborate effectively with other firms (Tan, 2006).

There should be avoidance of knowledge loss owing to the time interval in capturing the knowledge (Tan, 2006). A study conducted by Ebbinghaus, (1885) uncovers that information retained in the human memory drains over time. In the context of whole life costing practice, due to the complexity (Olubudun et al., 2010), the probability of not remembering an event during a whole life costing exercise (which may comprise the learning event where new learning is created) increases as time passes. Therefore, the capture of newly created or identified knowledge can assist in the reduction of knowledge loss or vital insights clue.

3.10 Summary

The outcome of the literature review describes the different definitions of whole life costing, the purpose and benefits alongside the whole life costing processes. Despite the importance of whole life costing in the construction sector, it is crippled by a number of obstacles such as the lack know-how skills by professionals in undertaking the exercise in the construction industry, the absence of data on whole life costing from related projects, lack of data collection mechanisms, etc. The literature review depicts that the capture and recovery of whole life costing knowledge are vital in addressing the barriers mentioned above of whole life costing practice, to better manage project knowledge and to enable the benefits of knowledge captured to be fully exploited. The capture of knowledge in whole life costing practice will avoid persistent knowledge loss problem of current practice due to a time gap and other constraints

CHAPTER 4 : RESEARCH METHODOLOGY

"Human knowledge is but a ripple on the water's surface. To go deeper, we must accept the fact that we don't know everything" **— Stewart Stafford**

4.1 Introduction

The aim of this chapter is to address the research design alongside the appraisal of different methodologies for research, particularly those employed in this study. Methodologies used by the researcher are those that could be used for gathering data and analysis, as well as assisting in discussing and reporting the findings generated from the study.

4.2 Research Methodological Plan

Many ways can be utilised to formulate a given research design so that the aims and objectives of a given study can be achieved. Blaikie, (2007) opines that either one or more approaches can be combined for a particular study. Moreover, researchers are expected not to focus on methods only but also carefully consider the problem examined in order to adopt the most suitable design for a given study (Morgan, 2007; Patton, 1990; Rossman and Wilson, 1985). Consequently, the research process "Onion" model propounded by Saunders et al., (2009) was adopted to represent the important research design for this study. It is adopted as an integrated approach which is multi-coated and needs careful assessment of each stratum until the core process is addressed as it relates to this study. By application, the vital coatings of the onion design need careful unwrapping so as to reach the central subject of how to gather the desired data to answer the research questions (Saunders et al., 2009). This is illustrated in Figure 4.1.

4.3 Research Philosophy

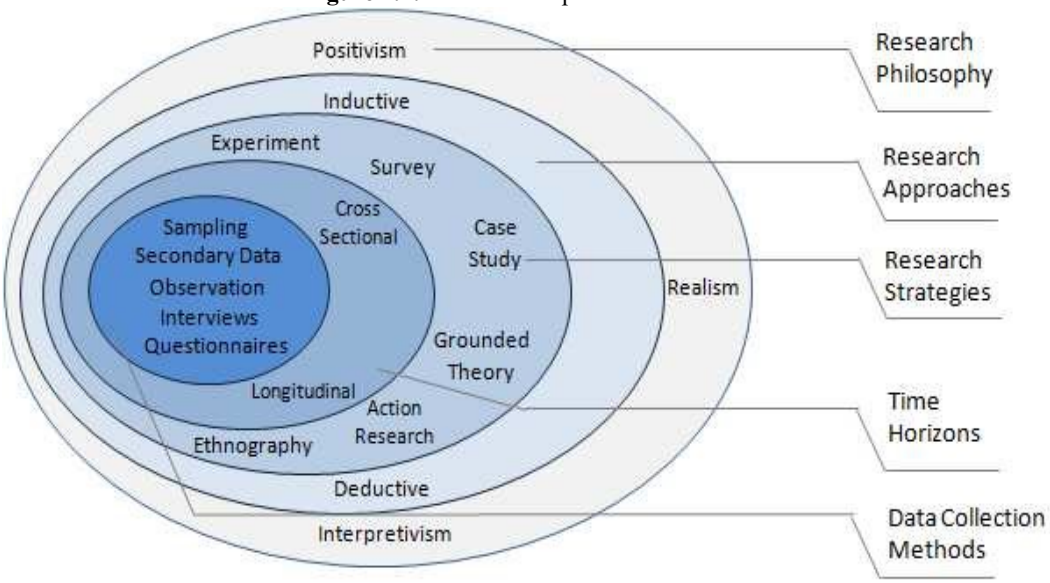
There are at least three reasons why an understanding of philosophical issues is very useful (Easterby-Smith et al., 2008):

- It helps to clarify the research design (more than simply the methods by which the data is collected and analysed).
- It can help the researcher to recognise which designs will work and which will not.
- It can help the researcher identify, and even create, designs that may be outside his or her past experience.

Research philosophy could be you to initiate and formulate knowledge alongside the nature of the knowledge established. Knowledge is born out of philosophical thoughts that underlie research methodology. When researchers make assumptions regarding what knowledge is (ontology) and how the knowledge is attained (epistemology), as well as what values go into knowledge (axiology) and how knowledge is written (rhetoric), a process of studying knowledge come into being which is

otherwise called methodology (Creswell, 2013). Accordingly, this section discusses two main philosophical issues that appear to be significant for any research (Saunders et al., 2009): epistemology and ontology.

Figure 4.1: The research process onion model



***Source**: Adapted from Saunders et al., (2009: p.108)

4.3.1 Epistemology

Epistemology is a way of looking at the world. It is composed of certain philosophical assumptions that guide and direct thinking and action' (Mertens, 2005: p.7). There are different types of research paradigms (Saunders et al., 2009), and understanding these helps in deciding suitable methodologies and research methods (Easterby-Smith et al, 2008). There are two main epistemological positions in management and business research: positivism and interpretivism (Thomas, 2011).

The first research paradigm is often described as positivist (Saunders et al., 2009; Easterby-Smith et al., 2008; Sobh, and Perry, 2006; Robson, 2002). The purpose of the paradigm is to establish facts, which are an absolute truth, value free and independent of social construct. Positivists generally assume that there is one true reality that can be discovered by means of rigorous, mostly quantitative and empirical study (Guba and Lincoln, 1994). Thus, positivist studies are usually quantitative, subjected to statistical analysis to either prove or disprove the hypothesis, and generally attempt to test theory, in order to increase the predictive understanding of phenomena.

The interpretivism paradigm argues that people and organisations are complex, unique and fundamentally differ from that of natural science. Interpretivists see the world as socially constructed. They attempt to understand phenomena through analysing meanings people assign to these phenomena rather than search for external causes or fundamental laws. Their research approach is inductive and concerned with discovering and interpreting social patterns (Walsham, 1995; Lacity and Janson 1994).

This paradigm argues that the study to investigate social science research requires a different logic to that of the natural scientist, in an attempt to grasp the subjective meanings of social action (Bryman, 2008). The purpose of this paradigm is to examine the meaning of situations in great depth, acknowledging that situations in the real world cannot be subject to control as in the laboratory.

4.3.2 Ontology

Ontology is concerned with the nature of the phenomenon or nature of the reality that a researcher intends to study (Saunders et al., 2009; Mason, 2002). The central point of orientation here is the question of whether social entities have a reality external to social actors, or whether they can and should be considered social constructions built up from the perceptions and actions of social actors. These positions are frequently referred to as objectivist or constructivist (Bryman and Bell, 2007). Objectivist ontology sees social phenomena and their meanings as existing independently of social actions, whereas constructivist ontology infers that social phenomena are produced through social interaction and therefore are in a constant state of revision (Bryman and Bell, 2007). This study adopted a combination of objectivist and constructivist perspectives, in order to add more depth and breadth to the analysis (Fielding and Fielding, 1986).

4.4 The Ontological and Epistemological Implication for this Study

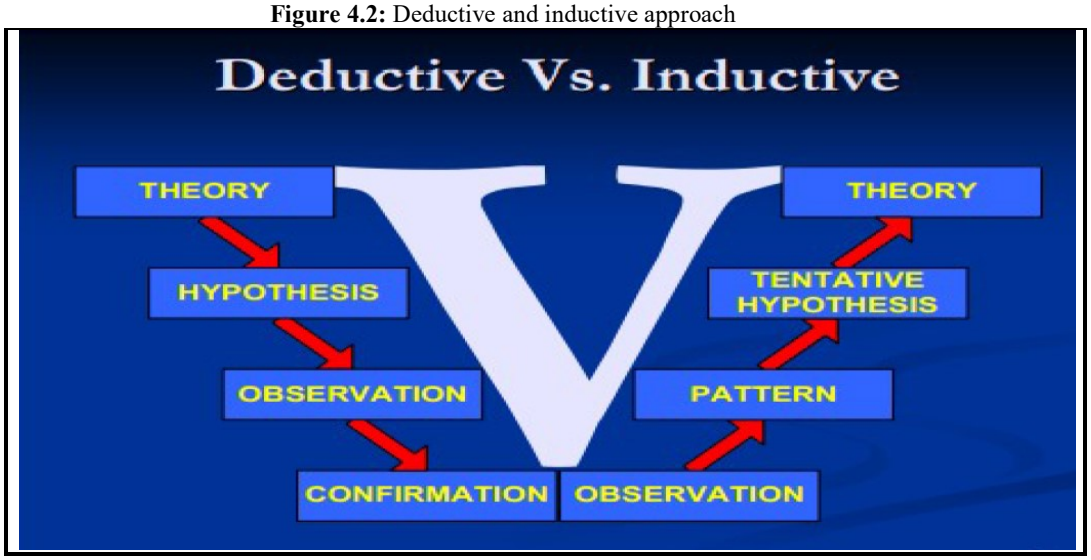
The implications of ontology and epistemology to this study are that both are essential to this study. Ontology, on the one hand, is a key to the formative stage of the study as it informed the researcher's perception of KM and the application or development of whole life costing as well as the opinions held in the construction management industry. While epistemology, on the other hand, was a key to the handling of the interview sessions and subsequent analysis of data obtained for the validation of the framework used for knowledge capture and recovery in whole life costing practice. Ontology covers all the constituents of reality regarding KM and how one can understand its existence. Epistemology here lays emphasis on the key constituents of "valid knowledge" and the entire processes that one can follow to attain it as embodied in this study (inherent in the various methods that can be employed to acquire, store and retrieve data). Therefore, ontology and epistemology are paramount to this study as both can hardly be separated especially when realism, positivism and interpretivism are involved as we see in the onion model adopted for this study in which all of these vital elements are embedded. No wonder, Crotty (1998) views ontology conflating with epistemology because both are mutually dependent and difficult to distinguish conceptually when discussing research issues. Crotty (1998) pointed clearly in the following words: "to talk about the construction of meaning (epistemology) is to speak of the building of a meaningful reality (ontology)".

4.5 Research Approach

There are two broad methods of reasoning in research, and these are the deductive and inductive approaches (Dainty, 2008). They are two separate methods of reasoning which have very different

conceptual approaches to them when conducting research, and are discussed in turn based on the conceptual framework in Figure 4.2.

Figure 4.2: Deductive and inductive approach



***Source**: Adapted from (Wilson, 2010)

4.5.1 Deductive Approach

Deductive research approach works from the more general to the specific, it tends to proceed from theory to data (theory, method, data, findings), usually referred to as top-down approach (Balarabe Kura, 2012). Specifically, it involves the formulation of hypothesis based on existing theory, and then designing a research strategy to test the hypothesis (Wilson & Chaddha, 2010). Monette et al., (2005) explained that deductive research approach works by means of hypotheses which can be derived from the suggestion of theory, which means that it involves deducing conclusions from propositions. According to Collis and Hussey (2003), the deductive research approach is the dominant approach in the natural sciences in which laws remain the basis of explanation, permits the anticipation of phenomena, predicts their occurrence and therefore permits them to be controlled. Accordingly, Robson, (2011) introduces the procedure through which deductive research can be implemented:

- Deducing a hypothesis from the theory
- Expressing the hypothesis in operational terms
- Testing the operational hypothesis
- Examining the specific outcome of the inquiry
- If necessary, modifying the theory

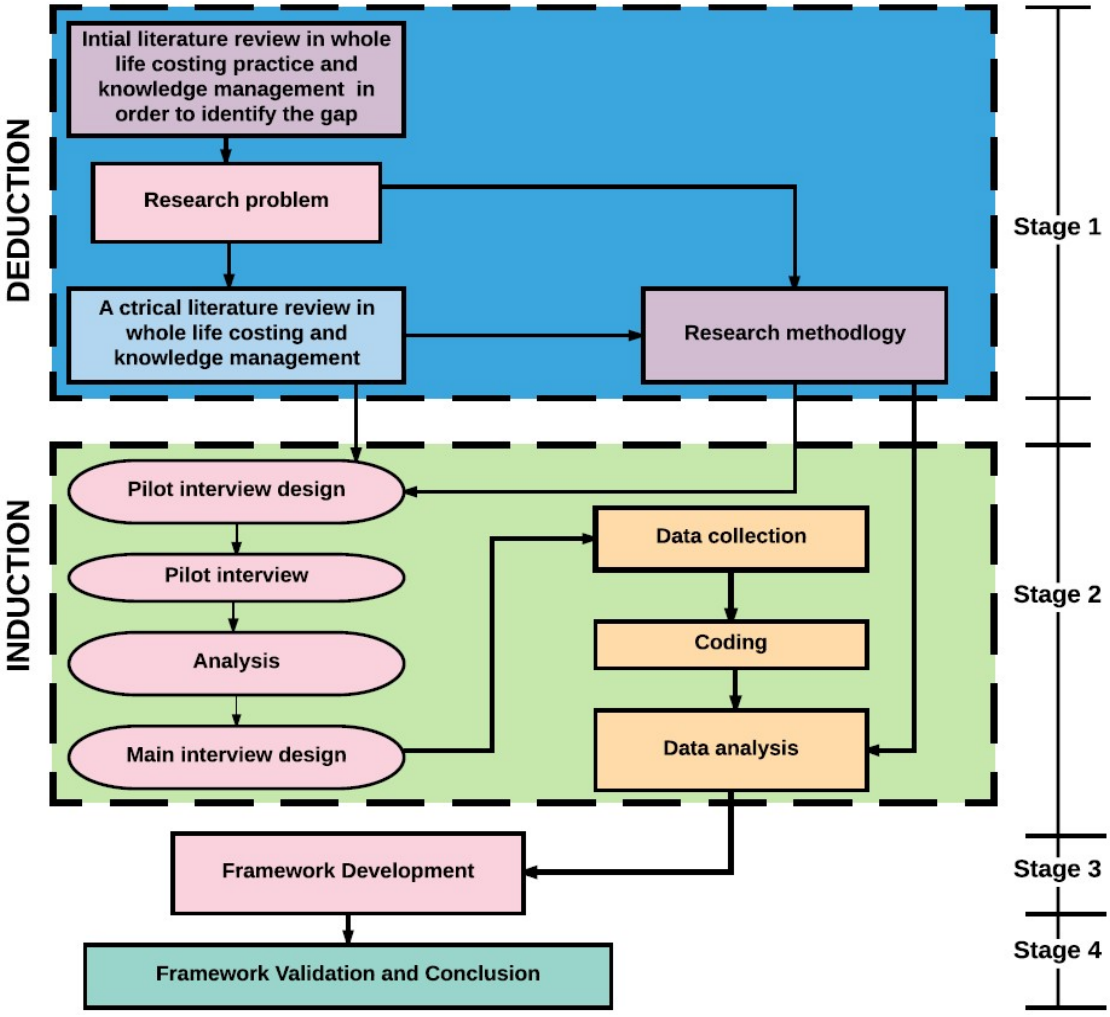
4.5.2 Inductive Approach

The inductive approach refers to the procedure in which theory would follow the data (in sequence from theory to method, to data and finally to findings) rather than vice versa as with deduction. According to Collis & Hussey (2009), the inductive research approach builds theory by collecting

qualitative data from personal interviews with the aim of understanding what is happening within a particular circumstance. They explained further that the researcher relies on the data that has been collected such as personal interviews to build theory with the aim of understanding what is happening within a particular circumstance. Basically, the inductive approach involves sense making from a research data, and the result of the process would be the formulation of a theory Saunders et al., (2009).

In order to improve the data analysis process this study combines elements of both deductive and inductive research approaches. The inductive approach is adopted at the stage one of the research which begins with the data first and then formulates a theory based on the data gathered while the deductive approach was adopted in the stage two of the research which formulates the theory first and then seeks out data to confirm or disconfirm this theory as show in Figure 4.3.

Figure 4.3: Inductive and deductive approach adopted



4.6 Research Strategy

Research strategy can be defined as the way in which the research objective can be questioned (Naoum, 2007). Strategies represent options and choices for the researcher. They promote, but are not in themselves methods for collecting data. There are eight common types of research strategy in social science, namely: experiment; survey; case study; grounded theory; ethnography; action research; cross sectional; and longitudinal studies (Saunders et al., 2009; Yin, 2009). The choice of appropriate research strategies should be guided by the research questions and objectives, the extent of existing knowledge on the subject, the amount of time and other resources available to the researcher, and the researcher's philosophical standpoint. A combination of two or more strategies can be adopted in one research. This study employed a multi-strategy method depending on the phase or stage of the research and adopted the onion model in order to capture the information needed.

According to Naoum, (2012), the manner in which the objective from research is probed is referred to as research strategy. Strategies epitomise choices and options for the researcher. These choices and option are classed as data gathering methods, they are encouraging. In the social science discipline, there are eight kinds of research strategy namely; action research, experiment, grounded theory, longitudinal studies, survey, cross-sectional studies, case study and ethnography (Saunders et al., 2009). Each research strategy is associated with a specific approach to gathering and analysing empirical data, also with their related benefits and shortcomings. No one is more fitting than the other for the purpose of research (Yin, 2009). The survey strategy was considered appropriate and was employed in this study to ensure the data is successfully gathered that could infer to the entire population. The reason for employing the survey research strategy is because it would be impossible to for the case to be manipulated during the study to see the reaction of people. The way people capture and recover knowledge cannot be measured. So, an experimental research strategy was unsuitable for this study. A wider generalisation would be attained when a case study strategy is adopted. As a consequence, the semi-structured interview was chosen as a suitable research strategy for this study.

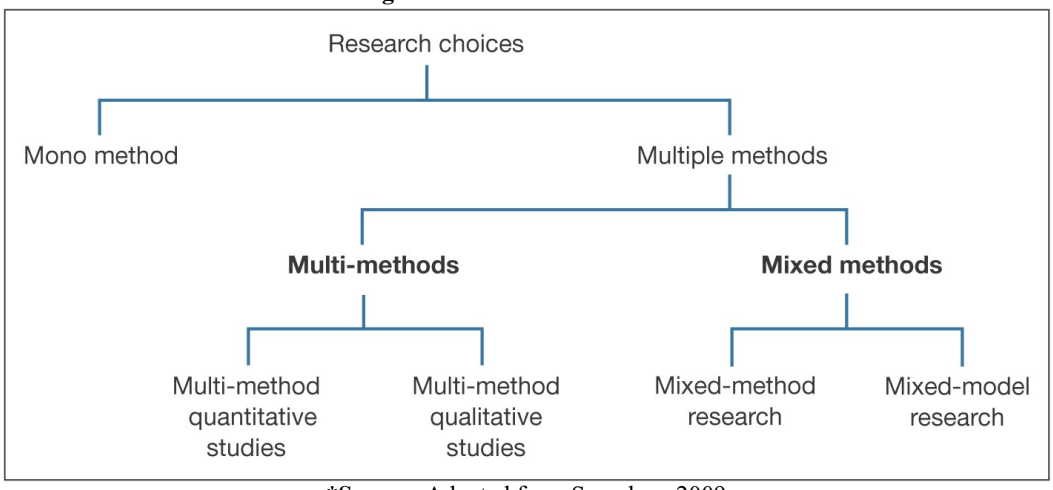
4.7 Research Choice

There are two research choices: 1) mono method and 2) multiple methods (Figure 4.3). A mono method study applies only one type of research method, either quantitative or qualitative, while a multiple methods study applies more than one method. A differentiation can be made within multiple method designs between multi-method research (multiple qualitative or quantitative methods) and mixed methods research (integration of quantitative and qualitative methods) (Creswell and Clark, 2011).

Several definitions exist for mixed methods research, however Creswell and Clark (2009: p. 5) define it as: "... a research design with philosophical assumptions as well as methods of inquiry. As a methodology, it involves philosophical assumptions that guide the direction of the collection and analysis of data and the mixture of qualitative and quantitative data in a single study or series of

studies. Its central premise is that the use of quantitative and qualitative approaches in combination provides a better understanding of research problems than either approach alone".

Figure 4.4: The research choices



***Source**: Adapted from Saunders, 2009

Writers such as Moser and Kalton (1971) and Bouchard (1976), as cited in Egbu, (1994), have argued that a combination of research choices is often more useful than a single one, since the different techniques yield different kinds of data, allowing a more comprehensive analysis of the phenomenon studied. Neuman (2011) suggested that it is better to look at something from several angles in order to get a fix on its true location. Just using quantitative data would be a positivist approach and would not be practical due to the large sample that would be required. An open qualitative approach would fit with an interpretive approach and could be undertaken by semi-structuring the interviews and combining with quantitative data. This combination of research choices would also mitigate, to a certain extent, the differing weaknesses in both methods (Amaratunga et al., 2002). Limitations in one method could be compensated for by the strengths of a complementary one (Marshall and Rossmann, 1999).

The use of a mixed method approach allowed multiple triangulations to take place. The two data collection techniques reciprocally helped in understanding and analysing the context and concept of knowledge capture and recovery in whole life costing and to validate the proposed framework. A literature review was used to address objective 1 and 2. The interview survey was used to obtain qualitative data to address objectives 3 and 4. Questionnaires were used to address objective 6. Edwards and Holt (2009) explained that triangulation could be applied either by the triangulation of data, investigators, theories, methodology, and/or by multiple triangulation. Table 4.4 outlines the five main types of triangulation, varied according to the nature of the component type (or mix) and the methods of triangulation used within this study.

Table 4.1: Types of triangulation

Type ID	Description (s)	Short explanation	Method used in the study
Data	Data triangulation	Entails gathering data through several sampling strategies, so that slices of data at different times and social situation, as well as on a variety of people, are gathered	Data was collected from 1 management level (Middle managers), practising quantity surveyors, project managers, and building surveyors
Investigator	Investigator triangulation	More than one observer is employed in data collection and/ or data interpretation	-
Theory	Theoretical triangulation	More than one theoretical scheme or theoretical standpoint is employed to interpret the phenomenon (e.g. via data)	• Theories from another discipline are used to explain a situation. • Comparison of general literature of KM, knowledge capture and recovery in whole life costing practice.
Method	Methodological triangulation	More than one method of data collection and/ or analysis is employed (e.g. may include a mix quantitative and qualitative sources)	• Use of semi-structured interviews • The use of content analysis • The use of questionnaire survey in validating the proposed framework
Multiple	Multiple triangulation/ Hybrid triangulation	Any combination of different observers, perspective, data sources, theories, methodologies, etc., used in the same investigation	-

Source: Adapted from Edwards and Holt, (2009)

4.8 Time Horizons

There are two types of time horizon to choose when performing research: cross-sectional studies and longitudinal studies. A cross-sectional research design was used due to time and cost constraints. A longitudinal study approach was not suitable as changes in knowledge capture and recovery approaches over time were not a subject of this study. The research objectives as drawn in Section 1.5 do not require a longitudinal study to be addressed since the study was not designed to observe any change over a period.

4.9 Data Collection Methods

There are two major sources for collecting data for a research study; they are the primary and secondary source of data collection (Saunders, Lewis, & Thornhill, 2009).

4.9.1 Secondary Research

Secondary research involves collating, summarising and reviewing existing data from more than one study to formulate collective evidence from previous experience and research (Bryman, 2008).

Despite the fact that qualitative researchers recommend to review the literature during the data analysis (Harding in Jupp, 2006; Creswell, 1994), a wide literature review was regarded as necessary and to be carried out initially in this research mainly because of four factors. Firstly, to properly frame the research problem, and clearly define the gap in knowledge that the research is set to cover. Secondly, to determine the most suitable research design. Thirdly, due to the inexperience of the researcher, inexperienced qualitative researchers need to cover the literature in the subject before the data collection and analysis; otherwise there is risk of data overload and lack of criteria to discriminate the relevant elements of data from the irrelevant pieces of information (Miles and Huberman, 1994). Lastly, to achieve good quality in qualitative research, training and knowledge are needed. It takes practice to sit with an open mind and an open agenda and not let nervousness get in the way of the free flow of information (Corbin and Strauss, 2008). Knowledge can help provide confidence to the inexperienced interviewer.

The literature set out to address the following points

- To clearly outline the knowledge gap this research covers
- To establish the step by step upon which this research is developed
- Identify and describe the major approaches of KM and knowledge capture and recovery.
- Provide a summary of techniques and tools of knowledge capture and recovery
- Present and discuss the most relevant studies.
- Demonstrate the functionality of whole life costing and conceptualising the effect of whole life costing uniqueness on the application of knowledge capture and recovery.

Various resources including databases, internet resources and online journals were searched, including those of the Association of Researchers in Construction Management (ARCOM) and the International Council for Research and Innovation in Building and Construction (CIB).

4.9.2 Primary Research

Primary research is concerned with data that are yet to be collected and generates novel information about a particular problem (Bryman, 2008). In this current research, a semi-structured interview was employed to collect data in the second stage of the research. A pilot interview and main interview were conducted to examine the existing KM practice, identify the techniques and tools available within the industry and explore the best practice of knowledge capture and recovery by interviewing experts from carefully selected companies

4.9.3 Interview Survey

An interview technique was used for data collection for this research. Researchers can choose from a wide range of methods of collecting information from sample members. The most commonly-used techniques of data collection include face-to-face interviewing, telephone interviewing and questionnaires (Roberts, 2007). There are different formats of interviews include face-to-face interviews which involving direct contact between researcher and the respondent or telephone interviews were the discussion is done over the telephone.

Gubrium and Holstein (2003) proposed that interviews are widely used techniques and undoubtedly provide reliable results for research. They indicated that interviews provide empirical data by asking people questions regarding their personal profile. However they indicated that the interviewer should ask proper questions and respondents will be obliged to provide the required information. Blaxter et al., (2006) described unstructured interviews as naturalistic. The interviewer can become more adept at interviewing; the researcher applies those strategies which enable interviewers to talk about the issues to a deeper level.

Creswell basically highlighted the importance of qualitative research and supported interviews to obtain quality data. Berg, (2009) indicated that qualitative methodologists prefer to obtain data through interviews, and this technique dominates in social sciences. This type of research takes time to undertake and time to analyse the data. Quality interview research focuses on what, where, and when. The qualitative methodology also stresses about concepts, description of issues, and detailed explanations. (Silverman, 2010) argued that research methodology is a way which addresses the issues in social sciences.

In addition to above, Berg, (2009) argued about the importance of interviews, and linked experience of interviewing in being considered the key to getting required data. He also suggested that interview questions should be written prior to starting interviews. The semi-structured interviews for this study were conducted face to face. Face-to-face interviews have the advantage of providing both interviewer and interviewee with non-verbal clues which promote the development of a rapport between participants involved. The main drawback with face-to-face interviews is that they tend to be cost-intensive. The research also involved travel to the interviewees' locations, which was a challenge regarding time and money. Prior to the main interview, a pilot study was designed to achieve five specific objectives:

- To collect primary evidence on the existing status of KM in whole life costing practice,
- To identify the KM techniques and tools available in knowledge capture in whole life costing,
- How effective are the available KM techniques and tools?
- What is the current practice of PR
- To identify appropriate interviewees within the participating construction organisation.

The pilot study was deemed the most appropriate method of data collection given the nature of the research (Naoum, 2012; Haigh, 2008). Three construction organisations with experience in the practice of whole life costing in construction project participated in the pilot interview, with organisations selected on the basis of geographical convenience and data availability. The sample size was determined by the purpose and time constraints of the pilot study.

4.9.4 Sampling

In order for this research's results to be a true representation of the complete group of people, the researcher has to choose the participants carefully. Population is the complete collection of elements to be studied (Triola, 2001). Identifying the correct population sample was deliberated. It was vital to ensure that a large population sample was used in the study in order to guarantee the study population was satisfactorily covered. RICS UK is a worldwide professional body promoting and enforcing the highest international standards in the valuation, management and land development, real estate, construction and infrastructure, so it was considered the appropriate medium for gathering the right organisation sample. According to the RICS website, it was discovered that 8000 construction firms were registered with the UK RICS carrying out different services such as project management, costing planning, risk assessment, health and safety, whole life costing and much more in the construction industry. According to Kumar (1991), the justification for utilising convenience sampling reliant on the judgment of the researcher. In other words, the research participants selected were the ones whom the researcher thought could provide the best information and were willing to be included in the study. It is noted that convenience sampling is frequently undertaken in business research (Zikmund, 2000).

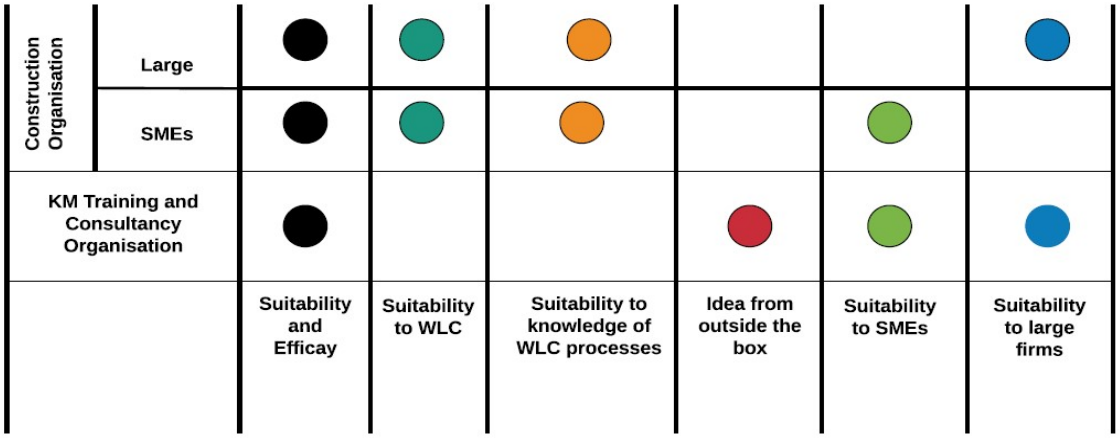
The selection criteria for the semi-structured interview were companies with:

- The active firm registered with RICS (unit of analysis in this study) and the contact person from management (embedded unit of analysis in this study) with experience in the use of whole life costing technique in construction project
- Moreover, those who were still in business
- That agreed to be a part of the semi-structured interview and the framework validation sessions.

As of 2015, RICS had 20,000 registered local firms and almost 8,000 active firms. An active firm was defined by RICS as a "local firm who has projects during the period their registration is in force. These firms are experienced and are serious about construction" (RICS, 2010). It was presumed that the views of these firms represented the present situation and attitudes towards knowledge capture and recovery within the firm. Emphasis was narrowed down to specifically identify the firm with experience in the practice of whole life costing in a construction project. The list of active firms with experience in whole life costing practice in construction project consisted of a total of 12 organisations

that were found to be active in the practice of whole life costing in construction projects. Invitations were sent to all 12-construction organisations to partake in this study. Four organisations agreed to participate in this study and during the interview arrangements; one organisation suspended the interview and later cancelled it. To enrich the study and prompt the most effective results possible, it was decided to involve two types of participants. Construction organisations and an idealistic representative organisation (an educational KM training and consultancy organisation). Four organisations yielded the total number of participants; three construction organisations and one KM training and consultancy organisation. The rationale using KM educational and consultancy organisation is because they are usually considered as pioneers in the fields in which they specialise. By having an opportunity to develop the practice and recommendations regarding KM and will most likely enrich the study, and may offer more thorough and reliable approaches.

Figure 4.5: Expectation criteria of the participants groups



4.9.5 Unit of Analysis

The unit of analysis for this study are organisation. The embedded units were individuals within the organisations. An organisation was defined as either an independent business unit within a larger company, or a standalone organisation. Organisations were primarily considered in terms of their sizes – small, medium and large. However, the classification guidelines and benchmarks to categorise organisations into "small", "medium", and "large" groupings remain highly context specific (Sedera, 2009). The numbers of employees for a small organisation varies by country and by industry. The European Commission (2007) clarified that the size of an organisation could be measured in terms of number of employees, annual turnover and balance sheet. In this study, the organisational size was measured by the number of employees, as this information was easily accessed, and because this study dealt primarily with organisational knowledge to which employees are the main contributors. However, Akintoye, and Fitzgerald (2000) and Newbould and Wilson (1977) have concluded that the choice of size measure is flexible and it does not matter very much in practice which measure are adopted as most measures highly correlate with each other. Newbould and Wilson, (1977) cited in

Egbu, (1994) are of the view that for practical reasons, only one measure should be chosen. Organisations having fewer than 250 employees were classified as SMEs, while those with more than 250 employees were classified as large. SMEs were further categorised into micro enterprises, small enterprises and medium sized enterprises (Table 4.2).

Table 4.2: Size of the participating organisations

Size of the construction organisation	**Number of organisation**	**Professional categories**	**Number of participants**
Small (less than 50)	1	Quantity surveyor	2
Medium (50 - 250)	1	Project manager and quantity surveyor	2
Large (more than 250)	1	Project manager and building estimator	2
Total construction organisation	**3**	**-**	**6**
Size of the KM training and consulting organisation	**Number of organisation**	**Professional categories**	**Number of participants**
Medium (50 - 250)	1	Co-director of course development	1
Total of non-construction organisation	**1**	**-**	**1**

Participating organisations	About the participating organisation
Organisation A	Organisation (A) is an integrated design and building firm founded on the principles of quality, innovation, respect and trust. Organisation A operates from a national network of key strategic geographic hubs: London, Brighton, Exeter, Haywards Heath, Norwich and Wakefield. Organisation (A) provides core services such as architecture, surveying, building service engineering, engineering and strategic development and consultancy.
Organisation B	Organisation (B) formed in 1954 and now has a staff of 76 and offices in Aberdeen, Glasgow, Leeds, Oxford, Melbourne and Sydney. Backed by a strong team of directors and senior staff, a sound client base and a reputation for continually developing expertise and knowledge, Organisation (B) has become one of the largest and most successful multi-disciplinary quantity surveying, project management and CDM co-ordination practices. Organisation (B). have a dedicated team of professionally qualified staff working in a culture of continuing professional development they combine specialist knowledge, skills, industry experience and technical expertise
Organisation C	Organisation (C) is a multi-discipline property and construction firm. Organisation (C) operates across all sectors, providing property consultancy expertise for asset management, modern procurement, planned maintenance programmes, innovative strategies and holistic delivery planning. core services include: project management, cost management, building surveying, building services engineering, building services maintenance management, property consultancy, architecture, civil engineering, structural engineering, health & safety, sustainability, legal support services, traffic & transportation, infrastructure commercial management.
Organisation D	Organisation (D) is a well-respected KM training and consultancy firm that produce bodies of knowledge are usually considered as pioneers in the fields in which they specialise.

Table 4.3: Participating organisations

4.9.6 Appropriate Number of Interviews

Qualitative study does not find the number of interviewees critical. According to Patton (1990, p.44), "in a qualitative study, there are no rules in the size of the sample. The size of the sample is dependent on what you want to know, the purpose of the study, what will be relevant, what's at stake, what will have reliability, and what can be done with the resources and time available". He also stated, "The validity, meaningfulness, and insights produced from a qualitative study have more to do with the information-richness of the selected cases and the analytical/observational capacities of the researcher than with sample size" (p.185). In this study, selecting appropriate participants who could provide plentiful information in representing the views of people in organisations was considered more important than the number of interviewees. Following this, individuals with sufficient knowledge and experience in the field of whole life costing practice in construction project were selected as appropriate interviewees for this study. The interviews in the main study involved four organisations (i.e. three construction organisations and one KM training and consultancy firm). Prior to the interviews, the human resource manager from each participating organisation arranged one to three people to be interviewed on an individual basis. At least one key person in each company who had knowledge of whole life costing in construction projects was contacted for an interview.

4.10 Data Analysis Procedure

Data analysis is an ongoing activity that helps to answer research questions and gives direction to future data collection. The analysis of data collected for this study was implemented in two phases: analysis of the pilot interview data and analysis of the main interview data.

4.10.1 Content Analysis

Data analysis happens to be one of the dilemmas of qualitative research. Tools and techniques are described in the literature (Miles and Huberman, 1994) that needs to be utilised based on the research objectives. Since the study at this stage was more exploratory in nature, content analysis was deemed appropriate for analysing the interview transcripts. A total of seven interviews were conducted, which was over fifty pages of interview transcripts to be analysed. The data collected was coded and analysed with the aid of content analysis, based on the guiding principle suggested by Gillham (2000), and Strauss and Corbin (1998). The data from the interview was immediately analysed after each interview so as to identify constant and regular themes. The inductive process suggested by Yin (1994) was employed with the intent of finding consistent themes that appear from the data and was augmented by the use of the deductive process to avoid misconstruction and misinterpretation of data. This whole iterative approach was successfully utilised within an interpretive methodological paradigm to recognise emergent and cluster themes or groupings while preserving the richness of the data (Huberman and Miles, 2002). The use of manual coding was considered suitable rather than computerised coding. According to Carley, (1990), manual coding has to do with the reading of text

and extraction of user-specified information considered relevant to its context and content. Nevertheless, as Morris, (1994) claims, that the use of manual coding in content analysis is more dependable but time-consuming. The following are the main reasons for the manual codification of data in this study.

- The number of interview carried out was relatively low (7)
- There were different groups of interviews involved
- The interviewees were asked a different number of the questions. The various groups of interviews used different terms on the same subject e.g. the word information management was interchanged for knowledge management.

After the content analysis, the picture becomes clear regarding what the most suitable method/s is/are. The suitable method depends on the content analysis. The method/s may come in different forms; one or more approaches would be suggested for use, without any change. Another possible form could be an integration of two method/s. The following scenarios are considered in the analysis:

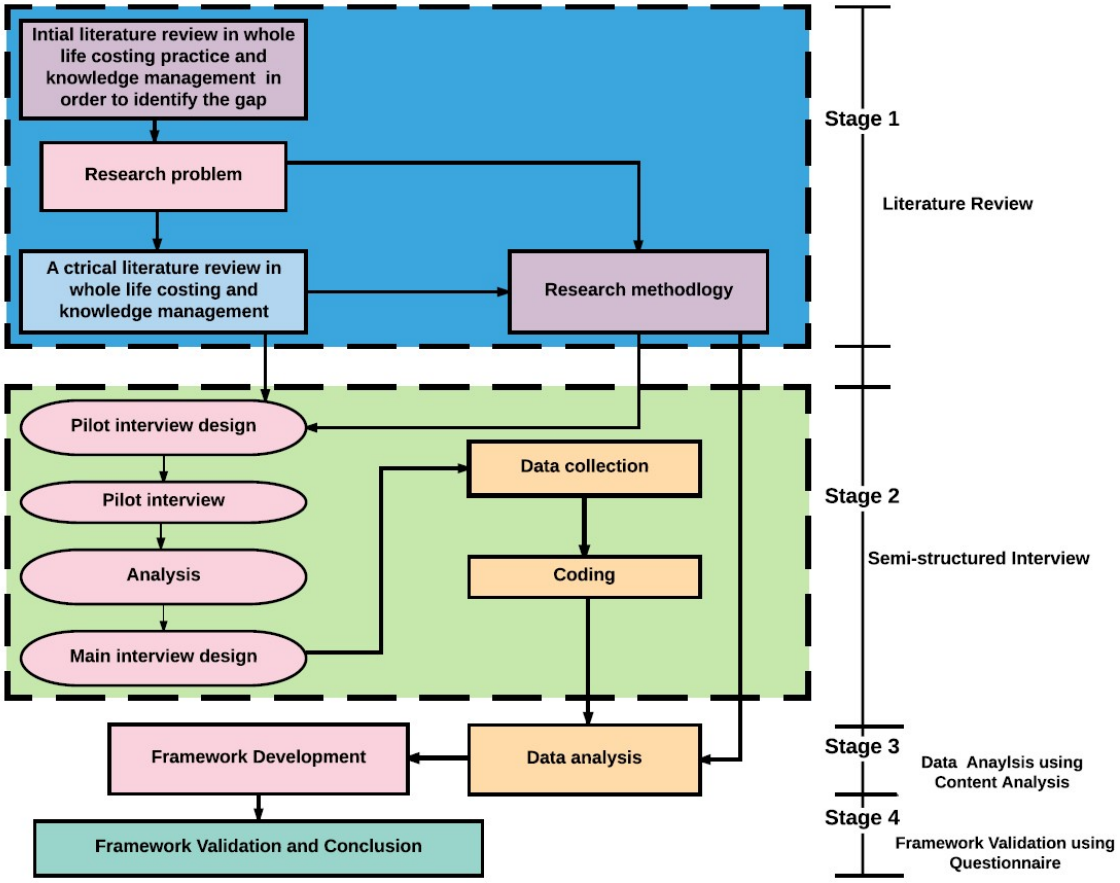
- In the case that all the participated organisations adopt one method/technique/tool for a certain KM process (e.g. knowledge capture); then the analysis will aim to show this without going further. This is simply because those organisations have a well-established method and the main aim of the study is to report their practices and utilise them in an integrated framework.
- If the organisations use different methods/techniques/tools for a particular KM process, then the aim of the analysis will be to identify those differences and then show them with evidence of both.
- The most suitable method,
- There is no one way better than the other, all of methods work to achieve the same level of performance or, the appropriate method depends on the need and/or the circumstances of the organisation/project.

The literature findings were also taken into consideration when the content of the transcribed interview data was analysed. This allowed the literature to be synthesised so as to identify any agreement or disagreement of theory vs. practice if any.

4.11 Research Design and Process

The research process is started with identifying the research aim and theories that based on articulating of the research problem, followed by research objectives and propositions, key aspects of this study shown in Figure 4.5.

Figure 4.6: Research Design



4.12 Research Procedure Adopted

4.13 Research Stage 1: Review of Literature

Saunders et al. (2009) viewed the proper establishment of the research problem as the most difficult yet most important element of research. The research problems of this study were established from the conclusions of the literature review.

4.13.1 Research Proposition Formulation

An initial literature review was conducted in the area of whole life costing and knowledge management at the beginning of the research in order to identify the gap. This resulted in the formulation of research propositions. According to Creswell, (1994) the research problem is defined by the research proposition or questions. For qualitative research purposes, Corbin and Strauss (2008) recommend the research proposition or question to be framed "in a manner that allows the researcher enough flexibility and freedom to explore a topic in some depth" (Corbin and Strauss, 2008, p. 25; Locke, 2007). During the first part of this research, the research problem is outlined by means of research proposition, aims and objectives.

4.13.2 Literature Review

After the research problem has been outlined, the literature review presented in chapter 2, and 3 introduces and discusses the knowledge in the subject area that is relevant to the research problem.

Objective 1: *To conduct the review of literature and document KM practice in construction and identifying the diverse KM tools and deployed in the construction industry*
Objective 2: *To conduct a literature review around whole life costing practice alongside exploring the use of KM in the construction sector and its applicability*.

Procedure: A detailed review of literature from various resources including databases, internet resources and online journals were searched, including those of the Association of Researchers in Construction Management (ARCOM) and the International Council for Research and Innovation in Building and Construction (CIB) which helped to clearly outline the knowledge gap this research covers, to establish the step by step upon which this research is developed, identify and describe the major approaches of KM and knowledge capture and recovery, provide a summary of techniques and tools of knowledge capture and recovery, present and discuss the most relevant studies and demonstrate the functionality of whole life costing and conceptualising the effect of whole life costing uniqueness on the application of knowledge capture and recovery.

4.14 Research Stage 2: Preliminary Data Collection and Pilot Study

4.14.1 Preliminary Data Collection by Semi Structured Interview

Objective 3*: To explore the existing KM practices by defining the tools and techniques commonly used and their efficiency in capturing knowledge from whole life costing practice, the capacity of recovery, and the existing practice of PR.*

Objective 4*: To explore and uncover the details common in advanced approaches deployed in knowledge capture and recovery in the course of undertaking whole life costing practice in construction projects.*

Procedure: A semi-structured interview was employed to collect data in the second stage of the research and so a pilot interview and main interview were conducted to examine the existing KM practice, test the problem and identify the techniques and tools available within the industry and explore the best practice of knowledge capture and recovery by interviewing experts from carefully selected companies.

4.14.1.1Pilot Study

A pilot study would provide an opportunity to test some of the research objectives and research questions; thus, enabling the researcher to make necessary changes or amendments before the primary

data collection is conducted. A pilot study acts as a rehearsal for the main study and helps refine the data collection instruments needed to collect data for the study (Yin, 2012). The pilot study will highlight any issues that have been overlooked in the design of data collection instruments. It will provide insights into the questions that have been phrased for this study and how the study is planned to be conducted. It can also provide insight into the layout and duration and length of survey or interviews that will help provide the ideal kind of results.

For the initial data collection, one data collection instrument was identify to be suitable for this study based on the information gathered from the review of literature. The data collection instrument was used to assess the viewpoint from whole life costing experts in construction organisations, to identify the existing KM tools and techniques used in knowledge capture and recovery in whole life costing, to identify appropriate respondents, to identify the most efficient way of collecting the data and to identify any other areas that could be investigated through a semi-structured interview. Three construction organisations was used to conduct the pilot and had several comments about the interview. He highlighted some issues with the total duration of the interview. He felt that the researcher should endeavour to complete the interview in about an hour; otherwise, the individuals responding to the interview will lose interest. Therefore, a note was made to keep track of time while conducting the interview.

4.14.1.2Interview Process

Prior to the commencement of the interview process, a list of questions was set to ask the interviewees which were checked by the researcher's supervisor and four research colleagues at the University (The Robert Gordon University, Scotland, UK) and experts in the construction industry.

The outcome of the peer review/discussion regarding the list of interview questions proved to be advantageous which led to the fine-tuning of the interview questions for the pilot study and main study stage. Pilot interviews were conducted with the intent of identifying the existing KM tools and techniques used in the participating construction organisation and to also test the interview questions and to improve the interviewing skills, as suggested by Creswell (2009). The interviewees were contacted to request their consent to be interviewed. Prior to the interview, the purpose and the aim of the research were communicated using a various media platform to ensure clarity regarding the research aim. E-mails were sent to the individuals in the organisations/link individuals who expressed a willingness to approach potential interviewees.

Interview sessions via face to face were organised in advance considering the suitability of time and place. This was to ensure that the interviewees were prepared and without disturbance by their surroundings. Arrangements were made by earlier conversation with the persons involved and through personal and official contacts.

The names of the interviewees and the organisations were kept confidential, and the actual names were immediately replaced during the interview with codes. Each interview lasted for about one hour and was undertaken in the office rooms of the interviewees (between 10.00am to 11.00am UK GMT). The interviews were arranged for the convenience of the interviewees. Most of the respondents preferred to be interviewed either in the early morning or the late afternoon. This was to ensure that they have a maximum concentration on the problems discussed and to lessen disturbance in their working schedules. Interview sessions were recorded using a free Smartphone app recorder called 'Dictaphone'. The quality of the voice recording was not an issue, particularly with Dictaphone app.

4.14.1.3Recording

Consent was obtained from the interviewees to record each interview session. The digital recording of the interview sessions was considered appropriate in this study in order to ensure accuracy so that any additional information that was not noted down at the time of the interview could be later transcribed for further analysis. As acknowledged by Gray (2013: p. 227) it is important that interview sessions are tape recorded as it assists the researcher record important information while allowing them to focus on the listening process, interpreting and refocusing the interview. It was vital to get the interviewees to speak freely to gather information and cover all the areas during the interview. Prior to the interview, questions were prepared beforehand, nevertheless as the interviews progressed and further questions arose; additional relevant questions were inserted naturally into the flow of the interview. The interview file from the Dictaphone app in the Smartphone was transferred onto a laptop immediately after the interview and then given a numeric code after conducting the interviews; the recording was carefully listened to and transcribed word for word. Listening to the recording for the second time followed by the typed transcription was done to ensure that the recording and the data transcribed were in agreement. This was done to ensure the consistency of both the data and interpretation. The interviews were manually transcribed due to the handful of interviews conducted and also in order that the researcher becomes familiar with the data.

4.15 Research Stage 3: Data Analysis and Framework Development

Objective 5: To utilise the findings gathered from objective 3 and 4 to develop a whole life costing knowledge capture and recovery framework (WLCKCR).

Procedure: The data gathered from stage 2 was analysed qualitatively. Content analysis was used to analyse the semi-structured interviews signifying the suitable method/s to be used in the framework. . Since the study at this stage was more exploratory in nature, content analysis was deemed appropriate for analysing the interview transcripts. A total of seven interviews were conducted, which was over fifty pages of interview transcripts to be analysed. The data collected was coded and analysed with the aid of content analysis, based on the guiding principle suggested by Gillham (2000), and Strauss and Corbin (1998). The data from the interview was immediately analysed after each interview so as to

identify constant and regular themes. The inductive process suggested by Yin (1994) was employed with the intent of finding consistent themes that appear from the data and was augmented by the use of the deductive process to avoid misconstruction and misinterpretation of data. This whole iterative approach was successfully utilised within an interpretive methodological paradigm to recognise emergent and cluster themes or groupings while preserving the richness of the data (Huberman and Miles, 2002). The use of manual coding was considered suitable rather than computerised coding. According to Carley, (1990), manual coding has to do with the reading of text and extraction of user-specified information considered relevant to its context and content. Nevertheless, as Morris, (1994) claims, that the use of manual coding in content analysis is more dependable but time-consuming. The following are the main reasons for the manual codification of data in this study.

- The number of interview carried out was relatively low (7)
- There were different groups of interviews involved
- The interviewees were asked a different number of the questions. The various groups of interviews used different terms on the same subject e.g. the word information management was interchanged for knowledge management.

After the content analysis, the picture becomes clear regarding what the most suitable method/s is/are. The suitable method depends on the content analysis. The method/s may come in different forms; one or more approaches would be suggested for use, without any change. Another possible form could be an integration of two method/s. The following scenarios are considered in the analysis:

- In the case that all the participated organisations adopt one method/technique/tool for a certain KM process (e.g. knowledge capture); then the analysis will aim to show this without going further. This is simply because those organisations have a well-established method and the main aim of the study is to report their practices and utilise them in an integrated framework.
- If the organisations use different methods/techniques/tools for a particular KM process, then the aim of the analysis will be to identify those differences and then show them with evidence of both.
- The most suitable method,
- There is no one way better than the other, all of methods work to achieve the same level of performance or, the appropriate method depends on the need and/or the circumstances of the organisation/project.

The literature findings were also taken into consideration when the content of the transcribed interview data was analysed. This allowed the literature to be synthesised so as to identify any agreement or disagreement of theory vs. practice if any.

4.16 Research Stage 4: Framework Validation

Objective 6: To validate the framework through academic and construction expert's evaluation

Procedure: The fourth stage of the research is the framework validation. Testing the general feasibility of the framework by applying it to a large number of companies representing the industry has not been possible in this research. Assuming that 180 randomly selected companies are a representative sample, and the required resources are available in those companies, it would only take five months to implement and test the framework (practically it would take years). However what if the framework did not work? This would mean a loss of time of 900 months (180 companies' × 5 months) and therefore considerable effort. The framework evaluation by experts was considered another alternative for the framework evaluation. In fact this method was considered advantageous with regards to value, risk, and finance. In this case the evaluation method by experts could be considered the most appropriate method even though the "generalise by implement" method was considered possible. The purpose of the evaluation method therefore was not to predict that the framework was applicable in the companies of the participated experts; but to obtain the expert's evaluation regarding the suitability of the framework in the industry. The suitability of the framework was not considered sufficient however; because the suitable framework did not necessary mean it would add value. For this reason, efficiency was another criterion the evaluation sought to answer. The feedback from validation experts during the framework validation wasn't used in the refinement of the framework because the capture and recovery of knowledge in whole life costing is an emerging area of research. However, it was put forward on the list of recommendation for further studies.
The data were collected via a web-based questionnaire survey. Web-based surveys are gaining in popularity (Dillman, 2000). Sproull (1986) found that data collection via e-mail has the advantages of producing adequate data, enhancing response rates, and engendering a willingness to further participate with the minimum expenditure of the researcher's time and effort and a high degree of convenience for the respondents. An online survey technique was chosen, since it is easier to access a large number of people and also provides an efficient way to collect responses from the participating organisations situated in different geographical locations in the UK.

The selection of appropriate respondents was also an important aspect of this research. An 'expert opinion' validation using a questionnaire accompanied by the proposed framework was distributed to 20 experts. The participants involved in the framework evaluation included two categories of experts: academic and construction practitioners. The practitioners are involved with whole life costing practice in the construction projects and therefore have a better understanding of the daily work. Their participation in a project which requires whole life costing practice implies they can work with other organisations that practice whole life costing in the construction sector and can understand the reality of work environments. Academics are expected to have a deep insight into the diverse methodological

viewpoints surrounding observation and analysis. Furthermore, the academics rely greatly on the construction industry as a primary source of information, so working as a collective body makes for ease of purpose acquisition. Emails were used as a tool to invite experts and included;

- An overview of the research project
- Request to participate in the evaluation of the framework for the purpose of validity
- Request the best times which suits each of the case study organisation for a 25 minutes interactive online presentation.

The proposed framework was presented to each participating organisation using Microsoft Office PowerPoint 2013 and a voice over was in cooperated. The presentation was interactive in which participants simplified the explanation; while diagram parts were moved in each presentation slides accordingly. The presentation was calibrated into 8 slides which took a narrative sequence of logic since it began by clarifying the parts of the framework independently and afterwards presented the strategic framework as shown the Appendix E.

Table 4.4: A summary of the adopted research methodologies in this study

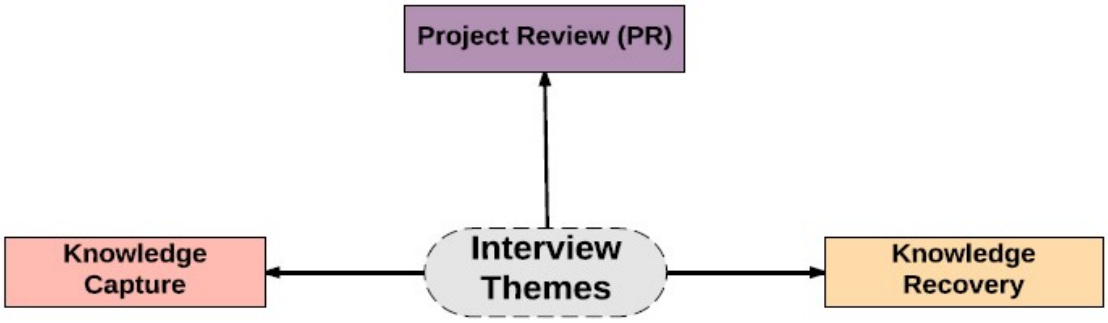
Research design and content			
Research methods	Mixed methods (qualitative and quantitative methods)		
Research	Cross sectional		
Unit of analysis	Construction organisations and KM training and consulting organisation		
Interviewees	Experienced project managers, quantity surveyors and a KM training instructor		
Framework evaluation participants	Academics and construction professionals		
Data collection	**Pilot interview**	**Main interview**	
	Pilot interview	**Main interview**	**Questionnaires from conceptual framework validation**
Interview time	20 – 30 minutes	30 to 60 minutes	•
Database	Royal Institute of Chartered Surveyors (RICS) directory 2015		Royal Institute of Chartered Surveyors (RICS) directory 2015
Sampling strategy	Purposive and convenience sample		Purposive and convenience sample
Recording instrument	Smartphone Dictaphone app		Online presentation and survey monkey website for questionnaire design.
Sample location	UK base construction organisations		• UK base construction organisations (contractor) • Academics from UK base universities
Sample size	• Three construction organisations • One KM training and consultancy organisation		• Ten participants from a UK based construction organisations (contractor) • Ten participants from a UK based university
Data Analysis			
Analysis	Content analysis		Statistical analysis
Analysis tool	Manual coding		-
Total number of participants	Seven participants		Twenty participants

4.17 Interview Themes

Researchers conducting qualitative research often employ theoretical lenses as a guideline in their research (Creswell, 1994). The questions to be presented to the interviewees during the interview sessions is the greatest concern and it is vital to determine them prior to the interview. Nevertheless, in the semi-structured interviews, it is essential that the context of the interview is established; by identifying the interview themes. There are many approaches used in setting up the context of the research, one approach may be fitting for one particular research study, but may not be appropriate for another. Anderson, (2014) who underlined that clarifying the objectives of the research or questions during the interview will influence the answers provided by the interviewees and will help the identification of key themes that need to be explored with the interviewees. Rugg and Petre, (2007)

added that themes could also be driven by theories discussed in the literature review, the experience of the research in the area of discipline, discussion with colleagues, fellow research student's common sense, or a mix of these (Saunders et al., 2009). The themes of the interview in this study were mainly identified based on the research proposition. Nevertheless, more specific areas were formed under each theme and were driven by literature (theory).

Figure 4.7: Interview themes

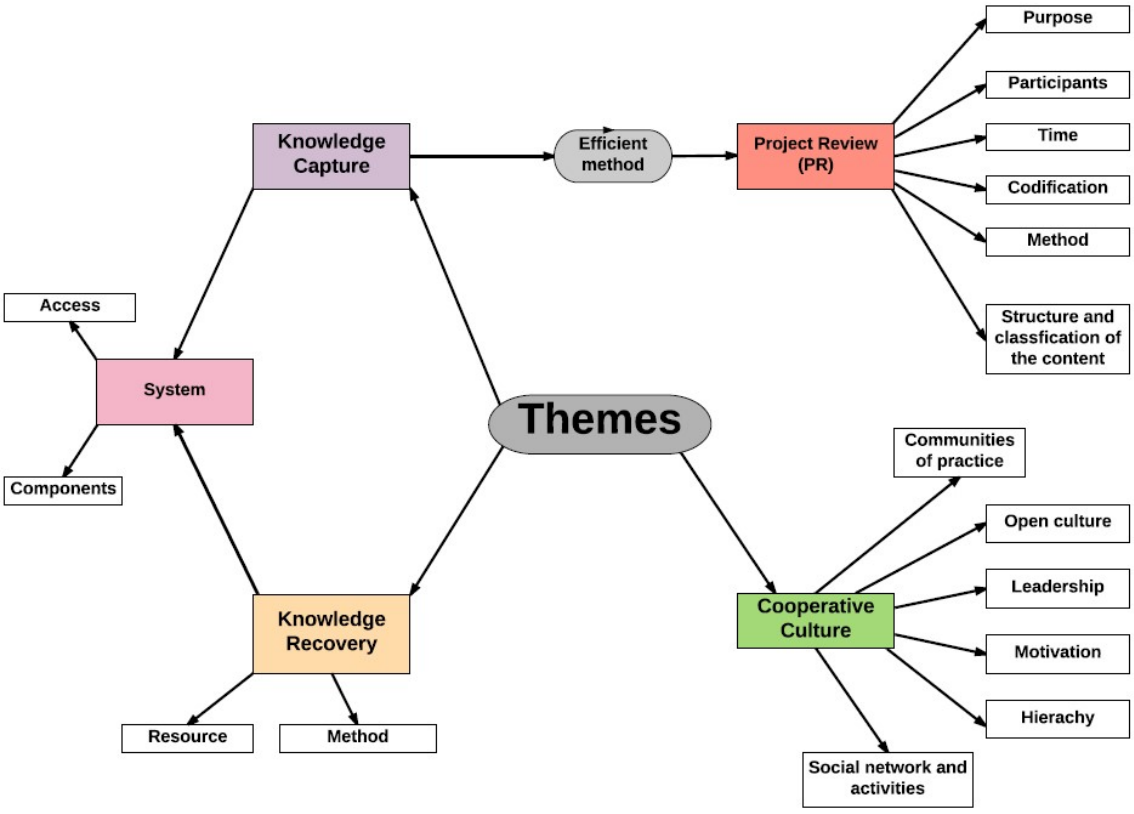


Three main interview themes were determined as shown in Figure 4.4 and also an in-depth exploration will be carried out into these themes. In order to avoid questions that will result in the interviewees providing specific answers and also to avoid the presentations of the researcher's comprehension regarding the research area, it was decided to commence the interview with open questions for every theme which is the "how" question. For instance, how does your organisation capture knowledge from whole life costing in a construction project? This assisted in obtaining a clearer picture by asking particular questions. However, in order to attain the research objectives in this study, it is essential to have some control over the interview. It was important to ensure that the discussion was on track and the key points identified previously were addressed. Using open questions does not necessarily imply it is possible to have control over the interview. Prompting and probing are approaches that can be utilised to assist in attaining the interview objectives (Gillham, 2000). The interview scenario is dependent on the answers provided. It was anticipated that some of the interviewees would go through those key points with no need to prompt them. Nevertheless, if key points are not covered by the interviewee, the interviewee will be prompted; (for instance, after the interviewees have described the approaches of capturing knowledge in whole life costing practice within their organisation, the interviewee can be prompted to find out what sort of technology was utilised in the knowledge capture). Furthermore, probing questions will be used to acquire more information from the subject (for instance, could you explain in detail how PR is conducted).

After the collection of data, it was discovered that the themes for interview might be invalid for data analysis. The reason was that the perception of the themes and topic before the interview was conducted were not the same as after the collection of data. So, it was necessary that the themes

developed previously be revised and revamped for the purpose of analysis. Themes may have other terms in the literature which refer to coding. Cording aids in the structuring of materials into chunks before bringing meaning to those chunks (Rossman and Rallis, 1998).

Figure 4.8: Context of the analysis



4.18 Research Ethical Considerations

Ethical issues area always encountered at all research stages (Saunders et al., 2009). Research ethics has to do with how a research topic is formulated, clarified, designed and having admittance to gathering data, processes and the storage of data, analyses of the data and writing up the research findings in an honest and responsible manner (Saunders et al., 2009). The general ethics suggested by Saunders et al., (2009) were observed in this study. These include:

Voluntary participation: the collaboration of potential interviewees was obtained via e-mail, followed by a letter (see Appendix D) to the organisations/link individuals who had expressed a willingness to approach potential interviewee. The opportunity to withdraw from the study at any point was given to all participating organisations. Each participating organisation completed a consent to acknowledge that their participation was voluntary

Informed consent: In order to obtain the consent of each participating organisation, a systematic approach was put in place. Consequently, before the data was collected, a formal covering letter was sent explaining the research objectives and the method of data collection alongside the intention to have the results published. Confidentiality and other related issues were discussed (see Appendix A). The researcher requested the consent of the interviewees to record each of the interview sessions.

Avoidance of harm: The basic ethical principle governing the collection of data is that no harm should befall the interviewee due to their participation in the research (Oppenheim, 1996). There are three kinds of harm that could befall interviewees in research according to Sarantakos (2005), these include mental, physical and legal. The three kinds of harm were considered and addressed accordingly; personal enquiries and issues that are sensitive were not explored and interviewees were treated with respect, eliminating the risk of mental harm. Legal harm was also not deemed as a possible risk because discretion was maintained and the interviewee's right was not violated.

Confidentiality: The key ethical issues were that the information collected from the interviewees would be kept confidential. Confidentiality was essential to keep the details of the participant's private (Miles and Huberman, 1994; Yin 1994). Due care and diligence were taken through all private interactions to maintain and respect the confidentiality and privacy of the interviewees (Miles and Huberman, 1994). For the interview, the participating construction firms were allocated with alphabets while their positions in the organisation were maintained. Names and matching identification alphabets were saved in a separate, private database which was only accessible to the researcher. Participants were assured that the information gathered would be kept strictly confidential and only utilised for the purpose of the research. The data collected would not be made accessible to any third party or utilised in any published material. A guarantee that the responses from the interviewees would be kept confidential may well have contributed to the truthful nature of the responses.

Anonymity: An agreement was reached regarding the anonymity of all participating organisations and individuals. Anonymity during the collection and analysis of data was maintained. The actual names of participating individuals and organisation and location were omitted in the thesis but have been replaced by pseudonyms. So that the quoted materials can be contextualised and presented in this thesis, an attribute of the interviewees (such as position and seniority) that matters to the argument will be provided in order that anonymity does not destroy the context of the data.

A comprehensive ethical clearance checklist was submitted to the Robert Gordon University Ethical Advisory Committee prior to the commencement of the data collection. This study received ethical clearance from them.

4.19 Summary

The different research philosophy, techniques and methods are explored and presented in this chapter. It also explained the approaches used in this study. Ontology and epistemology were both found to be vital to this study. Ontology, on the one hand, is a key to the formative stage of the study as it

informed the researcher's perception of KM and the application or development of whole life costing as well as opinions held in the construction management industry. While epistemology, on the other hand, was a key to the handling of the interview sessions and subsequent analysis of data obtained for the validation of the framework for use in knowledge capture and recovery in whole life costing practice.

A systematic review of the literature was employed in this study to enable development of the research problem. A pilot study was used to collect data through semi-structured interviews with three (3) construction organisations, the outcome of which guided the selection of the sample for main data collection. The main interview was conducted using three (3) construction organisation and one (1) KM training and consultancy firm. Saunders et al.'s (2009) research process onion model was explored while identifying the research philosophy, approach, strategy, choice, and data collection method.

CHAPTER 5 : Data Analysis

"There are known knowns. These are things we know that we know. There are known unknowns. That is to say, there are things that we know we don't know. But there are also unknown unknowns. There are things we don't know we don't know". **- Donald Rumsfeld**

5.1 Introduction

This chapter focuses on analysing and presenting the results gathered from the pilot and the main interview. The purposes of the interviews are to explore the existing good practice of how knowledge is captured and recovered in whole life costing practice and among participating construction organisations, also to discover answers to WLCKCR offered outside the construction industry in a sample which consists of KM training and consultancy organisation. The interview analysis ought to produce information that is adequate and enough to develop a conceptual framework for capture and recovery of knowledge in whole life costing practice in a building project in the next chapter.

5.2 Findings from Pilot Interviews

A pilot interview questions was developed to solicit the necessary data to explore the existing KM tools and techniques and their efficiency in whole life costing practice used in the participating construction organisation in capturing knowledge.

5.2.1 Existing IT tools commonly used and their efficiency

IT tools are considered enablers which assist organisations in sharing and processing knowledge (see section 2.12 for more detail: literature). This section aims to identify the existing IT tools used in the participating organisation and their efficiency. A list of IT tools was presented to the participant organisation. They were requested to identify the IT tools that are available and regularly used in their organisation.

According to participant organisation (A):

"*The most commonly used IT tools within our organisation are emails, websites and expert directory…… we find them very efficient because it allows us to share information amongst ourselves……. like the expert directory are employed to identify the right professionals and contractors to……. We use the emails for easy communication and sharing of information…. I rather send information via mail than printing them off….*"

While organisation (B) identify website and email as the most commonly used tools within their organisation.

"Website email plays a key role within our organisation…. Most times, confidential information which requires being shared amongst certain individuals within the organisation gets missing in

transit when posted and sometimes doesn't get to the right individuals on time……in this case, I would email are the best in information sharing ……. Web sites also play a vital role as well because it allows users search for information about products online ….”

Organisation (C) adopted similar IT tools commonly used in organisation (A). According to organisation (C):

“Email is the most commonly used IT tool in our firm…….it is an effective platform for sharing information……. Also, expert directory is commonly used to locate experts ……. In summary, I would say emails, website and expert directory are the most common and efficient tool within our organisation…”

From the three-participating construction organisation, Email was the most widely used in IT tool, followed by the website.

5.2.2 Existing KM techniques commonly used in knowledge capture and their efficiency

KM techniques are used as part of KM alongside the processes, methodologies and strategies (see section 2.10 for more details: literature). This section seeks to identify the existing KM techniques commonly utilised in knowledge capture in the participating organisation and their efficiency. A list of KM techniques was presented to the interviewees from the participating organisation. They were requested to identify the KM techniques regularly used in knowledge capture and their efficiency.

According to organisation (A):

“Training, PR, and knowledge team are the most common techniques deployed within our firm……. We deploy PR in our organisation since it aids us to identify faults made and promotes learning from the mistakes made and we find the technique to be very efficient…… currently, we are doing away with knowledge team because it cost much money to maintain the knowledge……. I would say PR is the common and most efficient followed by the training….”

Organisation (B) could only identify one KM techniques which is commonly utilised within their organisation by commenting:

“*From the list of the KM techniques presented. PR rings a bell, and it is mostly adopted within our organisation……. PR is very potent in our organisation in as much as it assists us in prompt and instant view of our performances on a given project to improve prospects for decisions in future*”.

While organisation (C) employs the same KM techniques as organisation (A). According to organisation (C):

> "*PR and training are the most utilised KM tool within our firm……..PR is effective in our organisation because it helps to enhance team discipline, prevents weaknesses within the project team and helps the organisation in painting their oversights and lessons learnt in the project which will help enhance the improvement of future projects……."*

From the above quotes from the different organisation regarding the commonly used KM techniques and their efficiency, PR was identified as the most commonly used KM technique followed by training. However, the section does not only identify the most commonly utilised KM techniques and its efficiency. It goes a step further to identify the purpose of the most commonly adopted KM techniques. Organisation (A), (B) and (C) consider KM as techniques which assist them in capturing mistakes and lessons learnt during a project. The literature findings and the interview analysis are in agreement, which considers PR as achieving the purpose of project knowledge capture (see section 2.9 for more detail: literature).

5.3 Findings from Main Interview

5.3.1 System

Knowledge management systems (KMS) are considered to be IT-based systems designed with the intent of improving and supporting organisational processes of KM and supporting the processes of creating and integrating knowledge into an organisation (see section 2.11 for more detail about KMS: literature). This section aims to identify and present KMS used among participating organisations. It also identifies the role of the system and how access can be gained from it, as well as the kind of network used in their development. Lastly, it examines the components that are found in such systems. In the course of the interviews, no specific theme was formulated for collecting data regarding the technology and system. This was basically due to the remarkable connections between technologies and other subject matter or themes as is the case in the capture and recovery of knowledge. So, it was resolved to gather ICT-related data while uncovering other themes so as to avoid IT being separated from its function. This technology-related data is now overt and patterned for accurate data presentation; moreover, presenting and analysing critical data that is system-bound in a different grouping and providing all the answers in this section in an unswerving scheme was crucial to this part of the study.

ICT in literature is viewed as an essential facilitator for the application of KM, which system makes up the main component employed to enhance KM (see sections 2.11: literature review). Consequently, it was believed that the system would be a component of KM practice in any reliable KM practice. The interview uncovers comprehensively that all the participating organisations operate with a KM system. When the question of how knowledge is captured in whole life costing practice is asked. Some of the participants began listing the available systems in their organisation. This gives a clear picture of how vital KM is to the participating firms.

According to organisation (A):

> "*Many reports are written about each project and filed electronically. We have a filing system called ……."*

While organisation (B) have employed a similar method to organisation (A) by commenting:

> "*We previously write reports in paper and store them in drawers. However, currently they are held electronically."*

While organisation A and B electronically write and file a report. The filing of reports electronically (technical library) was inclined by organisation (C) which was justified by the project manager.

According to organisation C:

> *"The idea is, instead of having pieces of papers lying around, it is best if it is uploaded on the organisation's intranet. It cost you nothing, and it takes a couple of minutes to put that up on the intranet and made accessible to all the project members within the organisation."*

Organisation C further added that; "*We are blessed to have IT competent personnel, who oversees all the IT related problems within our organisation*."

The system may be expensive or inexpensive; in either case, it may still be effective or ineffective, even when it is an expensive system. Organisation (C) is a small and medium-sized enterprise (SMEs) which has a system that was generated by an in-house project manager. If KM practice in organisation (C) is at the innovative stage, it may be concluded that SMEs can acquire a system that is affordable so as to accomplish all the forecast functions efficiently.

5.3.2 System access

The development of a system can be built using an internet, intranet or extranet network. In spite of the fact that the internet can be accessed by the public, the extranet offers access to certain users internally and externally in the firm, and the intranet limits admittance to the system to individuals within the firm (see section 2.11.1 – 2.11.3 in the three kinds of network). The systems of the three participant organisations are rooted on an intranet network.

According to organisation (A):

> *"We have an intranet system which grants you access when you switch on your computer, and that serves as the portal to the whole body of information on central services."*

Although the intranet is utilised as a premise for the system, access to certain aspects of the system or the entire system can be restricted to members of the organisation. There are three stages in accessing the system: admittance to view the system content, admittance to add content in the system, and admittance edit content. All the organisations that participated grant entry admittance to view content

to everyone in the establishment. This enhances the way data is shared using the system. Nevertheless, some parts in the system are restricted, and not everyone in the organisation has access to it. Two factors are considered to be responsible for such denial. Firstly, certain data is considered secret, the disclosure of the information could harm the establishment or its clients. Secondly, making such information open to some members might be disadvantageous to the organisation.

According to organisation (B):

> *"Many materials in our organisation is commercial; to a certain extent delicate and thus, limited to the project team."*

Some information in organisation (B) to a certain degree is not made available to the project team. Maybe it is the policy of the organisation to keep certain sensitive information limited to the project team.

Organisation (A) avoids client information disclosure and only utilised it within the organisation by commenting;

> *"Some of our clients like keeping some information private (undisclosed) and only some portion of it can be used by the organisation*."

Obtaining approval to add information to the system, it was discovered that three methods were used by the three participating construction firms. Firstly, to assign the duty of adding content to a certain person in the organisation. Similar to organisation (C) where the project manager takes responsibility for adding content to the system. Secondly, everyone could be given permission to adding content, but any added content must gain authorisation by a certain member. Thirdly, everyone could as well be given the right to add content to the system.

According to organisation (C)

> "*Yes. Information can be added to the system by everyone. However, such added information must be authorised by the team leader before it can be used by the project team."*

This is to some extent fitting because it could reduce the chances of system information overload.

Organisation (A):

> "*Content can be added to the system by everybody, but it is not everything you can add to the system. You can, however, your materials can be edited by yourself but not that of others."*

It should be considered that 'what is to be added' to the system does not imply the embodied work from a PR. Rather, it comprises the details of members in the organisation or details from outside the organisation, external links to the business; it could also be instructional tips regarding a step by step guide of how a job is undertaken, etc. When admittance is given to add content, information is limited

to some individuals in the firm, it could be any or both of these reasons; the first reason is that other members are either not equipped to add content while the second is that operating an open-door admittance to everyone in the firm to add information could cause unnecessary additions to the system. The first reason may, however, be resolved by ensuring that everyone gets the appropriate training on how to effectively add content while the second reason can be addressed through the authorisation procedure and by carefully instructing members on what to add. Therefore, the method adopted by the organisation (C) is deemed the most effective technique.

While some of the organisation's intranet is allowed to be opened internally, one participating organisation revealed that the intranet system can be accessed from anywhere.

Organisation (A):

> *"We have the sort of access to the firm's intranet network remotely…. if anything is added to the intranet….it can be accessed from elsewhere*."

5.3.3 System components

Notwithstanding the fact that every organisation that participated adopts a system for promoting KM practice, the elements and functions of the system are different from one firm to another. However, since this aspect of the study is technology-related, the issues linked to the goals of the components will be considered in subsequent sections. This section seeks to establish what the components of the system used in the participating organisations are made of.

According to organisation (A):

> "*Our system component is categorised in five ..... People, project, insights, network and essentials ……each of the system components mentioned contains certain information which could help us in the organisation carry out our work effectively……..like under the people component (the content is generated by member in our organisation which comprises of individuals skills, and industry profile, contact details, etc.)……under the project component (Information about the project, experience, lessons, and findings of evaluations from project team that can be shared)……insight component (Knowledge that has been verified as suitable for best practice which can be used in total assurance), network…. (Electronic discussion board (E-forum)) moreover, essentials…… (Approved policies and procedures) ……with all the content properly structured in the component system, we could easily find information that will assist in carrying out a task…."*

While construction organisation (B) system components are classed into two:

> *"Our system component is classed into two which are Project report……. (Lengthy reports regarding the project details and performance. Short reports looking at the lessons learned*

from the project) and document management system ……..... (File manager) ……..the documents management system in our organisation contains nearly everything you need to know….but we have a problem to locate information in the component due to the large amount of information stored in…".

According to construction organisation (C),

"*The system component used in their organisation is classed into four: "The system component utilised in our organisation is divided in the four which is Timesheet… (Process-based knowledge; information about all the existing and past works), Yellow pages……. (List of employees which, comprises of their interest, and contact details), paperless system…… (E-files about practice, public relations, project management, IT... etc. if you find information, then you download it into our filing system), and outside room…… (HIS (Research Station: technical information provider for bodies of knowledge like British standards)".*

Organisation (D) which is a KM training and consultancy organisation, has only two system components which are *Expert directory*

" ……. (This contains details of the employees in the firm), and knowledge nuggets…... (Processes-based classification database comprises of learning from previous projects."

From the above quotes regarding the system component, the system component of organisation (A) and (C) seem to be more comprehensive than that of organisation (B). The system component of organisation (B) comprises only two and they are not properly categorised which has resulted in information overload of the two components which has affected the easy recovery of information from the components. Apart from the e-forum which is a component in organisation (A), all the other components identified in the four-participating organisation can be presented in "Live pages or file" because, it makes navigation and information recovery a lot easier and faster (Zittrain, 2008). Live page is considered a tool which reloads resources from website resources such as HTML, and JavaScript as they update on the server, so, a recent version and up to date information can be viewed on the live page (Zittrain, 2008). File is a tool that stores information and data used by a computer programme (Zittrain, 2008). In a graphical user interface (GUI) such as Microsoft Windows, file aids the icon display that is associated with the programme that opens the files. Editing and updating data in live pages can be done online directly while updating data in a file format; it needs to be done on the desktop first, before uploading the file to replace an already existing version on the system. Again, with live pages, one can view the required information live, while on the file system, the wanted file has to be downloaded onto the desktop first before it can be accessed and read. This reveals the reason why all the construction industry's participants use live pages. Moreover, the system suggested by the KM training and consultancy organisation (D) depends mostly on live pages other than files, as it displayed on a live pages-based system on presentation and workshop handouts as the reliable

solution. It is, pertinent to point out the fact that all the organisations utilise document management systems (such as file manager) as a secondary storage. This indicates that most organisations depend on live pages when information is presented on the system, also the file system can be employed solely for the storage of external data.

5.4 Knowledge Capture

This part of the work aims at examining how knowledge is captured in whole life costing practice. From the interview data collected, the capture of knowledge, in this case, depicts reconstructing tacit knowledge into explicit knowledge by converting into audio, text and visual outlook format (see section 2.6.2 for more details regarding knowledge capture).

Expectedly, the primary KM technique utilised by organisation (A), (B) and (C) for knowledge capture in whole life costing in construction project was PR technique. In organisation (A) and (C) e-discussion board is utilised solely for recording shared knowledge. While organisation (B) utilised short reports for knowledge capture. The short report approach adopted in organisation (B) helps in the capture of experience and new knowledge which is then presented in a short article format that could easily be accessible.

Organisation (B):

> "*We have a vast information database, where each department have their pages within the system. So, when anybody intends on carrying out something new somewhere or any discovery of any sort that is beneficial can be reported for recovery. Such findings will be uploaded onto the website so that it can be accessible to everybody in the business. This begins the process of disseminating the knowledge in the entire organisation*."

Nevertheless, without strongly connecting the newly discovered knowledge with the project processes, task and activities, one may not be assured that the needed knowledge is fully represented, and vast knowledge may be lost. (See section 5.6.6 for further information)

Another secondary technique for representing knowledge from project is the use of e-forum which is commonly adopted in the internet world, and it is dependable for collecting modified knowledge that is required by the users. The use of e-forums in knowledge representation in the building projects may be viewed as a new technique. E-forums are very common and highly effective if considered especially by bigger companies. This was confirmed by the quantity surveyor in organisation (A).

Organisation (A):

> *"We run what is called skills networks where all project managers and quantity surveyors who want to talk together can do so easily. You can sign on to these networks were, and anyone in*

any of the branches may seek to find answers to questions in the forum, and individuals around other branches can send in their answers to the question."

Another method utilised in the capturing knowledge is through the representation of shared knowledge via telephone and emails. In this method, individuals are provided with a comprehensive knowledge regarding facts of experience.

Organisation (A):

"Every item and email written or sent out passes through the system as captured knowledge" and "All knowledge distributed around the firm via, emails, notes from telephone conversation, everything is captured…"

Regardless of the problem, the method adopted in organisation (A) may pose (information overload), it would ultimately enhance effort and time use hence duplicating a fundamental technique that had been designed and maximised by others. The benefits of this method are that the information gathered from the email communication and the telephone notes could be part of what formulates the project profile and information.

According to organisation (C):

"...If you are executing project Y and e-mail or letter to ... (MR X) .... The emails sent to (Mr X) are logged automatically into project Y... So, anything correspondence is encapsulated on project Y."

Therefore, every finished project profile holds the entire correspondence exchanged during the project.

5.5 Project Review (PR)

It is evident (in section 5.2.2 of the interview analysis) that PR was underlined as the most common and efficient KM technique amongst the participating building organisation. Therefore, as was expected, all participating organisations in the interviews adopted PR as the main method for the capture of knowledge in the project. This section aims to explain the application of the PR technique among the organisations that took part in the interview sessions; beginning with the aim of carrying out the project review, examining the approach, actors and the time frame for executing project review, and finally looking at the technique of systematising the PR.

5.5.1 The purpose of PR

Having a basic knowledge of why a PR is employed in a construction project can help in comprehending the concept underlying the processes of PR. The responses from all the participating construction organisations can be categorised into three classes. The purpose of the PR in the first category is to follow up project accomplishment, and only one organisation adopted PR for this reason.

According to organisation (B):

> *"The main purpose of the PR is to keep senior members with up to date information on what is going on. Such knowledge is not sought for the sake of it, they strive to know how the business is performing by making a thorough evaluation of the progress or otherwise of the organisation and spreading out across the firm such information to put everyone in the know regarding the performance of the organisation".*

However, the project performance evaluation is sometimes not considered as part of the processes of knowledge capture. Nonetheless, the information gathered regarding the cost and time can be useful when making future decisions. This is not to say that the information linked to project tracking should not be part of the captured knowledge. Such information may not be sufficient, which is the reason why the quantity surveyor from organisation (B) recommended the adoption of PR in projects to be carried out in such a manner that reflects the abundance of knowledge capture than is currently the case.

Organisation (B) furthermore commented:

> *"I believe there are project knowledge that has been left out (not captured) via the PR technique. also, there are knowledge segments that should be shared across the firm.....it is important that people are made aware of such knowledge and though it is somehow difficult to spread such knowledge across the firm, ... I would say individuals chatting with each other and the word of mouth about such knowledge would go a long way to spread ideas about the projects in focus".*

The second category carries PR to monitor project output and capture project knowledge.

According to organisation (C):

> "*To make sure that people are working efficiently and competently, we carry out a hindsight review... one could say, "This method was used, but we would have been better if we used another."*

In essence, project performance monitoring could likewise be regarded as "capture knowledge" since details regarding cost and time can be extracted by an organisation and then used in upcoming projects.

Organisation (A):

> *"To ensure that the best possible job is done when brought in individuals who know exactly what to do are assigned the job. People are much incorporated in the project critique as well, which makes it a competitive derivative of all. It is just the best because it is hard to miss... Also*

in instances, where knowledge can be grasp by people and feedback into the system. At the moment, it is not something we are good at. But however, we are trying our best to be good at it."

Organisation (D) which is a KM training and consultancy organisation carry out PR to monitor project performance and capture knowledge in the project.

According to the KM training and consultancy organisation (D):

"To find out what achievements and failures were experienced in the course of that particular project so that mistakes are not repeated, after-action reviews are the powerful technique to be used for knowledge capture."

It is evident that PR can be utilised as a reliable technique for capturing inclined knowledge concerning the project. It is clear in (see section 2.7 of the literature and section 5.2.2 of the interview analysis). Out of the three the participating construction organisations, two organisations employ PR in order that the project knowledge needed can be gathered. Organisation (B) does not do so, and the project manager of organisation (B) clarified that PR should be utilised to capture knowledge. The KM training and consultancy organisation (D) also reinforces the view that PR should take place to apprehend the knowledge sought. Moreover, project performance monitoring can also be regarded as a step in the capturing process of knowledge that is demonstrated by the participating KM training and consultancy organisation (D) so as to understand the projects positives and negatives resulting in the generation of new knowledge.

5.5.2 Method of PR

The manner in which PR is carried out in a construction organisation could assist in distinguishing some units of PR comprehensive practice. The PR is undertaken via a meeting; although, there were certain variations between participant construction organisations regarding how they convened. Five diverse methods were discerned. The first method is by administering interviews side-by-side with the meeting. The interview is administered by a team leader with appointed project team members. These interviews can be utilised for the purpose of knowledge capture and also to gain factual information about the participants.

Organisation (C) commented:

"I also conduct interviews, with assigned project individuals so we specific details regarding the entire project participants …"

The individuals interviewed are sometimes from within or outside the organisation but were part of the project. It reported that these interviews are main contributions into the organisation specialist's record base or profile. Hence, organisation use the member profile created for upcoming projects.

It is evidenced in section 5.4.2, that the majority of the participating organisations have an expert inventory. The expert inventory could be termed an expert directory in other organisations. However, developing an expert directory/inventory through administration of interviews in each project with members might indicate that people are given additional consideration which is viewed in the statement by organisation (C):

> *"The quintessence of the basic project knowledge is connected to individuals participating in the project….it is individuals from within and other industries that are involved."*

Further comments from organisation (C) indicate they have their own well-established expert directory designed from inception which further stated;

> *"Initially, an enormous expert directory was created. When all the details and information is received from the client. Such information includes names, phone numbers, area of specialisations, their roles, how to reach them……it is stored in the expert directory so they can be reach at any given time."*

Utilising interviews for acquiring further information regarding project members may be seen as a good technique to creating an all-inclusive expert directory. Face to face or direct interaction can lead to the desired information in a more experienced form than giving out forms for individuals to fill in. The interview process permits the interviewer to act on responses and demand further information regarding the ideas of interest.

Inversely, interviews can likewise be adopted for knowledge capture, which is the case with organisation (C). However, in such situations, the interviews are carried out by the knowledge managers who are not directly part of the project. So, general enquiries are projected from the knowledge manager, because he or she does not have any in-depth knowledge regarding the project.

Checklist techniques are employed in the second approach when conducting PR. The checklist is quality which matches all the kinds of projects undertaken. The term checklist is sometimes interchangeable with the term questionnaire by respondents.

According to the comment by organisation (B)

> "*The meeting takes one hour to two hours; the questionnaires were collected and acted upon as well. Questions were then asked and closely followed."*

The presentation technique is employed in the third approach when carrying out PR. The presentation technique was realised by some project members. After the presentation, debate followed immediately."

Organisation (A):

> *"Some certain sections of the work are presented, and general discussion commenced by members of the project team. It is authorised with actions, and after the project is completed, there are series of reviews which helps identify the lessons learnt in the project."*

It is evident that presentation is an ideal channel if project members showcase a clearer picture of the project, in a systematised manner and for a short period, for non-project participants (e.g. clarifying what has transpired in the project; and what should have occurred). Following this, PR participants can have a better discussion regarding the project.

After conducting a few searches, it was discovered that some of the participants who conduct PR in organisation (A) were non-members of the project (see section 5.6.3). This may be the reason why the presentation technique was employed in the PR session. However, a question to consider is: what if the presentation technique was utilised in the PR session with all the project members - can this add value to the PR? No conclusive response could be deduced from these interviews. There is an absence of evidence showing any proofs that the adoption of the presentation technique in PR can be value adding.

The first three approaches is being adopted in the participating construction firms, while the fourth approach reported from organisation (D) a KM training and consultancy firm which is a non-construction firm is a straightforward process-based approach that was proposed by organisation (D) by commenting that:

> *"It is a definite process one has to follow with step by step questions to be answered or statements such as: what are we hoping to accomplish; what did we accomplish – be it success or failure. There is an intermission between those two things. You want to take a keen look at that gap and say: "How do we close the gap," This generates new experiences and lessons and to ensure it is done differently next time, one has to be sure the information is catalogued for use in case it needed. You do not walk out of the meeting and forget what you have just talked about."*

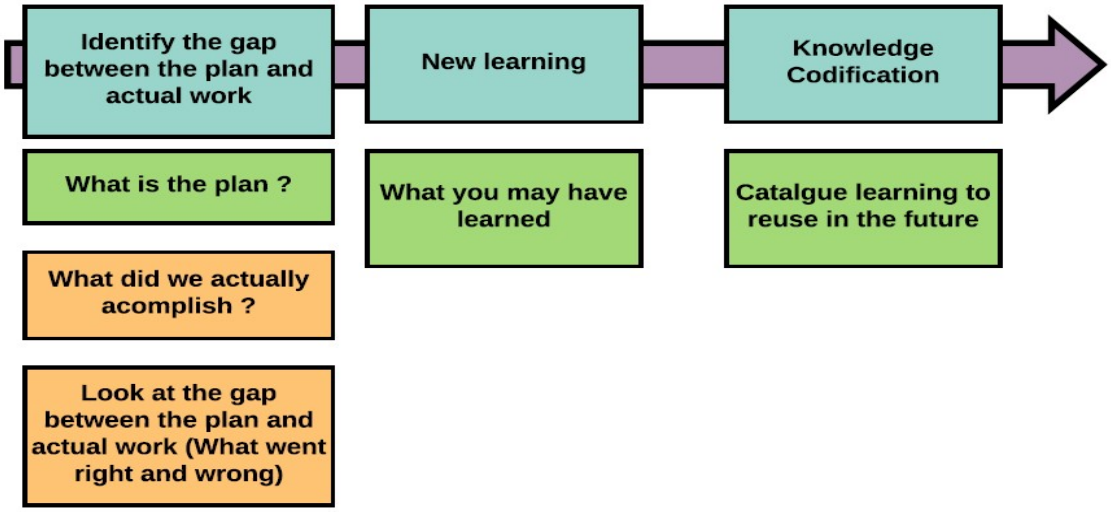
The procedures in this approach can be classified into three major parts. The first one aims to identify the gap between the project design and execution progress. That could be attained by providing answers to the three questions as outlined in Figure 5.1. After the gap has been identified, the second procedure is to look for an answer which breaches the gap. This procedure is further clarified in another section in the interview:

According to the KM training and consultancy firm organisation (D):

> *"To discover in a particular project what went right and wrong. So that lessons can be learnt, and mistakes would not be repeated in the future".*

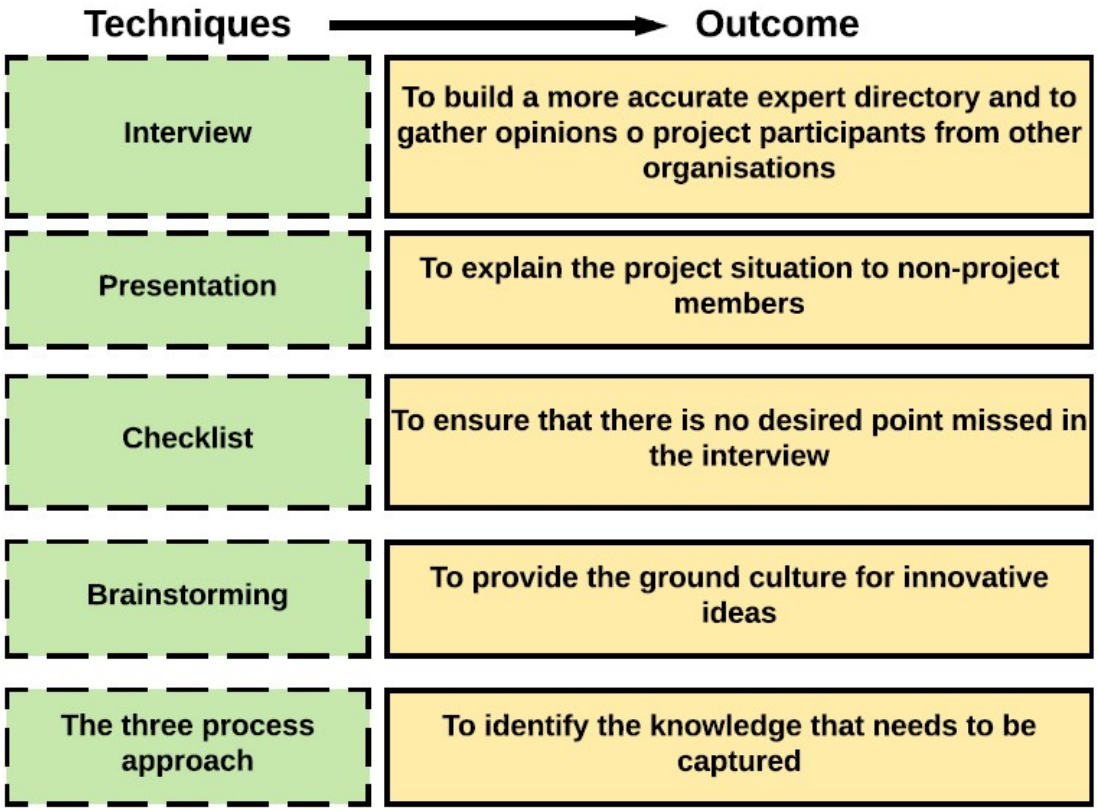
A comparison of what has been accomplished with the plan is viewed by organisation (D) as an appropriate way of discovering what went right and wrong. That can result in the identification of new knowledge that has been acquired. The third procedure is the codification of the new knowledge so it can be applied in upcoming projects.

Figure 5.1: Method of PR in organisation D



With an in-depth look at the approach adopted by the participant organisations, it is evident that the approaches may not be a substitute for each other; but instead are bonds of techniques, each performing a particular task as shown below:

Figure 5.2: Techniques implemented by participants to conduct the PR



Effective KM practice amongst participant organisations could be regarded as a credit to the experts that took part, as every one of them is basically responsible for the management of knowledge, or is at least a key person in the KM board. As long as people tend to underline what they regard to be their strengths (Hoe & McShane, 2010), it may be suggested that the participant organisation highlight the strengths of their techniques since it lies with them. This is not necessarily so because they want to cover their limitations; as some were mentioned without any problem; but possibly it is because strength points to spontaneity when the questions are asked. This corroborates the findings of Bonnard who revealed that this often occurs "consciously or unconsciously" (Hoe & McShane, 2010). Moreover, participating industries hold meetings to carry out the interviews; but none of the respondents said this in a direct way. This shows that they skip to the issues they believe to be the most productive and dependable in their practice. This can also imply that their responses focus on the positive side of the technique.

Fortunately, participant organisations also came up with five techniques, each covering a side of the PR, and none of them can be regarded as a substitute for other approaches.

The first two techniques (interviews and presentations) can be achieved independently. On the other hand, the three other techniques (checklist, brainstorming, and the three processes approach) can be considered as interrelated techniques. Each technique is part of an entire approach that amounts to

attaining the targeted purpose of the PR. A point list in the checklist may, therefore, undergo the three processes technique. The second process (of the three processes design) can be attained by employing the brainstorming technique. The brainstorming technique in its idealist form is activated when the question: "what have you learned?" arises.

5.5.3 PR participant

This section aims to identify those who are part of the PR process. Options that were discovered can be classified into two phases. In two of the construction companies that participated, it was discovered that those who were part of the work/project are the ones who were included in the PR which was also suggested by the KM training and consultancy firm (organisation D).

The second approach is utilised by one of the construction company. It points to the fact that those who participated are either known by the positions they hold or selected by a senior member of project team.

Table 5.1: PR participants

Participating organisations	**PR Participants**	
	Participants of the project/work/activity	**Known or selected people**
Organisation A		The project director and the project manager were in charge of the review. They select whom to invite, and this could be co-workers within the project team.
Organisation B		These are the senior managers on the project. Therefore, there are about four, five or six people.
Organisation C	This is all-inclusive and involves the entire team, including the younger participants	
Organisation D	Only the active participants were involved	

The inclusion of many participants in the project/work is crucial because they understand more about the project/work. Therefore, it is expected of them to have a wide knowledge of the project and its progress as well as the lessons learnt. The participation of other members will depend on the knowledge and skills such individuals acquire.

As showcased in Table 5.1, the positions of the non-project members taking part in the PR may show that they are professionals and their attendance may lead to better results. It is also anticipated that the appointed non-project members will either add value to the PR, learn from PR or achieve both. The

practice of other participating construction organisations and the KM training and consultancy firm shows that the participants of PR are the project members. Nonetheless, this does not imply that the non-project members who can add value to the PR were denied participation. However, it certainly indicates that project member's participation is significant.

According to organisation (A):

> *"Occasionally our clients are invited. It can be an essential communication tool to have them there and point out some of the issues in before them and some of the clients."*

While organisation (C) excludes their clients from PR and involves project contractor.

> *"At the end of a job, we conduct project review with the contractors."*

Organisation (B) excludes external participants when conduction PR, but invites external parties into their organisation's progress meeting. According to organisation (B):

> *"The participation of members from other companies is not part of our project reviews. I suppose one aspect of the project review that was not given due attention was the client's project review. This is because progress meetings will be held what which might be considered above our reviews, and a company may well have people from other companies present. We could as well have some of our key subcontractor's present, and some of the designers may be there also."*

Following the participation of the parties connected with the other project in the PR, it was discovered that some of the organisations that partook carried out the PR without orderly arrangements with the other project parties. Other participant organisations conducted the PR with some participants from other organisations who were involved in the project. Finally, some other organisation conducted the PR with other categories involved in the project, but that was however at the end of the project.

5.5.4 Time of PR

The time frame set for carrying out the PR is a significant factor that may have an effect on the value of the final product. This is notwithstanding, the fact that time lags may account for the loss of some knowledge as there may be no time for conducting too many reviews during the project. The practices of the construction organisations that were part of the reviews can be grouped into two categories: i) stage-based ii) and time-based review.

In the stage-based review, the time between reviews will depend on the length of stages; whereas in the time-based review the time between reviews is fixed. The monthly and daily reviews are the two methods reported under the time-based review. The KM training and consultancy firm (organisation D) supports the daily review and detests delaying reviews (e.g. stage-based and monthly-based

reviews). He attributes this to two factors: i) the loss of knowledge due to the time lag between action and review, and ii) the ability to use project knowledge in the future activities of the same project.

KM training and consultancy firm (organisation D) commented:

> *"The key variable is how many times the reviews are conducted. Too many people wait until the end of the action and may go months or years, and that's too late. They should think of it more as action reviews, and not matrix reviews. The first thing is if you have a complex activity that goes on for three months, and you wait the whole three months, you will have forgotten what has happened. The second thing is that you won't be able to take advantage of it during the project."*

Some of those that were part of the reviews from the construction companies recommended that it was fascinating to see daily-based reviews in construction projects. However, while they stated that it usually happened in an informal way without capturing knowledge, they also showed how it might be difficult to execute such formally in a construction project. This is due to the fact that the project team may have little or no time to do daily reviews and it may, therefore, be difficult to organise daily meetings.

Organisation (A) disposes of daily reviews by commenting:

> "*We will be talking about formal reviews, and I do not think you can do them daily in any beneficial way. What we also have is Senior Engineers talking to the Junior Engineers. Answering their questions is an informal review process which happens every day. So, it is a bit similar to the British Petroleum (BP) process in a way; it is very much informal, but almost a social process."*

While organisation (C) suggested a way of conducting daily reviews: *"That's interesting. If everybody had to fill in their timesheet and write what they did and about what he or she had learned today. We could try that."*

Organisation (B) also disposed of the daily review because it is not formally conducted by commenting:

> *"It might be possible if it was very informal. I mean suppose we do it on an informal basis at the end of the day. The three-key people on site or however many there may be, would sit down over a cup of coffee and talk about the day. Such knowledge will not be captured and retained and will not be retrievable because it is purely informal. To try and do this formally on a daily basis, I am not saying it would not be of benefit; but I cannot imagine how you would be able to put in these kinds of resources and take the time to do it. It will be interesting to see you know."*

No single evidence was shown claiming that the daily-based method could work in construction projects. Moreover, despite the fact that some of the participants thought that it was interesting to see daily-based reviews in the construction project; it was also evidenced that the daily-based review could pose challenges to execute in construction. This finding does not necessarily indicate that the daily-based review is not appropriate for construction, but it shows that the obtained information did not disclose a strong foundation to support the use of the daily-based review in the construction project.

Table 5.2: Time of conducting PR

Participating organisation	Time of conducting the PR	
	Time based	**Stage/Phase based-review**
Organisation A		Stage-based and after project completion
Organisation B	Monthly-based and impromptu reviews.	
Organisation C		After each work stage - probably every six months.
Organisation D	Daily or at worst once a week.	

With reference to knowledge capture, the monthly based review can be regarded more as an effective approach than the stage-based review since a stage in a construction project can last for months. Therefore, the time lag between action and review will always be brief in the monthly based review. It may seem that in the stage-based review, more participants in this stage will have time to be part of the review. However, as shown in Table 5.2, organisation (B) performs reviews on a monthly basis, and no report of a problem related to participation was discovered.

The stage-based review is obviously significant because it gives reviewers a wider picture of the stages. Employing the stage-based review side-by-side with the monthly reviews ensure the gains of reducing the time lag between action and review and enhancing a wider view of the stages. It would also be crucial to do a review after every project completion as suggested by organisation (A). At the completion of the project, a greater strategic insight can evolve from the oversights discovered on the project.

5.6 Codification

The last format of the PR found that the organisations that took part were grouped into three sets. The first being the review notes which contained two columns: tasks/activities in one column, and commentary about those tasks/activities in the other. The reviews relating to many companies that

were part of the process were short and consisted of about two lines on average for each task/activity. The comments may relate to the progress or the knowledge gained in the task/activity.

According to organisation (A):

> *"It is a form with some columns in it and contains someone's commentary. Someone is given the task of responding and dealing with this."*

While organisation (C)'s approach of codification is similar to organisation (A). As stated by organisation (C):

> *"We have a system of hindsight reviews. It contains two columns, observation and commentary".*

The second method is the generation of a report which will usually include the progress and lessons acquired. According to organisation (B):

> *"We do monthly reports on every project, and that captures all the information."*

The KM training and consultancy firm (organisation D) condemned the second approach 'lessons learned and reports', and recommends another approach (the third) which is practised by organisation D. The approach is to write short reviews or 'knowledge nuggets which refer to a piece of vital information in categories of interest to the user which sometimes consist of hyperlinks, relevant files and dialogue boxes (Bali et al., 2009).

Comment by the KM training and consultancy firm (organisation D):

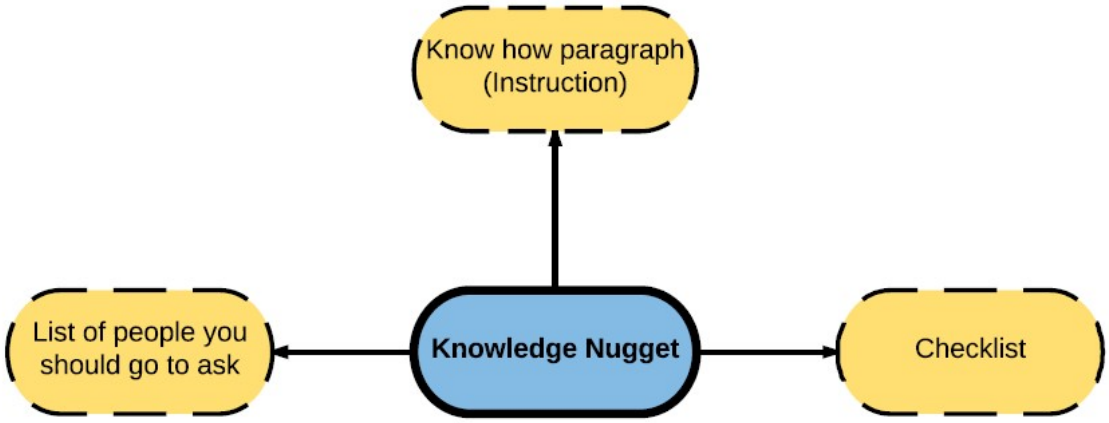
> *"Most people come out with a lesson learned report. The trouble with this approach is every single report may contain many issues in it, and make it covered in a knowledge storehouse. I prefer briefings after action reviews, where the contents may be a nugget or two that may come out of what has happened in a day."*

The challenge associated with an oversupply of data as pointed out by the KM training and consultancy firm (organisation D) is a familiar problem in KM practice (see Sections 2.8.3 and 2.8.5: literature review). Knowledge nuggets are therefore seen as a solution utilised in organisation (D). A further explanation about knowledge nuggets shows that it could contain instructions, a checklist or names of members of the organisation who can offer help in this area.

KM training and consultancy firm (organisation D) further commented:

> *"The knowledge nugget could be a checklist, a paragraph, that says you ought to do this, and we sometimes call this the key to success. It could be a list of two or three people whom you should go talk to if the knowledge base does not have an answer."*

Figure 5.3: Possible forms of the knowledge nugget in organisation D



The review size can vary from project to project. The PR size is dependent on how big or small the project is as indicated by a number of interviewees. Nevertheless, a rough estimate provided uncovers that the PR produced by participated organisations ranges between a paragraph and 80 pages.

According to organisation (B):

> *"It can be up to twelve pages in length about reports on progress and reports on performance and business performance, and there is a wide range of various subsections to depict how the project is getting along."*

Two reports on project performance measurement and knowledge capture are generated by organisation (B):

> *"Perhaps one page provides details regarding what we did on this job; how money was saved; or how it was speedier or more secure or really that it didn't turn out well as we anticipated"*

While an average of a five-page report is produced for a typical project by organisation (A): According to organisation (A):

> "*A five-page report can be produced for a typical project which may be classed as middle-sized projects".*

The case in the KM training and consultancy firm (organisation D) may distinguish the participating construction organisation. This is because the KM training and consultancy firm (organisation D) is using it after the action review. Organisation (D) commented:

> *"We generate a page, page and a half; sometimes it could be just a paragraph."*

The one page or a page and a half generated by organisation (D) refers to the size of one review, and the review is conducted daily or weekly (KM training and consultancy form organisation D); while other participating construction organisations refer to the size of the final report generated of the PR. This means that the review size in organisation (D) can be equated to the review size generated that the participating construction organisations.

It is a demanding undertaking to discover the best method which may be suitable for the participating construction organisations: progress report, review notes, knowledge nuggets approach and lessons learned. To find out which is more appropriate, the methods will be considered from two angles: the number of pages; and the form of the content. In order to identify the most suitable method, one has to consider two factors: the form of the content and the number of pages.

It is widely acknowledged that information overload can act as a barrier when retrieving the required knowledge. The KM training and consultancy form (organisation D) allied this problem with the lessons learned approach. Therefore, the length is not necessarily connected to the lessons learned approach.

A distinct benefit of the review notes approach is that a short number of pages are usually generated; because of the short comments and remarks made. For example, the quantity surveyor of Organisation A (who utilises review notes) with the outcome of their review is estimated to be about an average of 5 pages.

While the KM and training consultancy firm (organisation D) commented about the knowledge nugget method:

> *"Knowledge Nuggets are very comprehensive; sometimes just a single knowledge nugget is required to carry out a task…"*

As quoted above, the average number of pages of PR report could range between five to twelve. Nevertheless, organisation (B) has a one-page report that targets the gained knowledge and may appear uncommon. It cannot be claimed that one page is incapable of giving enough information, but it can be said that one page could be the least but not the average, and it may be inadequate in many cases.

Concerning the form of the content knowledge, the nuggets approach with an extra advantage is presented. Three forms of the desired knowledge are embedded in this approach: 1) instructions; 2) checklist; 3) or names of members in the company who can help in that area (KM training and consultancy firm organisation D). While no clear-cut form of the knowledge captured have been found or established in the other two approaches, the required forms of knowledge identified appear to have more potential because it gives more clarity to the evaluators about regarding what the captured knowledge or information should look like. The three identified forms of knowledge could be seen as

an essential component of the review. While the first (instructions) and second (checklist) forms may be used by all the organisations that participated, (though none of them has stated this), the third form (listing names of people can offer help in this area) is perceived to be required in some instances. However, it could be proper to have such data in the expert directory, as discussed in greater detail in section 6.7.

Review notes offer short comments on activities/tasks of the project that can be re-used in future projects. The knowledge nuggets technique attains the same principle as its information enhances the job to completion, and brings forth diverse knowledge forms in a methodological way. Where it can apply to a construction project, no challenge is seen preventing the use of the knowledge nuggets technique in construction projects. That is due to two factors: i) none of the remedies of the knowledge nuggets method is new to construction projects or unattainable and ii) the approach has no traits that make it simply relevant to a particular size and type of project. This approach is considered fixable as in most of the other approaches in KM and can be utilised in diverse environments.

5.6.1 Knowledge structure and classification

The manner in which knowledge is categorised and arranged will influence the extent to which this knowledge can be easily obtained.

5.6.2 Representation form

It was discovered that the participating construction organisations have those review notes, reports, or knowledge nuggets in their KM system (section 5.3) either as live pages or files. While, before the file can be accessed, it needs to be downloaded to the computer desktop; live pages can be recovered and read directly from the KM system. Files cannot be edited from the system; whereas live pages can be directly edited/updated from the system. It was revealed that two out of three participant construction organisations store their PR in live pages; however, some organisations (organisation B) rely on files, considering that organisation (C) utilises files in addition to live pages.

Table 5.3: Knowledge storage format in the participating organisations

Participating organisation	The format of stored knowledge	
	Live Pages	File
Organisation A	×	
Organisation B		×
Organisation C	×	×
Organisation D	×	

It is not difficult to comprehend that displaying PR in live pages is viewed as more proficient than storing them in files. Organisation (B) happens to be the only participating construction organisation

that adopts files to PR storage. The paper format or files are not the most suitable way of project knowledge storage.

According to organisation (B):

> *"Presently, it all done electronically. It is very much a typed word document. We have not yet advanced to any smart way of documenting reports".*

Three key methods were uncovered to be used in knowledge classification in project 1) by project 2) by business/discipline and 3) by the process.

The first method, the classification of knowledge by project, is utilised by all the participating construction organisations. This classification method has to do with storing data of every project in one section. Nevertheless, this major method can be sectioned into two structures; sectioning the knowledge from the project i) by project phase/stage which was revealed to be done in organisation (B), and ii) by project processes which are revealed to be done in organisation (A) and (B).

The second major method of classifying project knowledge is to categorise the project knowledge based on the business or discipline, project and processes. For instance, an organisation carrying out a job on costing planning, project management, and structural engineering in a construction project, would categorise the knowledge captured in three subject area. (Costing planning, project management and structural engineering). The content of each of the subject areas will be separately located, and the project content of every subject area will be categorised by process. Only multidisciplinary organisations can adopt this method, and this clarifies why the method is adopted in organisation (A) because it is an international multidisciplinary firm.

According to organisation (A):

> "*Information is often captured by the different discipline (subject area) in the project team and then stored. Because in each discipline (subject area) for instance, the cost planning of a project ……there are processes that need to be followed when undertaking costing planning, likewise the same with the project management processes and the structural engineering process."*

The third major method of classifying project knowledge is to store the knowledge captured with no linkage to project. The KM training and consultancy firm (organisation D) suggested this method. One of the main sections of the system (knowledge base) for the KM training and consultancy form (organisation D) is the knowledge nugget section which contains a list of processes, and each of the processes in the knowledge nugget contains activities. The classification of the processes content and activities content are based on the work breakdown structure (WBS). Project knowledge nuggets are saved in the activity that the knowledge nugget comes from. Which means, knowledge nuggets form

the elements of activities; and the activities are a subcategory of the processes. Processes and activities in the system are the same as the processes and activities of the projects conducted by the KM training and consultancy firm (organisation D).

According to organisation (D):

> "*A process is defined and each of the defined processes contents activities, which are additional knowledge nuggets and the elements of this activity……..This knowledge nugget is arranged according to the activity in which you were involved daily in the knowledge base; allied with this particular activity. This is not categorised in the general knowledge because it would get lost."*

The classification of knowledge by project may not be considered significant in certain kinds of construction, and this is not the case in a construction project. This is demonstrated by the three-participating construction organisations; as knowledge is located for each project together. This method could be required in construction because in some cases, it is important to have a full picture of the project. Not contextualising the information taken out of construction project may be misleading in some cases, as the knowledge required in a particular area may vary according to the size, project location and type.

Sub-categorising the project based classified information into stages or phases driven category of the knowledge of the project is deemed more fitting than not having any category. The kind of category could assist in easily locating the needed knowledge going to the exact stage or phases of the whole life costing processes when required. However, a whole life costing stage in a typical construction project could have several of the processes and activities (see section 3.6 for the different stages and processes of WLC in construction project), and this may reveal how much time it could take in some cases to find the required data about a particular task.

However, another solution was discovered in organisation (A). Knowledge discovered by an individual in the project team or the organisation needs the have the new knowledge content reviewed by experts before adding to the system (knowledge base).

According to organisation (A):

> "*A system called branding is adopted in our organisation. We try to attach a little note to the newly discovered knowledge, which gives an individual in the organisation an idea whether the information has been reviewed by experts and given the approval for use."*

The system of branding can only be utilised with knowledge entries by individuals that have not been approved for use and PR is excluded because it has already been reviewed by a group of experts.

Organisation (C) adopts a similar method whereby content can be added to the system (knowledge base) by every member of the organisation, but the content needs to be approved before it can be published and disseminated. A quote from organisation (C):

> "*The line manager has approved your content…… it is to ensure that the quality of the information is dependably good and usable."*

The quotes mentioned above with the information provided in section 5.4, give an indication that the construction organisations that participated give approval to individuals to add contents to the knowledge base (system), however such content from individuals are classed under general knowledge and not classed within project knowledge. As all the participating construction organisation classify the PR content by project each project will be tagged with its profile. This implies that any additional entries outside the project context by individuals cannot be found on the project profile.

5.7 Knowledge Recovery

The method of knowledge recovery that is presented by the participating construction organisation can be divided into two types. Firstly, the utilisation of the search engine. Once a keyword is typed into the system (knowledge based), related knowledge of the previous project can be obtained. The three-participating construction organisation utilise a search engine for knowledge recovery.

According to organisation (C):

> "*The search engine prompts for various keywords, which when I type in a keyword, straightway a PDF opens. I find this quite handy, information is found very speedily, and it was pretty good."*

Another method of knowledge recovery is by navigating and selecting the required project. This method is practised in organisation (A):

According to organisation (A):

> "*You click on an icon on the system called Project 1, and it will ask what you want to learn about the project…… You either use the search with keywords if the name of the project is known or the project number that can be typed straight into the system. It pops up with some basic information and links to other related information. The related information might be about the location of required knowledge…"*

The KM training and consultancy firm (organisation D) use the second method employed by organisation (A).

According to KM training and consultancy form (organisation D):

> "*In our organisation, the search engine is not needed…… all that is required is to know what your processes are …you enter into the system (knowledge base) ... Which search based on the processes and activity."*

Adopting search engines for knowledge recovery from the previous project is vital for construction organisations. This is because in some situations the precise location of the knowledge required is unknown and the search engine could assist in such circumstances.

Furthermore, discovering that the participating construction organisation uses a search engine may indicate its significance.

The expression of the KM training and consultancy firm (organisation D):

> "*Because we do not use the search engine in our organisation for knowledge recovery does not mean we do not support search engine utilisation, but it certainly implies it is not the most fitting from our organisations perspective."*

Organisation (A) may also be in agreement with the KM training, and consultancy firm (organisation D) as both utilise the *"navigate and select*" method for the main method for knowledge recovery. It is quite challenging to support one method over the other unless the project knowledge taxonomy is well-known. The very wide taxonomy or content without taxonomy (i.e. relay a single project on the phase or stage) may seem fitting to be recovered by the use of a search engine. The content with exact taxonomy based on activities, or small tasks, could be quickly recovered by navigating to the exact required task or work activity.

With the use of a search engine results can be found quicker, but not always with the right information, or results could contain the correct information after filtering. On the contrary, the required information can be easily found and quicker when the "navigate and select" method is used.

According to organisation (C):

> "*Currently, the system in our organisation is not that sophisticated. Because it often asks a question and a drop down of so many information which you have to filter through. A sophisticated, intelligent system I think would minimise the number of results you get back".*

While there was an absence of evidence indicating that individuals should begin the search for a solution from the system, some indications revealed when there is a need for an answer, the system should be the first place to check. Some participants did not specify the first point of check when seeking for a solution; their relating to "how is knowledge recovered in project" may indicate that the knowledge base (system) has priority to start with.

According to organisation (A):

"*When people find solutions to the problem, they are very quick in checking the system".*

The knowledge base (system) of organisation (B) is somehow linked to the intranet. According to organisation (B):

"In our organisation, there is a database of information (knowledge base) which is linked to the intranet……..so if you need to get solutions to problem you go through the intranet……There is also word of mouth whereby individuals in the organisation speak to each other…."

The response of the participants from the KM training and consultancy firm (organisation D) also indicate that if the knowledge needed has already been captured and stored in the system this is the place to go to.

According to organisation (D):

"If the knowledge has been captured and ready for use. Then certainly we can rely on the system…."

However, in a case where the knowledge required has not yet been captured, what would happen in such situations? Bearing in mind, when the question regarding the sources of retrieving knowledge is put to the interviewees. The majority of the interviewees acknowledge individuals as their major source of knowledge. The knowledge that has not been captured cannot be recovered. Consequently, if the knowledge required has not yet been captured, the appropriate way to discover the knowledge required as recommended by the participants is by looking for the right individual in the organisation.

Apart from organisation (B), construction organisations have an expert directory and yellow pages. The KM training and consultancy firm (organisation B) utilises an expert directory which provides them with details of members in the organisation and their area of proficiency (see Table 7.4- Section 5.4.2). Hence, an expert directory is a suitable method for finding the right individual to enquire.

According to organisation (A):

"There is an intranet web page is created for everyone which you can write down things about yourself which cover your experiences, your area of interest, your contact details……. let's say, for instance, you go to the search tab and type in the keyword like "risk assessment" …… names and contact of individuals with experience in risk assessment will pop up".

A more comprehensive practice has been revealed in organisation (A) which has indicated what is to be done when searching for solutions to the problem. As discussed above, the process may commence with looking into the knowledge captured and stored in the knowledge base (system). Subsequently, in the event where the information required has not yet been captured and stored in the knowledge base

(system), individuals in the project team in organisation (A) (the expert's directory) should be utilised to search for the knowledge required or via experts in the subject area.

Where the solutions cannot be found in the knowledge base (system), or the expert directory and individuals in the project time, the organisation (A) (discussion board) could be used by individuals at all levels of the organisation.

According to organisation (A):

> *"when you encounter a problem, and you need to speak to a project manager sitting next to you or locate your superiors who are more experienced and ask them if they have encounter such problem and if they have or know of anybody in the organisation that could help. Your best point of start is with your immediate project team. If they cannot help because they do not have experience or knowledge, then you can turn to the electronic networks."*

The knowledge recovery practice in the KM training and consultancy firm (organisation D) commences with taking a look at knowledge related to the task connected with the knowledge-base (the system). It should be deemed that the knowledge base may be where to find the solutions.

KM training and consultancy firm (organisation D):

> *"In a situation where the solution to the problem, your best bet would be a knowledge nugget which could just be a list of three or four individuals whom you could speak to……..."*

In an unpublished report provided by the co-director of course development of the KM training and consultancy firm (organisation D), supplementary information was uncovered regarding the procedure for knowledge recovery recommended and adopted in the KM training and consultancy firm (organisation D). It was revealed that in a situation where the solution is not found in the knowledge base (system), and therefore the individual seeking for knowledge should ask for assistance.

Assistance can be provided in two forms: it could be provided by an expert in the required area or by a community of practice group. The community of the practice group as discussed in the literature (see section 4.11) can be formed in either a formal or informal way. When the solution to a problem is found, it should be shared and approved by experts. The solution found should be shared and validated using an electronic discussion board. When the solution to the problem is validated by a discussion group, the solution should be summarised in a manner that would be valuable to the knowledge base (system).

Subsequent knowledge acquired is often sent to the knowledge base manager for approval to ensure that the new knowledge can be placed in the right section of the knowledge base so it can be reused to solve similar problems by those encountering the same problem. It is referred to as "connect and collect".

It may be obvious that the participating organisations adopt a similar practice which it comes to alleviating problems. Nevertheless, the organisations that participated may not have an organised procedure to accomplish this when there is no solution found in the knowledge base (system). The reason may be due to the claim that it is only common sense to locate the most fitting individual in the organisation to enquire with. Nevertheless, the advance practices of retrieving knowledge provided by organisation (A) and the KM training and consultancy firm (organisation D) may have revealed the benefits in identifying an organised procedure in order to retrieve the required knowledge. The approach of organisation (A) and the KM training and consultancy firm (organisation D) may appear similar when overlooking the utilised terms and viewed from the functional viewpoint. The only difference could be that, in the KM training and consultancy firm (organisation D), when the knowledge required is found outside the knowledge base, it should be shared and approved by expert and then posted in the right section of the knowledge base (system). This is to ensure that any solution that has been found and utilised to solve a problem should not be left without being codified.

In organisation (A), the knowledge may be codified when the solution is obtained from the discussion board. Subsequently, there is no direct way to reform and place this knowledge in the right section in the system in order to reuse it again in the future. Nevertheless, there is a team in organisation (A) in charge of gathering the usable knowledge and placing it on the system. Everyone can post knowledge which they think is needed. The validation of this added knowledge is by using the branding system.

Organisation (A):

> *"There is a system used in our organisation called branding; we tag information with symbols. For instance, if a particular information has been thoroughly looked at it would be marked with the symbol (+) which means it is okay to put them in the system for future use. If the information is waiting to be thoroughly reviewed and approved you find the symbol (?)…. if the information is irrelevant it is marked (X)…. You need to have a rethink before you adopt this because information marked as (X) for you may be right for someone else ……. So, this exercise of branding is very vital, but caution must be applied …"*

Knowledge recovery practice has indicated how it is strongly associated with the sharing of knowledge; particularly when there is no solution to the problem in the system. Both organisation (A) and the KM training and consultancy firm (organisation D) utilise the electronic discussion board as a platform for asking for assistance and sharing knowledge. It may be obvious that the discussion board can be used in the construction industry, and organisation (A) is not an exceptional case.

5.8 Hierarchy

Prior to the commencement of the interview, process was not considered in the outline. Nevertheless, it was mentioned by the two participating construction organisations, which may be relative to the

capture and recovery of knowledge. It was later decided to ask the following interviewees about their organisational hierarchy.

It was discovered that all the construction organisations that participated in this study have a flat organisational hierarchy.

According to organisation (A):

> *"We have a flat hierarchy. Our organisation is run by a small global board of about nine (9) people who lead the entire organisation. Then we structure ourselves in a matrix system by geography and also business sectors."*

Organisation (B) and (C) also have a flat hierarchy. The flat hierarchy appears to be an influential factor that enables and facilitates knowledge sharing amongst members of the organisation. The need for a flat hierarchy to facilitate knowledge sharing was also supported by the co-director for course development from the KM training and consultancy firm (organisation D) who commented:

> *"A flat hierarchy is needed. This would benefit the organisation in knowledge sharing".*

5.9 Culture

Having an open culture and social network allow organisational members to access everyone in the hierarchy. An open culture may act as a catalyst to enable the sharing of knowledge, and thus the capture and recovery of knowledge.

According to organisation (C):

> *"We adopt an open culture in our organisation."*

The workspace design is also considered a factor that can assist the enhancement the open culture.

Organisation (C):

> *"We have a very small workspace which everyone can hear each other"*

The organisational culture could be a critical factor to the effective allocation KM; the co-director for course development from the KM training and consultancy firm (organisation D) said:

> *"It is about culture".*

If there is a prolific platform, this enables knowledge sharing.

> "*KM is not all about information technology, but it is about culture, and people working together, change management, the connect and collect model is just the best for my own point of view…. because it is a mix of knowledge nugget and when collecting we fall back to the*

knowledge base for collection, linking individuals together, with common interest. Having the best assistance for each other and we want the assistance to be enriched……"

This is the concept as considered by the KM training and consultancy firm (organisation D) and is about linking individuals and obtaining knowledge.

The subsequent sections outline the components of an open culture practised by the participating organisations.

5.10 Motivation

As the participating construction organisations revealed, there is a need for a motivating strategy to be sure that knowledge is always shared, for capture and reuse. Several techniques of motivation have been demonstrated by the participants. However, it looks like the most appropriate technique is by illustrating the benefits of knowledge sharing to both the organisations and individuals. One of the participating construction organisations adopts this approach in addition to the KM training and consultancy firm (Organisation D).

Organisation (C);

"*We have to believe that we have to share knowledge."*

Organisation D:

"You need to convince a person about something that is true, and when you share, you are improving your knowledge. As much as you are helping another person, you are improving your knowledge. The expression I'd like to employ to describe this very quickly is: "You don't know something until you teach it. Sharing your knowledge is increasing your knowledge."

Another technique utilised by the participating construction organisation may be called feedback-based motivation or that which demands to know what individuals want. It helps to ascertain why people are sharing knowledge and why they would not give this as well as their opinions on the KM approach available. It also shows them that the top-level management are aware of their needs and looking for constant improvement.

Organisation D*:*

"I went over to our Berlin office a month ago just to spend a day talking to the people there and to find out what they liked and did not like. This was as a means of encouraging them to participate more actively in the system. I was not directly saying that I wanted you to do this; but that if you tell me what you like and dislike and take in feedback to see if it can improve things."

The third approach to motivation is using recognition and bonus scheme to appreciate those providing good effort in the organisation.

Organisation B*:*

> *"We run an internal staff recognition scheme in addition to the bonus scheme. When people do a particularly good piece of work or share a good example, then that would tend to be recognised through the recognition system. People might get flowers, chocolates, not necessarily a big thing, but recognition that we do take it very seriously and we appreciate it when people go out of their way to do something that is very good gives a unique feeling."*

All the methods of motivation identified here revolve around one concept, and this has been summarised by the KM training and consultancy firm (organisation D by illustrating that: people will think in the way that paints the puzzle; "what is in it for me".

Organisation D:

> *"We have to convince them that it is advantageous to them. The expression is, "What's in it for me?" If they don't see an advantage, you will never get them to do it. However, if they see it as advantageous, they will do it happily."*

5.11 Communities of Practice (COP)

The community of practice can be developed naturally because of common interests or can be formally created by the management of the organisation (for more information about COP, see 2.10.1). These two forms of COP were found in the construction organisations.

According to organisation (C):

> *"Every Wednesday, we have a lunch whereby, outside people come in to talk about products or systems; engineers might talk about some of the things they have been doing, or we have people giving in-house talks;*

The form of CoP employed in organisation (C) not be viewed as CoP. However, technically from definitions from the literature in section (COP) would class it as CoP.

Organisation (B):

> *"We have what we call best practice groups. We will all listen to a particular subject, and then we will chat amongst ourselves and deal with issues. This works at many different levels in the organisation."*

CoP can also be built through technology as in organisation A:

"We run things called skills networks where all structural engineers who want to talk together, site engineers on their own or engineers; can sign on to these things. Someone in San Francisco will ask a question on the forum, and as the sun rises around the world, you can see people waking up, coming into the office, reading the question and forwarding their answer."

5.12 Social Networks and Activities

The participated organisations also consider having social activity and evolving social networks which are avenues of cementing the connection between individuals, and developing trust so they can know each other well (see section 2.8). This, in turn, can make it easier to share knowledge between individuals.

Organisation C*:*

"Every Friday we take turns to have lunch together, and it's quite informal, but it leads to a chance of meeting everybody. We just started having a Friday evening, informal series of people giving little talks about things that interested them, and it is certainly more informal."

Organisation B*:*

"The social structures are very amateur at the moment, but they are getting better as they should, but they are pretty new."

Organisation A*:*

"We do have a social network."

The chairman highlighted the importance of social networks and provided another perspective relating to the social network.

Organisation D*:*

"I've seen a social network as not necessarily being hierarchical but as something independent. It's the shadow, the informal hierarchy. The social network is extremely important. It is the people in there who do a similar job or practice or a professional who generally can perform together because they help each other. Those very much in knowledge management support the communities."

It was also found that organisation A provides a coffee shop with a seating area whereby everyone in the organisation can come at any given time for free. Organisation C has a tea point, where people can meet and talk. During the director meeting in organisation A, the seating area was found to be very popular with people drinking and chatting.

5.13 Leadership

Another factor seems to have an impact on the application of the KM. This is the support of the leadership. Some of the participants maintained that it was very important that leadership had to stand behind the application of the KM and support it.

Organisation B:

> *"We are supportive, and it is very much around the encouragement of people to do what is expected of them."*

In organisation A, leadership has to show everyone in the organisation that KM is everyone's responsibility.

Organisation A:

> *"The role of leadership is to make it crystal clear to everybody that when you are a knowledge-based organisation like us, it is our life buddies, and everybody's duty and responsibility to capture and share knowledge."*

If the leadership does not support the KM then, there is no way to success. This was stated by the Chairman of organisation D.

Organisation D*:*

> *"Leadership has got to be a 110% behind the KM. If it isn't, you will not be successful, and you will need to work on getting it that way. Top leaders have an absolute imperative to participate in knowledge management. They have even to go as far as to use an expression that I often use which is, "Burn your bridges behind you; we cannot go back, we need to be moving in this direction."*

5.14 Summary

This chapter set out to explore the best practices of WLC knowledge capture and recovery (WLCKCR). Data was obtained from four cases based on semi-structured interviews. The following conclusions can thus be drawn from the data analysis. The successful application of knowledge capture and recovery is grounded on the deployed method, processes and technique. However, other factors including open culture, motivation, social networks and social activities, the structure of the organisation community of practice and workspace design are regarded as vital to whole life costing, knowledge capture and recovery application. It is essential that leadership must stand behind this initiative by providing continuous support and make the right resources available.

A knowledge base with components to manage project knowledge, the discovery of experts and sharing of knowledge saves effort and time and enables enhanced WLCKCR.

One of the key significant findings to emerge from this study is that the project review is the major method for capturing project knowledge. Some techniques are therefore deployed in a project review to achieve a variety of functions. This includes the checklist, brainstorming, and the three processes approach; in addition to interviews and presentation as secondary techniques. Together, monthly, and at the end of stages, reviews were found to be capable of avoiding knowledge loss without affecting the demanding work. The outputs of project review are considered practical and reusable when short (on average, five to twelve pages) and in the form of checklist and instructions. It should also be available in live pages on the system. Categorising project knowledge based on both project processes, and processes with no link to the project, appeared to maintain the context and make knowledge recovery fast and straightforward during the project. It was also stressed that retrieving knowledge should start with the system by either searching or navigating to the desired activity; otherwise using the community of practice. The next chapter will bring the findings together and provide a framework for WLCKCR in construction.

CHAPTER 6 : FRAMEWORK DEVELOPMENT

"You never change things by fighting the existing reality. To change something, build a new model that makes the existing model obsolete." — R. Buckminster Fuller

6.1 Introduction

This chapter contains the presentation and discussion of the results gathered from the preceding chapters in a bid to construct a framework for WLC knowledge capture and recovery for use in construction. The technique of designing the framework is grounded on revealed causal mapping.

6.2 The Significance of the Proposed Framework

A framework is a defined as a *"way of describing some part of the organisational situation which is of concern to the participants of study*". (Tomlinson, 1990, p.11). It is suggested by Fellows and Liu (2015) that the reality being modelled should be captured in a framework and should also contain the vital features of that reality while being reasonably inexpensive to develop and user-friendly. The framework constructed to tackle a complex situation can aid the project team and managers to reduce risk, impose consistency and provide logical and generic structures in making decisions (Bell, 1994).

The framework proposed in this research was developed to tackle key research questions and the aim posed in this research. The framework outlines the key variables that encourage knowledge capture and recovery and people approaches and highlights how knowledge can be captured and recovery and value enhancing practice can be managed and implemented. The framework was developed from the key variables identified from the qualitative analysis. The data gathered from the previous the chapter was utilised to formulate the proposed framework. The aim of this chapter is to merge the results obtained from the previous chapter so as to identify relationships alongside erecting the framework.

The framework will be constructed using revealed causal mapping which emphasises cognition as a system of cause-effect relationship which aims to capture the structure of the human cognition of a text which is either documented or interview-generated (Narayanan, 2004). This approach is viewed as a way of displaying the views of an individual in a field or domain (Axelrod, 2015). This can be achieved connecting a practical result with a theoretical grouping which is then linked into a network of causal relation (Nelson et al., 1999). This approach is mostly utilised in the field of social sciences (Huff, 1990) and it can also be used in the formation and testing of theory (Nelson et al., 2000). In order avoid any challenges due to some variables and construct, during the framework construction, a decision was made to consider how reliable causal mapping is when utilising an island of themes, accounting for hierarchy, using nubs and potency, and reducing concepts via emerging proprieties (Bryson, 2004).

The proposed conceptual framework was built on the existing literature research into the current situation of the participating construction organisations regarding the problem of whole life costing in

the UK. As a result, it can be directly applicable to the participating construction organisations. The main aim is to ensure that the conceptual framework will assist construction organisations in the capture and recovery of knowledge in whole life costing in the construction industry. The proposed research framework, therefore, defines a generic methodology to guide UK construction organisations to systematically and effectively capture and recover whole life costing knowledge with the possibilities of improving knowledge performance in their organisations. The development of the framework was scrutinised and verified by a panel of professionals and the final framework incorporates their views and comments (see Chapter 8).

6.3 Required Information

In order for decisions to be effectively facilitated during a project, several forms must be ready and available. In this study, an examination of the sort of knowledge will offer good practice for carrying out a certain task in the project. This knowledge is referred to as project insight. In some cases, it was discovered in order to have a better understanding of project insights, sets of information such as project correspondence and project data must be made available. There two sets of information make up what is known as a "project portfolio". Data such as audits, procurements, project scope, cash flow, etc. are contained in the project data. While, codified emails, telephone notes and forms that are connected to the project are contained in the project correspondence (section 5.4 ad 5.6).

6.4 Knowledge Capture

From the interview analysis, two main methods were found to be employed by the participating organisations for capturing knowledge; knowledge captured by individuals and knowledge capture via the PR method. Members of the project team are advised and encouraged to codify in short form the new knowledge acquired, taking into account that desired knowledge is associated with the activities of a project or process; so, it can appropriately be located and recovered from the system. Individuals can filter knowledge from a discussion board where knowledge is discussed and shared by experts (For further information, see Section 5.4: Interview analysis). Furthermore, in that situation where a project team member is seeking to get a solution regarding a problem he or she encounters, when the desired solution to the problem is found, this solution is to be captured and placed in the appropriate section in the knowledge base (system) (see section 5.7 for more information).

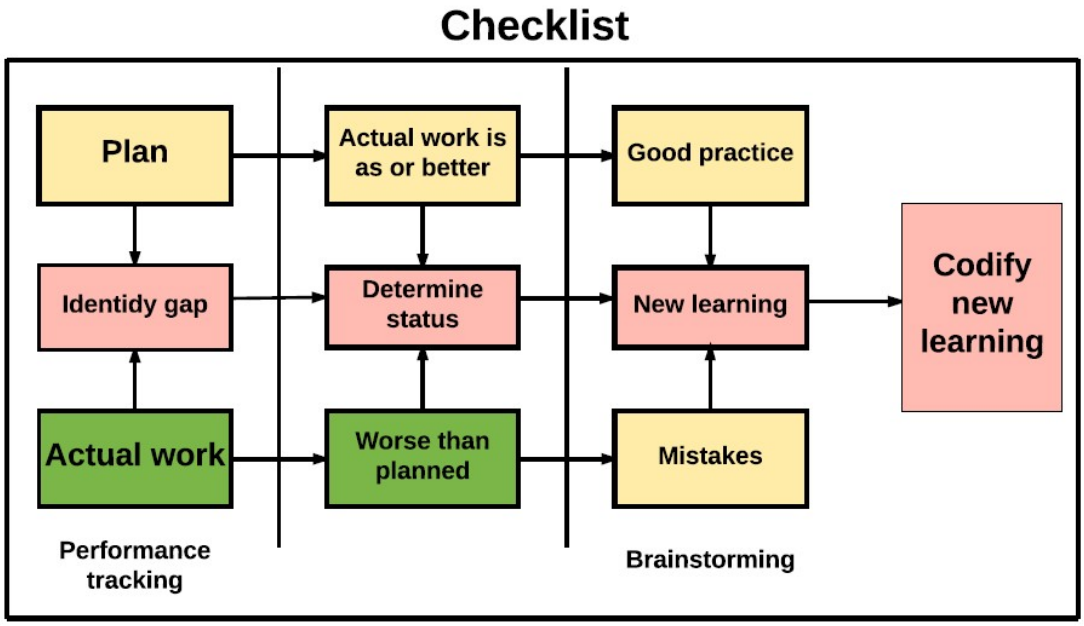
Previous studies have recognised how vital it is to capture knowledge, identify the desired knowledge and locate the knowledge required that has already been codified and have it stored in the knowledge base system (sections 2.7, 2.7.3). Nevertheless, the knowledge capture situation revealed above provides a defined way in which project knowledge can be captured. The manner in which recovery of knowledge can result in capturing new knowledge has not been described previously.

6.5 Project Review (PR)

From the interview analysis, it was uncovered that PR is the key technique employed in capturing knowledge (section 5.5) and is also identified as the most common technique adopted in the participating construction organisations (section 5.5). This endorses the findings from the literature (see section 2.9). Nevertheless, it is confirmed in the literature that PR is a technique used in capturing knowledge, and it is considered the most effective approach for capturing knowledge in the participating construction organisation. The findings from the literature are in agreement with the findings from the interview analysis, in which the PR method should fill the aim of project knowledge capture. The matured PR practice in the participating construction organisation and the KM training and consultancy firm put forward three PR components where each component performs a specific task and function. The PR component is the checklist, the three processes approach and the brainstorming technique. The PR parts identified are braced by the use presentation and interview, which can be advantageous in this particular situation.

The study has gone a step further towards improving our comprehension of detailed PR practice. Before the commencement of PR in a project, a checklist is formulated in the subject area that is to be discussed, so the PR participants do not miss out vital points in their review. The purpose of PR is for information generation with the intention to uncover the lessons learned from the project. In order for this to be attained, a detailed PR report, the performance tracking of the project must be made, by making a comparison between what has been planned and what has been done. The response to these enquiries will result in the gap being identified between the planned project and what has been carried out. After the determining these results, it is then analysed using the brainstorming technique. The brainstorming technique is adopted in a situation to investigate why some parts of the project went well and to identify the lessons learned from the successful experience. Conversely, investigating what did not go well in the project will assist in the identification of the mistakes that were made and lessons can be learned from analysing these reasons. The new lessons or good practice learned should be codified as shown in Figure 6.1 and put in the right section in the system (knowledge base) to allow easy recovery.

Figure 6.1: PR method



6.5.1 Interviews

Although a few or all parties externally were key PR participants, in some cases, PR is often carried out with no involvements of other parties (sections 2.9 [literature], and, 5.5.3 [Interviews analysis]). In this situation, PR was conducted with key actors in the project, and also with other parties when possible with the intent to gather the required knowledge from other parties. The opinion of experts externally who were involved in the project is considered very important to the project (see section 5.5.2). According to literature, the interview techniques are utilised to map out knowledge, competency, and the area of proficiency of individuals in the firm, as employees are a firm's intellectual capital resources. Report from the literature revealed that the use of interview technique had nothing to do with the capture of knowledge in projects. It was discovered that the interviews are conducted with members of the firm so that the expert directory content can be enriched. Face to face deliberation can prompt the required knowledge effectively rather than requesting forms to be filled by project people (section 5.6.2).

6.5.2 Time of PR

As is evident in the literature (Section 2.9) PR could be conducted on one occasion after the completion of the project or the completion of each stage, as a timed based review (i.e. weekly, monthly, quarterly) or 1 to 2 years after the completion of the project. From the interview analysis, the participating construction organisations employ PR at the end of stages and the end of the project. Nonetheless, it was revealed that the two types of PR adopted by the participating construction

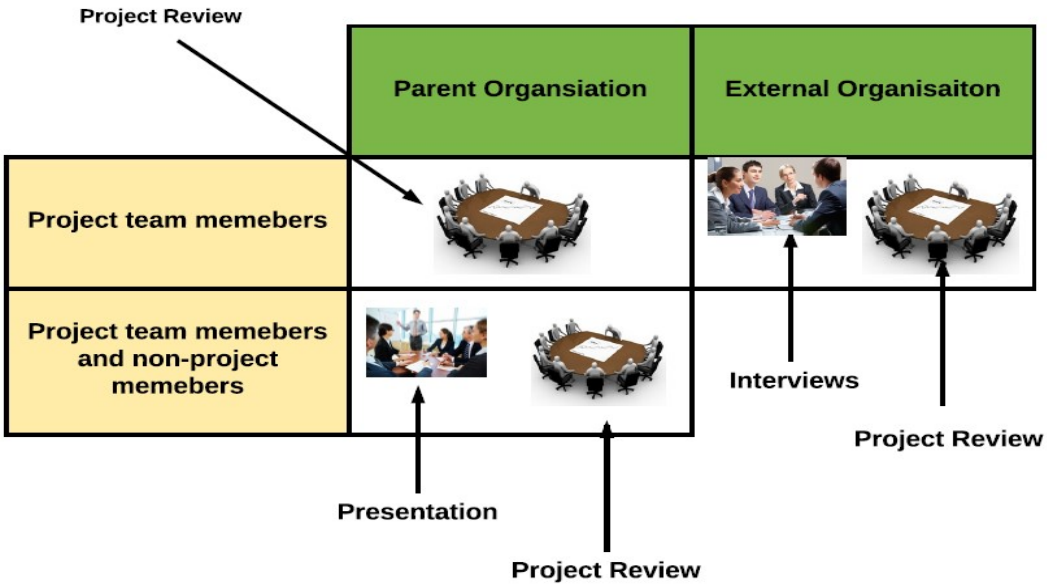
organisation could be more efficient when carrying out both monthly and at the end of every project stage, providing that a stage review is a review of the whole project (see section 5.5.3).

The time lag between action and review will be shorter in a month to month based review. This limits the likelihood of learning being lost in the course of the work. Toward the finishing stage, PR provides a clearer picture of the strategic perspective of the project. Monthly PR can produce the project reviewers with new knowledge from a wider perspective.

6.5.3 Participants of PR

It was recognised that the project participants are the most suitable individuals to be present in the PRs due to their in-depth comprehension of the project. So, they ought to appreciate the lessons that have been realised (section 5.6.3). Regarding senior experts, it was seen that the contribution from them could enhance the PR. On the other hand, it was also found that in the case of incorporating a non-project member into PR team, it is important that the presentation technique be employed to present what the content of the project insights are and what has been accomplished, to the non-project individuals (see section 5.5.2). Nevertheless, from the interview analysis (section 5.5.3), it was indicated that individuals from other firms involved can attend the PR occasionally. However, if they are fully participating in the PR, it is important to interview them in order to identify the key players in the project as shown in Figure 6.2.

Figure 6.2: The use of PR techniques in relation to participants



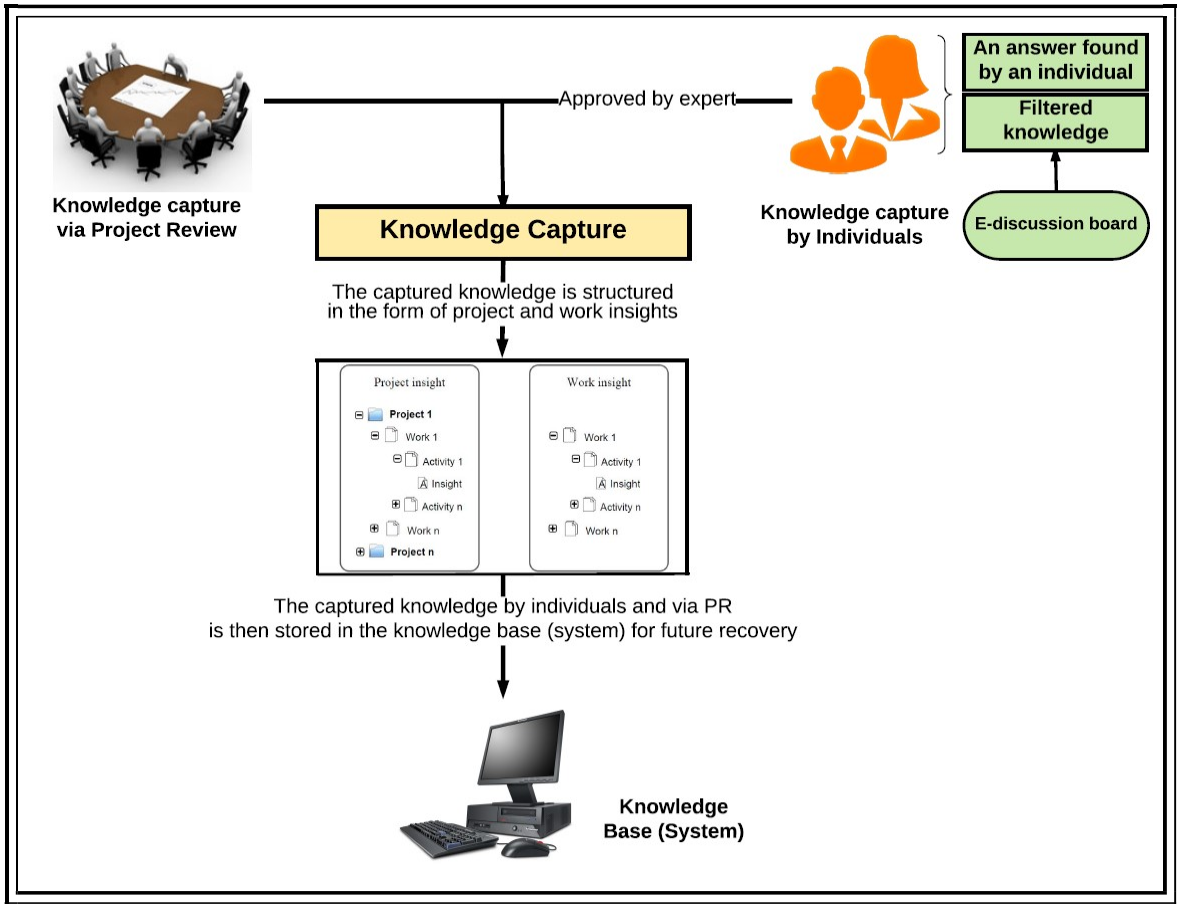
6.5.4 PR outcome

The final outcome of the PR was found to be one of the major problem associated with PR. This is on account of a report covering the lesson learned to be produced (Section 2.9). This report can be a lengthy one which can be released in either an electronic or paper document format (section 2.7). In an

advanced practice of PR, the reports produced ought to be short, to-the-point knowledge nuggets and remarks, undertakings and activities (project insights). The best PR practice reveals that the average size of PR report (project insight) ranges from six to thirteen pages. Checklist and instructions were viewed as the appropriate project insight forms (section 5.6.1). If a similar activity is to be carried out in the future project, the best practice of PR linked to that activity can be provided to the project team. When codifying project insight. It is important that is done on live page (section 5.6.6), which need to a categorised and structured in the right section in the system for easy recovery for future use. As uncovered in the literature (section 2.10) PR was adopted for measuring and tracking work performance, which is crucial in producing project insight (section 5.6.1). Nonetheless, project insight related data should be codified separately so as to enable individuals to locate the project insight easily without having to examine huge files with a surfeit of data.

In summary, knowledge can be captured using the two key methods reported in the interview analysis which is knowledge capture by individuals in the organisation and via PR method. Figure 6.3 demonstrates how knowledge could be captured using the two methods.

Figure 6.3: Knowledge capture model



6.6 Taxonomy

Having all the data from a PR report in one file happens to be the traditional method of structuring PR. The files are then classed into different sections such as performance studies, project audit, human resources aspect and time and cost studies (section 2.9). Nevertheless, this situation is not in agreement with the detailed practice uncovered in the participating construction organisations (section 5.6.1). In order to easily access the insight of a specific project work, the insight linked to each project must be categorised and classed based on the project, work and activities. Nevertheless, it revealed that an additional taxonomy method is needed: the classification of insights according to work/activities with no link to the project.

Every project insight has to be categorised based on the work/activities in the project. In this way, the insight into the exact sections of work in a project can easily be accessed and recovered as shown in Figure 6.4. Where the insight is classified according to activities/work with no relation to the project as shown in Figure 6.5. This classification method groups all the insights of a specific activity that have been gathered from earlier projects in one section. This assists individual in carrying out work on

a project to access accumulated experience and learning associated with the activity they are presently carrying out. Work insight contents are similar to project insight content; furthermore, insights added by project individual have to gain expert approval.

Some of the participating construction organisations are involved in more than one field of business, for instance, cost planning, structural planning or construction management. In this case, it would be important that the project insight and work insight from each business be classified separately (section 5.6.1) and Figure 6.5.

Figure 6.4: Project and work insight

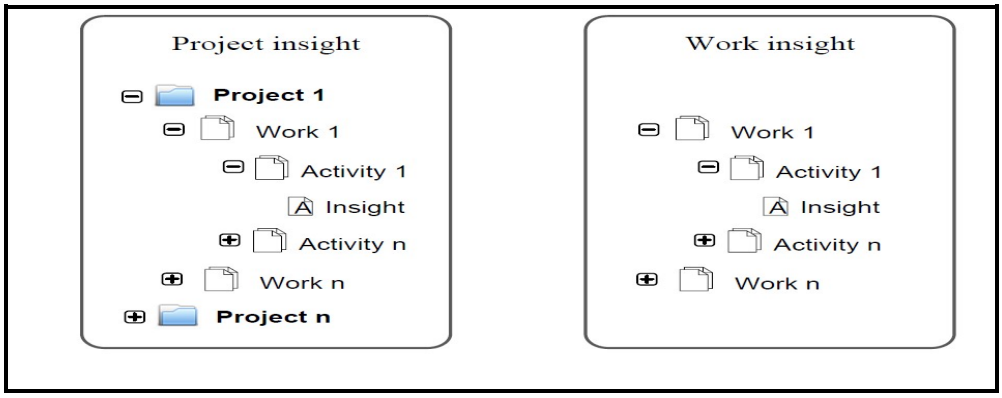
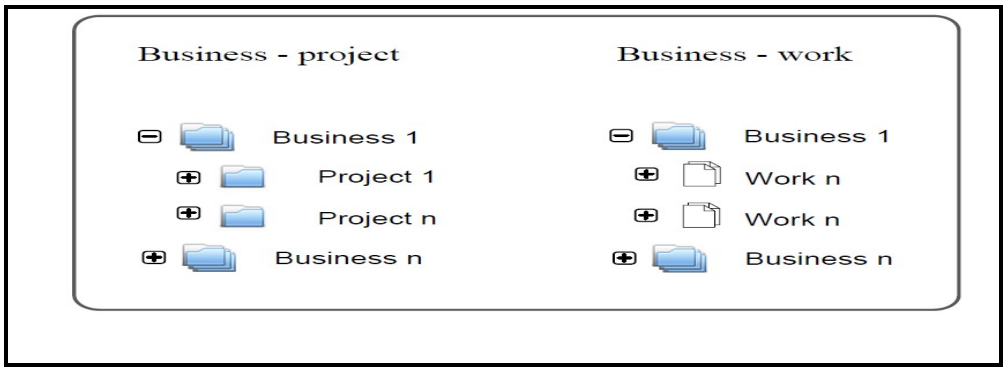


Figure 6.5: Business insight



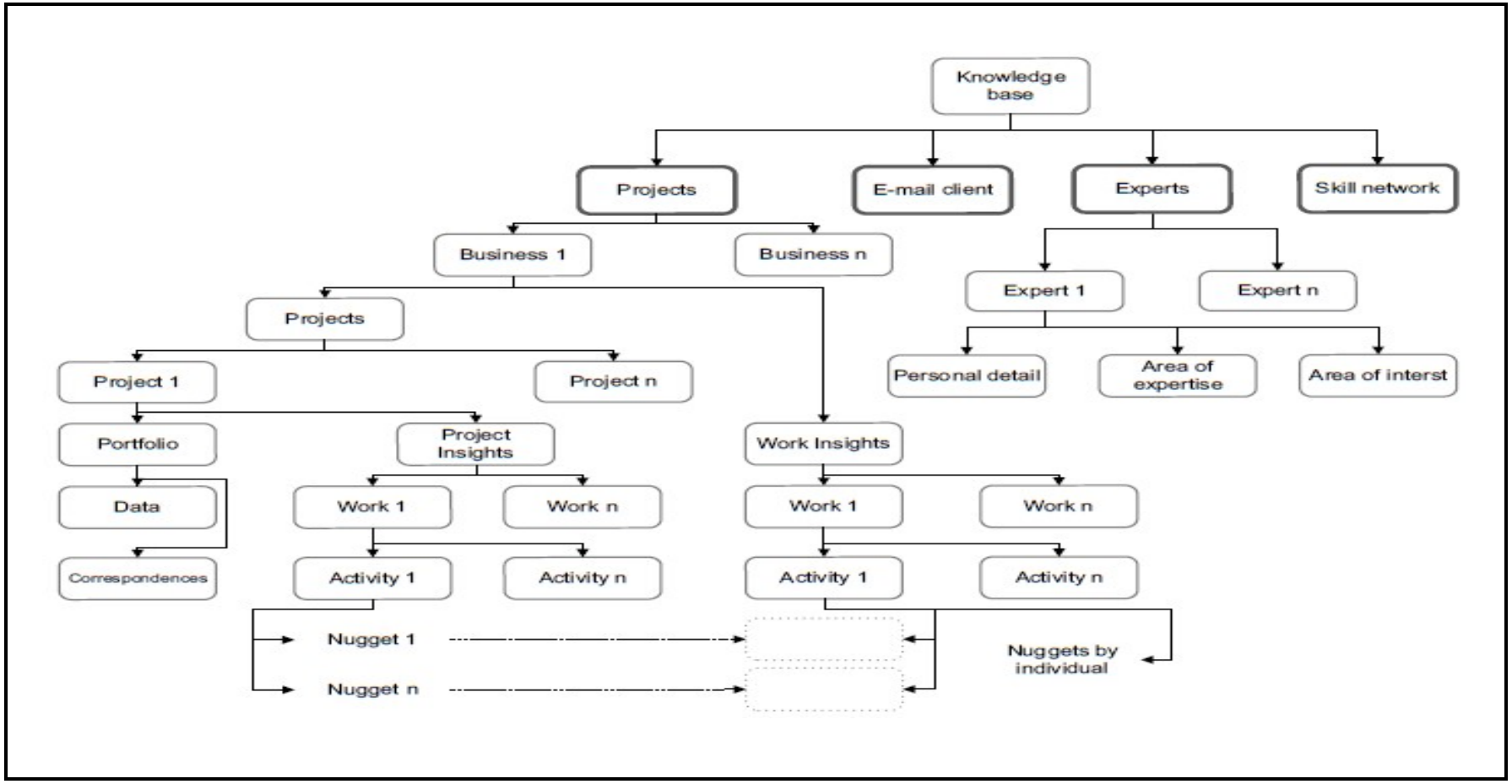
6.7 Knowledge Base (System)

The results generated from this research support the discoveries of a great deal of the earlier research conducted in this discipline (sections 2.7, 2.6.4). The implementing system was uncovered to a vital enabler to KM. A system for capture and recovery in projects was deployed in the four case study organisations (section 5.3). However, there is an indication in the research analysis that, if the appropriate tool and the right content categorisation are not structured appropriately, it could make the system ineffective. It is also revealed that the intranet network should be the platform where the system can be erected, and every member of the organisation should be given viewing admittance to

the system. Furthermore, the capacity regarding the adding of content is needed in some parts of the system, such as work insights and the expert directory. Owing to the issue of discretion, restrictions can be applied to certain information of the content (section 5.3.1).

A system is required for a mature practice of capture and recovery of knowledge in whole life costing practice in project which is made up of four components. The first is to manage project knowledge with the ability to classify the knowledge content. The content of the taxonomy inside this component must adopt the discoveries in section 6.6. Features such as keywords, tags and search engine should be included and displayed on live pages. The second component in the system is the section which manages the profile information of the organisation which comprises the personal information of the members, area of interest and area of expertise.

Figure 6.6: Knowledge base structure



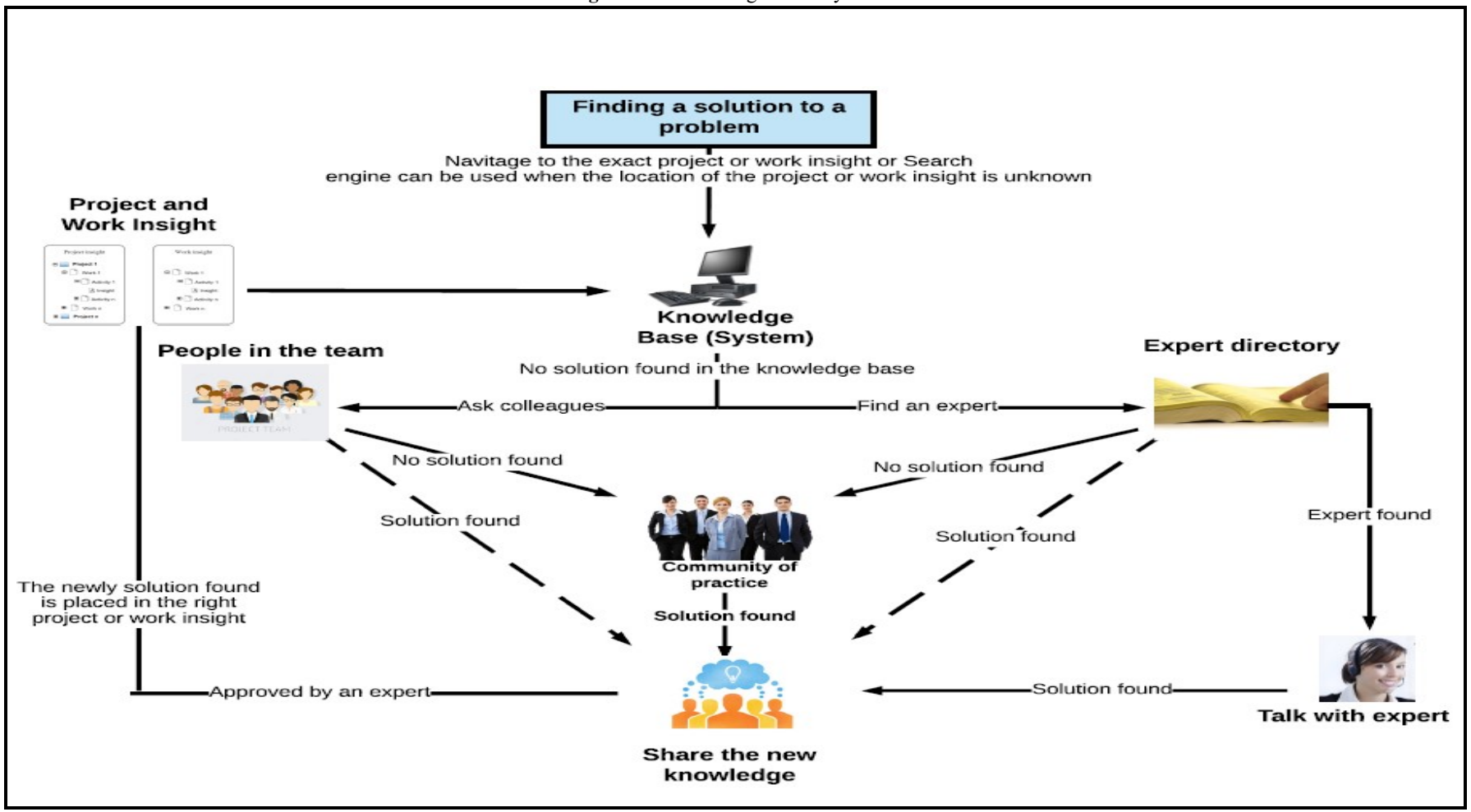
This component is referred to as the expert directory which aids in finding the right experts to be located. Email was revealed to be the third component employed in the four participating organisations as a platform for knowledge sharing and correspondence from a project (section 5.4.2). It was considered advantageous to have the captured correspondence from the project inside the project portfolio component, so it can be accessed to provide the perception of project insights if required (section 5.5). Finally, components that provide the right discussion environment about the practice should be included in the system. The component acts as a CoP platform and is an alternative means of seeking solutions to problems encountered**.**

In summary, the knowledge base is also termed the "system" which is constructed on the intranet network. The system provides admittance to every member in the organisation to view the content and should be displayed on a live page. The knowledge base system comprises four key components which are; project, email clients, expert directory and skills network as shown in Figure 6.6.

6.8 Knowledge Recovery

Literature has identified the navigating and search engines as the two main tools used in knowledge recovery (Section 2.6.5) and presented in this research. Nevertheless, using navigation for knowledge recovery is a straightforward undertaking, as the work insight has already been organised and placed in a well-organised section in the system. The navigating tool can be utilised to access content with the exact taxonomy (like that in this research) based on the activities/work (activities/processes) and could make knowledge recovery quicker by navigating to the desired work needed. The search engine is deemed fitting for finding the required knowledge when the position of the knowledge is unknown in the system (section 5.7). Fascinatingly, a flow diagram on how to go about seeking a solution to the problem has been simulated based on good practice.

Figure 6.7: Knowledge recovery model



An individual in the project searching for solutions to a problem should commence by using the navigating tool when the required knowledge location is known or the use of a search engine when the location of the desired knowledge is unknown to find solutions in the system (knowledge base). If no solution to the problem is found in the system (knowledge base), then the individual should proceed to use either by asking colleagues in the project teams or the utilisation of expert directory to locate the right expert in the required discipline. Where no solution can be obtained from the project team members or expert directory, then the individual proceeds to get solutions from colleagues in the firm with the same interest in the same discipline (CoP). In a small-medium enterprise, it is likely to be through face to face dealings, while in large firms, it is evident that the use of an electronic discussion board is an effective method for CoP. When the solution to the problem is found, it is a good practice to share the solution so that project individuals can learn and utilise it in the future. Sharing this newly acquired knowledge can be attained by adding it to the right sections in the system (knowledge base). However, it can only be utilised by others after it has been codified (sections 5.7).

6.9 Leadership Support

Despite the fact that literature has advocated that leadership is an influential factor for effective capture of knowledge (section 2.8), the data collected from the participating organisations in this research underlines that leadership in the participating organisations are in full support of KM application. If there is no support from leadership regarding the application of an approach for whole life costing knowledge capture and recovery, then the proposed framework will be ineffective. The support from leadership begins by connecting strategic values with sharing knowledge. Encouraging and inspiring individuals in the organisation to share and capture knowledge was also discovered to be crucial in leadership. To facilitate the capture and recovery of knowledge in the participating organisations, all the necessary resources have to be in place in order to ensure there is no obstacle preventing individuals from accessing the desired resources. Within the participant organisations, the need for leadership in the organisation to paint a clearer picture to every member of the organisation, that it is the responsibility of every member to capture and share knowledge (sections 5.8 – 5.13).

6.10 Open Culture

From the data gathered shows that an open and cooperative culture is influenced by three major essentials which are identified and discussed in the next sub-sections

6.10.1 Organisational structure

It is revealed from the interview results gathered from the participating organisations that the structure of the organisation is vital in capturing and recovery of knowledge because it influences the sharing of knowledge within their organisation. A flat organisational structure is recommended from the interview findings gathered because the hierarchy levels are fewer and also it will aid the wider communication and knowledge sharing amongst organisational members. Although very little was

discovered in the literature regarding the linkage between the structure of the organisation and knowledge sharing (section 2.8).

6.10.2 Social network and community of practice

From the interview analysis, it was discovered that the social network influences the sharing, the capture and recovery of knowledge (section 5.12). This result agrees with earlier studies in the literature (section 2.8) that effective communication between project team members can be achieved when a strong social network is available. This allows knowledge to be shared freely within the organisation. Nevertheless, one fascinating discovery about social networks was that it could shadow the formal hierarchy and allow individual's access to every member of the firm. The growth of the social network is dependent on support from a leadership that creates social events. This research proposed some concepts and events for encouraging social network, such as informal talk sessions, project team members having weekly lunches together, communal coffee/tea points, casual gatherings during weekend and seasonal celebration of events such as Christmas. It was also revealed communication between members in an organisation is affected by the workspace design; an open plan workspace design can result in better interaction between project members (section 5.9).

Organisational learning is dependent on a community CoP as stated in the literature (section 2.8). However, this research demonstrates that CoP can naturally be established because of common interests or can be established formally by the management of the organisation. A variety of CoP forms was suggested from the findings, these include monthly meetings with the purpose of discussing news and development, best practice groups, quantity assurance sessions and the use of electronic skills network (e-discussions boards) by large organisations (section 5.11).

6.11 Motivation

As anticipated, in order to ensure continuous knowledge sharing in an organisation, a motivational strategy has to be put in place. The finding of this research provides backing to other research which considered motivation a vital factor for effective KM adoption in an organisation (sections 2.6.4 and 2.8). This research identified some motivational approaches. Nevertheless, one particular approach was emphasised in the interview analysis as being crucial: the demonstration of how the sharing of knowledge can be beneficial to organisations and individuals. There is a need for individuals to recognise how important knowledge sharing could enhance their knowledge and performance on the job. As stated by the KM training and consultancy firm (organisation D); "You do not know something until you teach it."

Another motivational approach concentrates on the demand aspect. Where individuals are asked what exactly they want to know and what their thoughts are regarding the present method: rather than concentrating on the supply aspect (providing organisational members with the only opinion from the top management). The method is carried out through what is known as feedback-based motivation.

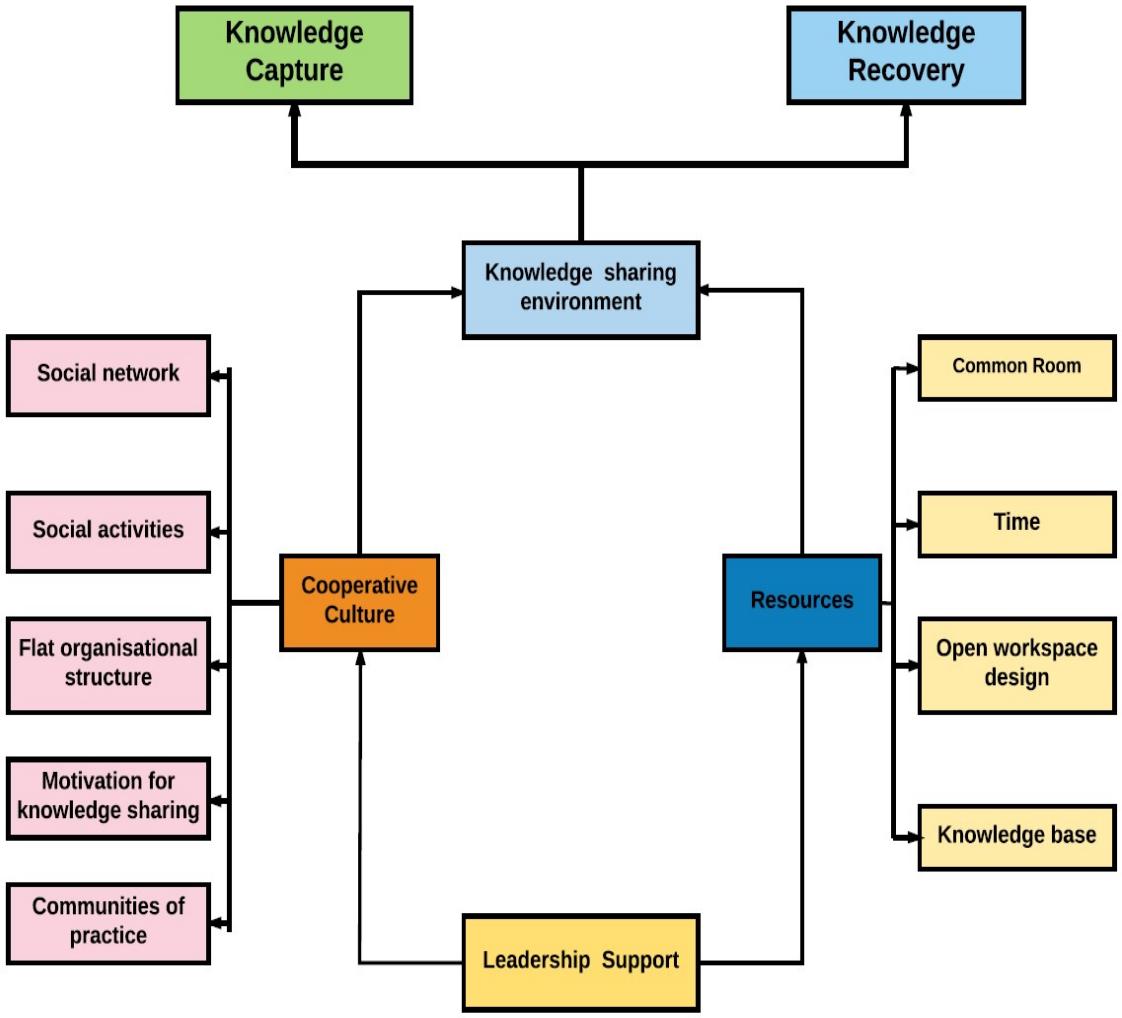
Bonus and recognition schemes were considered to be practical. This method was seen to be widespread in literature, and it was thus anticipated to apply to all the four cases; nevertheless, only one case implemented the method. The last method connects motivational strategy with the organisation's strategic values and considers the sharing of knowledge as part of the organisation's values which awareness is created for individuals on the importance of knowledge sharing (section 5.10).

6.12 Strategic view of the Framework

An observer view into the research findings helped in the major identifying categories and the establishment of the cause and effect relationships. In the research context, one key problem that emanated from the research findings is that the capture and recovery of knowledge within the participating organisations will be unsuccessful without productive ground in which knowledge sharing can be supported. It is true that the capture and recovery of knowledge has to be carried out in accordance with best practice approach, nonetheless, no matter how effective the knowledge capture and recovery approach is, the lack of knowledge sharing environment makes it unsuccessful. Even though it is not part of the research agenda, the term knowledge sharing has become one of the most frequently used terms in this research. An appropriate knowledge sharing environment was revealed to be affected in the participating organisations by two elements: the existence of resources required and a co-operative culture. Those two elements required full leadership backing.

The research reveals that having an open culture in an organisation will increase trust between members in the organisation and connect them before a knowledge sharing activity can be facilitated. Nevertheless, this is not enough in isolation if knowledge is to be effectively captured and retrieved. The absence of a robust approach, well-structured knowledge taxonomy and a system with a suitable feature, then there could be some considerable knowledge loss. An appropriate knowledge sharing environment can provide organisations with an enormous amount of information, but without filtering what is vital from the huge amount of information generated it could result in an overload of information which could possibly become an obstacle to knowledge recovery.

Figure 6.8: Strategic view of the framework



6.12.1 Knowledge Sharing Environment

Leadership is responsible for providing backings for creating an open culture and access to all resources required in facilitating knowledge sharing. An open culture needs well-established approaches and activities that contribute to cooperative culture creation, the culture that encourages individual in the organisation to share knowledge. The research study has revealed that a cooperative culture can be attained by creating several approaches and sustaining them.

Knowledge sharing motivation: This can be achieved by demonstrating how beneficial the sharing of knowledge can be to organisations and their workers. Furthermore, the use of feedback-based motivation, via bonus and recognition schemes and by setting knowledge sharing as essential to the organisation's values.

A flat organisational hierarchy: it is suggested to have a flat organisational hierarchy. This is because a wider interaction between individuals in the organisation can be attained when there are fewer levels between the top and bottom of the hierarchy.

Social network creation: knowledge sharing can be achieved by linking individuals together. To accomplish this, there must be a strong relationship network between members of an organisation. The manner in which a social network is created is dependent on resources and social activities. Social networking can assist in overcoming the obstacle of vertical hierarchy and works to provide every member access to other members of the organisation.

Maintaining Social activities: in order for the social network to be enriched, social networking must take place regularly. This research has recommended some activities and ideas that can enrich social networking, such as hosting weekly lunches, having coffee and tea points, holding formal evening events and informal talk sessions and shared common areas where individuals can gather and chat.

Establishing communities of practice: The quality of the knowledge shared is reliant on individual experience and background. The purpose of CoP is to connect individuals with the same interests together in the area of expertise, in order to increase the chances of improving knowledge pooling. It can be established by the creation of best practice groups conducting monthly meetings to deliberate about the development in the organisation. Electronic discussion boarded in some large organisations and SMEs can be an effective method of establishing CoP.

6.13 Summary

The proposed framework which aids knowledge capture and recovery in WLC practice is presented in this chapter. A few suggestions have been made regarding the knowledge taxonomy, structure, models and system. In order organisations to effectively capture and recover knowledge in whole life costing, using the proposed conceptual framework they must have similar characteristics of the participating organisations such as, there must be a full leadership support and knowledge sharing environment, a cooperative culture which supports social networking, social activities, flat organisational structure, motivation for sharing knowledge, community of practice, and also an organisation that has resources such as common rooms, open workshop design space, a knowledge base. Nevertheless, the formulation of this framework is based on good practice analysis which requires validation by practitioners; this will be presented in the next chapter.

CHAPTER 7 : Framework Validation

"It is not that I'm so smart. But I stay with the questions much longer." — **Albert Einstein**

7.1 Introduction

This chapter focuses on the validation presented in the previous chapter. The eternal framework validity will then be discussed. The second part of this chapter will analyse and discuss the findings obtained from the evaluation of the framework. The framework assessment has been carried out by academics and expert practitioners and has measured the suitability, and efficiency of the framework in the building sector.

7.2 Validation of Proposed Framework

The aim of the validation process is to present the developed framework to respondents in construction organisations in order to minimise the threat to the reliability and validity (and furthermore increase the chances of generalisability) of the refined framework. Furthermore, this validation approach is closely interwoven with the concept of triangulation, which is a useful approach to ensure the validity and reliability of qualitative research (Hair et al., 2007; Saunders et al., 2007).

The data was collected via a web-based survey. Web-based surveys are gaining in popularity (Dillman, 2000). Sproull (1986) found that data collection via e-mail has the advantages of producing adequate data, enhancing response rates, and engendering a willingness to further participate with the minimum expenditure of the researcher's time and effort and a high degree of convenience for the respondents. An online survey technique was chosen, since it is easier to access a large number of people and it also provides an efficient way to collect responses from practitioners in different locations in the UK

The selection of appropriate respondents was also a significant aspect of this study. An 'expert opinion' validation using a questionnaire accompanied by the proposed framework was distributed to 20 experts. They were selected based on four criteria: their involvement in the pilot study data collections, they participated in the previous semi-structured interviews, their e-mail address was available and 28 construction practitioners in the three-construction organisation were contacted and only 12 were interested in the framework validation. 12 validation questionnaires were sent to the practitioners, but only 10 responses were completed and returned. Each of these ten experts had over six years of field experience in the adoption of WLC practice in the construction industry. Due to the handful of practitioners for validation, it was also considered to use academics in order to boost the results of the framework validation. It is expected of academics to have in-depth and methodological views as they are acquainted with observation and analysis. The industry is the primary source of information for academics, so it does not imply that they will be isolated. Many academics are involved in the practice. In order to have a balance between the two groups of experts used in the framework validation; 10 academics were used in the framework validation making a total of 20

experts used for the validation. The co-operation of potential respondents was obtained through e-mail and telephone, followed by a letter (see Appendix 3) to the organisations/link persons who had expressed a willingness to approach potential respondents.

Table 7.1: Participants in the framework validation

Experts		Job title	Year of experience
Practitioners	Organisation A	Project Manager	35
		Project Manager 2	15
		Quantity Surveyor	20
		Building Surveyor	7
	Organisation B	Quantity Surveyor	6
		Project Manager	33
	Organisation C	Cost Estimator	15
		Quantity Surveyor	8
		Project manager	27
		Construction manager	7
Academics		Senior Lecturer A	12
		Senior Lecturer B	30
		Lecturer C	6
		Lecturer D	7
		Lecturer E	8
		Lecturer F	10
		Reader G	31
		Reader H	21
		Reader I	15
		Lecturer J	5

A sample of the validation questionnaire and feedback is presented in Appendix E. The questionnaire for validating the proposed framework consisted of three parts. The first part focused on general questions regarding the respondents' organisation with respect to job title or position, the number of employees and years of experience. The second part evaluates the framework using a score based rating the suitability and efficiency of the proposed framework and using an open-ended question to elicit the opinions of experts regarding the benefits, limitations and way of improving the framework.

7.3 Results

7.3.1 Framework suitability

Participants were asked to show their rating of the suitability of each of the components of the framework; where 1 was structured as unsuitable and 5 as suitable. The answer from the analysis revealed that the suitability levels for all approaches were regarded as being too complex.

As shown in Table 7.2, the lowest mean value for the knowledge base structure is 3.74 of 5. Although it is not showed in the value that the knowledge base structure is 100% suitable, it still shows that it is likely to be more suitable than unsuitable. However, the structure approaches, the knowledge capture and recovery components were preferred as they all have a score of 4 out of 5. The skewness measure was a negative value which demonstrates that the mass of distribution concentrates more on the side of suitability.

Table 7.2: The framework component suitability

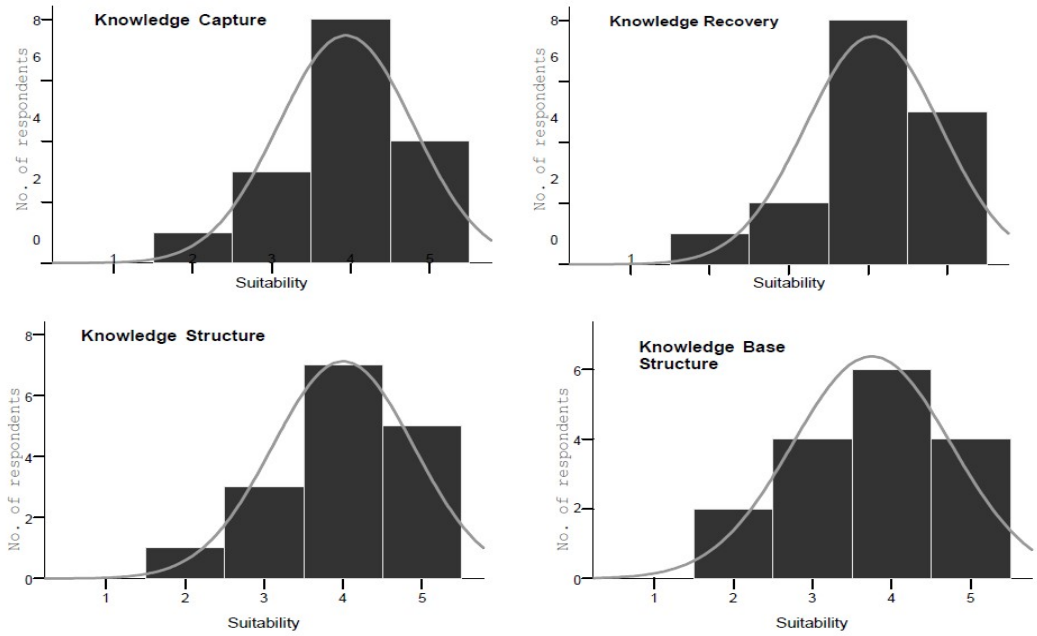
		Knowledge Capture	Knowledge Recovery	Knowledge Structure	Knowledge Base Structure
N	**Valid**	20	20	20	20
	Missing	0	0	0	0
Mean		3.829	4.0364	4.2893	3.864
Std. Deviation		.8864	.8943	.8694	1.00000
Skewness		-.645	-.842	-.687	-.325

Figure 7.2 shows that most of the expert participants gave a 4 or 5 rating for the suitability of all the framework components. With regard to the knowledge base structure, the suitability was rated below 3 by two expert participants (i.e. 2). The normal curve illustrates that the approximation of the average of all components almost falls within the 4th rate of suitability. By all the indications, it is evident that the whole framework component is suitable for construction organisations.

The answers presented in Table 7.6 can be classified into four main groups: Firstly, the framework improvement is a continuous process, and its applications are considered to be the most fitting way to enhance the framework. Secondly, improving the framework can be accomplished by tackling teamwork, time and profitability which have already addressed in this study. Profitability is an important aspect that can declare how important the capture and recovery of knowledge of whole life costing in a construction project is and therefore, is one of the areas to be embarked upon. Nevertheless, developing a model which measures economic profit alone is enough to undertake a research project. Thirdly, the effort is in the linkage of the IT system with the approaches of capturing and recovery of knowledge. The knowledge base (system) is a section of the proposed framework, and

it is also important that people are trained in the utilisation of knowledge base (system) which is linked to the approach of knowledge capture and recovery. Lastly, the utilisation of labels to differentiate between optional activities, compulsory and resources. This has been presented differently in this research as the majority of the activities and resources were thought to be significant if knowledge was required to be captured and retrieved effectively. It was decided only to highlight the resources or activities that were recommended but not deemed essential.

Figure 7.1: Suitability of Knowledge Capture, Recovery, Knowledge Structure and Knowledge Base Structure



7.3.2 Framework efficiency

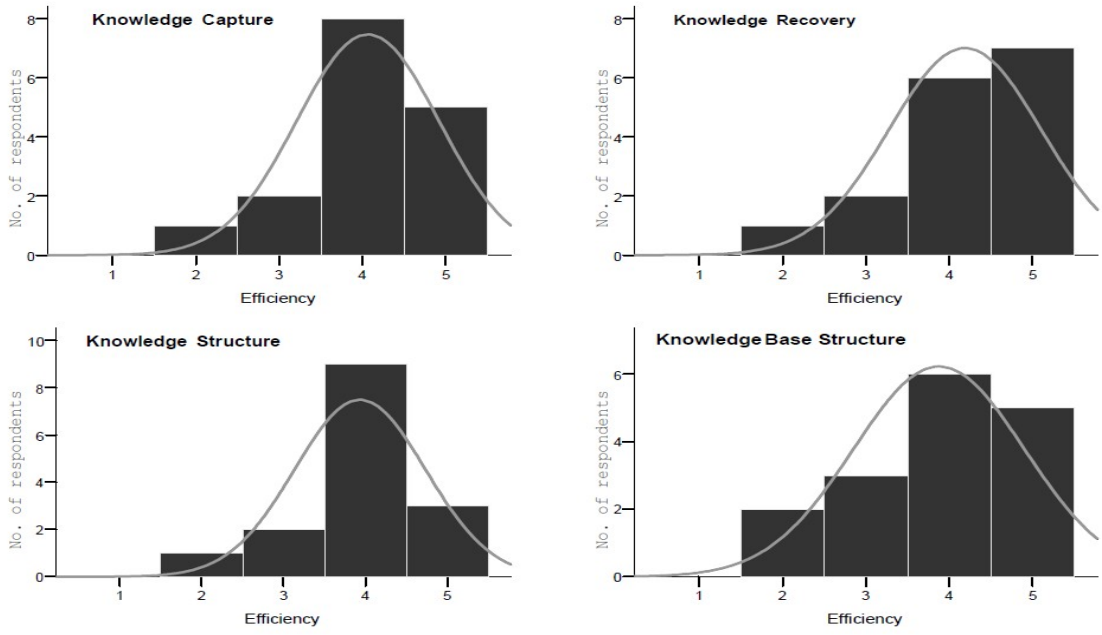
Expert participants were requested to score their rating for the efficiency of each of the components of the framework; where 1 is structured to be inefficient, and 5 represented efficient. The mean value of efficiency for all the components as shown in Table 7.3 is above 3.75 and ranges between 3.87 and 4.18. The skewness measure has a negative value which means that the mass of the distribution is tilted towards the side of efficiency.

Table 7.3: The framework component efficiency

		Knowledge Capture	Knowledge Recovery	Knowledge Structure	Knowledge Base Structure
	Valid	20	20	19	20
	Missing	0	0	1	0
Mean		4.147	4.174	3.824	3.784
Std. Deviation		.83965	.94024	.95792	1.0853
Skewness		-.834	-1.183	-.832	-.592

As shown on the histograms in Figure 7.3, the majority of experts who participated in the study evaluated all components with a score of 4 or 5 rating of effectiveness. Knowledge recovery thus turns out slightly more efficient than the other components of the framework. The normal curve shows clearly the approximation of the average rate of all components which almost lies in the four rates of efficiency. All the indicators collectively show that those components will be efficient when applied.

Figure 7.2: Efficiency of Knowledge Capture, Recovery, Knowledge Structure and Knowledge Base Structure



7.4 Feedback Analysis

The Feedback received from the validation survey could be considered the opinion of the participating experts during the validation, and the knowledge is considered as adequate for analysis and recommendations. The expert comments and views obtained were used to update the framework. The expert criticism confirmed that the developed framework could be adopted in the capture and recovery of knowledge in the whole life costing practice in construction projects. Overall, a commendation

from all the participating experts acknowledged that the framework could be used as a reference or guide in enhancing the knowledge capture and recovery. Table 7.4 presents some of the expert views and their comments.

Table 7.4: Comment and suggestion received on the knowledge capture and recovery framework

Organisation	Position	Feedback
A	Project manager	The framework looks very fascinating with the entire fanciful diagram. I am kind of wondering how flexible the framework is regarding whether it must be a complete package, which means all the factors must be taken into account to reflect knowledge capture and recovery or possibly have some factor and that knowledge capture and recovery work. I am asking this question because any organisation that wants to use this model will be frightened that they have to follow all these steps in order to capture and retrieve knowledge effectively. I think there should be a mechanism to show that it is packaged-oriented which would give the end users enough room in applying what is within their capacity and encourage them to enhance further as they see the benefits of capturing and retrieving knowledge regarding performance enhancement, knowledgeable workers and other factors that will strengthen organisations. I hope it makes sense and my comments and feedback are beneficial to your study. Best of luck
A	Quantity surveyor	The framework looks very usable and can be practically implemented. I consider it a good starting point for knowledge capture and recovery for achieving an organisation's outcomes
B	Senior quantity surveyor	The framework requires to be showcased more attractively and also some comprehensive examples should be used so it can without difficulty understood
B	Project manager	The framework looks great, and I like it, particularly how the knowledge base structure is classified. This will assist save time when searching the knowledge base for the right information
C	Construction manager	It seems very general
C	Project manager	It is tough to make a judgment on these core issues just on the presentation. Nevertheless, I am quite inspired by the approach to knowledge capture. Although it is an excellent presentation, it provides insufficient information.
C	Construction manager	There is so much sense in the framework WLC and project management perspective. However, the capture and recovery of knowledge are complex and resource intensive activities and can be difficult to the project team if appropriate motivations are not allied with the expectation of leadership regarding the sharing of knowledge
C	Quantity surveyor	Brilliant presentation. It did cover quite a number of things we don't see as significant in our daily work in the delivery of the project
Academic	Lecturer A	I think your framework will be extremely effective when properly applied. Also it is highly applicable. In terms of advantages, I think it is simple to read and understand by any person who has a basic level of knowledge and its management

Academic	Lecturer E	It seems very general.
Academic	Lecturer B	It looks good to me. The challenge is to make it happen in practice

The feedback from experts mentioned in Table 7.4 can be divided into four classes shown in Table 7.5.

Table 7.5: Feedback classification

Classification	Comment
1	This class considers those which highlight the role of capturing and recovery of knowledge.
2	This category considers those which stresses the need for such a framework, due to the awareness of the problem, and thus confirm the motives for this study.
3	The category considers those who indicated that the framework might entail enormous determination and construction projects already involved in demanding work. This issue has been discussed in the statement of the problem (section 1.4) whereby the problem lies on the capture and not the recovery side. To minimise the problem, the project review was used as the main technique for knowledge capture which already exists in projects, instead of introducing a new approach. Also, the daily based reviews were rejected in this study for the same reason. Furthermore, a strategy for motivation has been identified in the framework to ensure the application of knowledge capture
4	Fourthly and most importantly, an applicable and efficient framework will also need careful application and effort. This has been mentioned by several experts and is therefore considered a critical point because good theory does not necessarily guarantee successful application

One of the academic experts classed the framework as very generic. In fact, the framework is looking at a particular area to explore, which is related to the capture and recovery of knowledge in WLC practice. The capture and recovery framework has provided comprehensive details on what is to be done in a particular scenario. The capture and recovery of knowledge cannot be undertaken alone without support from the leadership and a cooperative culture. However, it is worth revealing that this expert chooses the rating of 3 for all the rating based questions which is seen as statistically biased. Nevertheless, it was thought that the personal details of the academic experts were provided which matched the tracking information. Therefore, the response was valid, and his views were appreciated. Other valid points were also considered linked to the framework advantages; and impressions of the framework presentation.

7.5 Framework Improvement

The section puts forward the questions which were asked regarding how the framework could be improved. Table 7.6 presents the feedback by the experts regarding the framework improvement.

Table 7.6: Feedback from experts

Organisation	Position	Feedback
Organisation A	Project manager	By trial and error
Organisation A	Quantity Surveyor	The improvement of the framework should be after it has been applied.
Organisation B	Senior Chartered estimator/quantity surveyor	I didn't analyse the presentation critically in order to make a thoughtful contribution in this direction.
Organisation B	Project manager and quantity surveyor	What problems should be tackled? Teamwork, profitability or and time?
Organisation B	Construction manager	I think it would be a great idea if the framework can be tested on a geographically distributed and functionally complex firm
Organisation C	Senior project manager	I think it would be good have labels of "must-have", "good to have" and "should have" which can be used to differentiate between the activities and sections that are compulsory and optional. This might make your framework more flexible when applying as I think organisations will vary in their capabilities and levels of implementation
Academic 6	Senior Lecturer	Having the framework linked with the IT system which enables its process and archives all knowledge captured after arranging it.
Academic A	Senior Lecturer	Show an example of how it will work practically

The answers presented in Table 7.6 can be classified into four main groups: Firstly, the framework improvement is a continuous process, and its applications are considered to be the most fitting way to enhance the framework. Secondly, improving the framework can be accomplished by tackling teamwork, time and profitability which have already addressed in this study. Profitability is an important aspect that can declare how important the capture and recovery of knowledge of whole life costing in a construction project is and therefore, is one of the areas to be embarked upon. Nevertheless, developing a model which measures economic profit alone is enough to undertake a research project. Thirdly, the effort is in the linkage of the IT system with the approaches of capturing and recovery of knowledge. The knowledge base (system) is a section of the proposed framework, and it is also important that people are trained in the utilisation of knowledge base (system) which is linked to the approach of knowledge capture and recovery. Lastly, the utilisation of labels to differentiate between optional activities, compulsory and resources. This has been presented differently in this research as the majority of the activities and resources were thought to be significant if knowledge was required to be captured and retrieved effectively. It was decided only to highlight the resources or activities that were recommended but not deemed essential.

7.6 Summary

This chapter presents the results from the framework validity. It has confirmed that validity depends on the inherent validity of the methods of collecting and analysing data also the inferences leading to the framework development. Twenty validation questionnaires were sent to two groups of experts (construction experts and academics). These experts are professionals who are regarded as skilled to form an accepted logical opinion on the proposed framework. The assessment of the conceptual framework for knowledge capture and recovery in whole life costing practice by experts confirms the framework is suitable and efficient for use in knowledge capture and recovery in whole life costing in construction project. The feedback received from this validation survey can be considered as the opinion of the suitable experts and the knowledge provided is considered sufficient for analysis and recommendations. Although the feedback wasn't used in the framework refinement due to the area of knowledge capture and recovery in whole life costing is an emerging area of research. However, it has been put forward for in the list of recommendations for further research. In doing so the final objective of this current study, which is "to validate the proposed conceptual framework" was addressed. The next chapter presents the conclusions, recommendations and suggestions for future research arising from this PhD research.

CHAPTER 8 : Conclusion and Recommendation

"Don't wish it were easier. Wish you were better." — **Jim Rohn**

8.1 Introduction

The conclusion of the study undertaken to develop am framework for knowledge capture and recovery in whole life costing is presented in this chapter. The research undertaken is summarized, outlining the key findings and recommendations for further research are made. The research limitations are also outlined. Lastly, the chapter highlights the research contribution to the field of knowledge.

8.2 Research Background

The overall aim of this study was to develop a framework for knowledge capture and recovery in whole life costing practice. This was accomplished through the formulation and the use of appropriate research methodologies. These methodologies include an extensive review of literature, interviews, questionnaire survey. The research findings were attained through the research methodologies summarised below.

The stage one of this research was undertaken through an extensive review of literature in the area of whole life costing practice in order to identify the gap. The findings from the literature in the area of whole life costing practice uncovers that in spite of the benefits of implementing WLC as a valuable approach for comparing alternative building designs allowing operational cost benefits to be evaluated against any initial cost increases and also as part of procurement in the construction industry, its adoption has been relatively slow due to the lack of tangible evidence and "know-how" skills and knowledge of the practice i.e. the lack of professionals in many establishments with knowledge and training of whole life costing practice, this situation is compounded by the absence of available data on whole life costing from relevant projects, lack of data collection mechanisms etc. This has proven to be very challenging to those who showed some willingness to employ practice in a construction project. In order to address the aforementioned whole life costing problem, it was considered to approach the problem from the knowledge management perspective, by investigating into how knowledge from whole life costing practice can be captured and recovered. An extensive literature review was undertaken in the area of knowledge management and it was established that the implementation of KM in construction firms happens to be the driving force to improving organisational performance (Hsu, 2008). It was also established that knowledge acquired when undertaking a project is often loss due to the absence of an effective strategy to knowledge captured and recovery for use on future projects. As construction firms are regarded as knowledge based business (Rezgui et al., 2010). Their day to day jobs undertaken is dependent on the knowledge, ideas, documents, workers skills, information sourcing from electronic media, individuals and electronic media. With this affluence of knowledge, construction projects can be executed efficiently. Regardless

of the fact that construction firms are knowledge intensive, it is contended that the knowledge of their employees is not effectively put to use (Suresh, 2006). Due to the diverse amounts of knowledge by individuals, skills and capabilities that vary across the firm, it is significant that they are guided and effectively coordinated to capture, share and recover knowledge so as to enhance the performance of the firm (Almahamid et al., 2010).

Further review of literature suggested the importance of knowledge capture and recovery approach in whole life costing practice. It was established that the capture of knowledge could assist the project team to reuse the knowledge, as lessons learned from one project can be carried on to future projects, resulting in continuous improvement, provides knowledge that can be used in the operation and maintenance phases of an assets life span.

Stage two of the research was carried out through the use of pilot and main semi-structured interview to gather data from three construction organisation and one knowledge management training and consultancy organisation. The purpose of the interview with the aforementioned organisation was to collect data regarding the existing KM tools and techniques employed in the capture and recovery of knowledge in whole life costing practice also exploring the advanced practice of knowledge capture and recovery in the participating organisations. The third stage of the research was analysing the data collected from stage one and two which was then used to design the framework for knowledge capture and recovery in whole life costing practice. Lastly, the framework was validated using construction practitioners and academics in order to measure the suitability and efficiency of the proposed framework (Stage 4).

8.2.1 Research Objective 1: Literature Review on KM Practice

The first objective of this study was the conduct an extensive literature review in the area of KM in the construction, identifying the KM tools and techniques which support the knowledge capture and recovery in the construction. It was established that many construction organisations are employing different initiatives in other to remain knowledgeable and also have a competitive edge in the construction industry. KM is acknowledged as a tool that could bring about the much-required innovation, enhance business performance improve project delivery and also lessons learned from one project could be captured and reused on future project, resulting in continuous improvement.

The literature also identified the KM tools and techniques that support knowledge capture and recovery. The KM techniques include project review, communities of practice, mentoring, apprenticeship, while the KMS are intranet, extranet, internet, electronic discussion board and expert directory. The aforementioned KM tools and techniques forms part of KM this is utilised alongside KM strategies, processes and methodologies.

A project review (PR) is viewed as a suitable and popular technique utilised in capturing of knowledge in projects. PR is mostly emphasized on the project activity assessment. It is carried out after key phases of a project, where lessons learned are collected at the conclusion of the project. Also, it is carried out only once after the completion of the project.

8.2.2 Research Objective 2: Literature Review on WLC Practice.

The second objective of this study was to conduct an extensive literature review in the area of whole life costing practice. The purpose the objective was to present back ground knowledge about the practice, its benefits, and the management barriers that limits the widespread of the practice and to establish how knowledge management could be employed as tool to address the management barriers to whole life costing. In spite of the benefits of implementing whole life costing as a valuable approach for comparing alternative building designs allowing operational cost benefits to be evaluated against any initial cost increases and also as part of procurement in the construction industry, its adoption has been relatively slow due to the lack of tangible evidence and "know-how" skills and knowledge of the practice i.e. the lack of professionals in many establishments with knowledge and training of whole life costing practice, this situation is compounded by the absence of available data on whole life costing from relevant projects, lack of data collection mechanisms etc. This proved to be very challenging to those who showed some willingness to employ practice in a construction project. The deployment of knowledge management in practice can enhance whole life costing analysis execution, as lessons learned from one project can be captured and reused in future projects, resulting in continuous improvement, provides knowledge that can be used in the operation and maintenance phases of the assets life span.

8.2.3 Research Objective 3: Exploring the Existing KM Practice in WLC Practice.

The research objective was achieved through the collection of data via semi-structured interview from construction organisation with experience of whole life costing practice. Due to a handful of construction organisation that were willing to participate in the research. It was considered to employ a knowledge management training and consultancy organisation because it is acknowledged that respected educational and consultancy organisation that produce bodies of knowledge are usually considered as pioneers in the fields in which they specialize. By having an opportunity to develop the practice and recommendations regarding KM. Such organisations will most likely enrich the study, and may offer more thorough and reliable approaches.

The findings uncovered in this objective is that the PR method was identified as a major technique used in knowledge capture. A comparison of the interview finding and the literature findings regarding the purpose of undertaking project review in project. It was revealed that the literature finding and the interview findings are in agreement. The outcome of this established the most suitable knowledge

capturing method which led to further investigation into how project review should be undertaken detail.

8.2.4 Research Objective 4: Exploring the Advanced Approaches Deployed in Knowledge Capture and Recovery in WLC

This was achieved through data collected from a semi structured interview with three construction organisation (Main interview).

The key findings from this stage confirm project is supported by a number of techniques in order to for the purpose to be attained. These consist of the checklist, brainstorming and the three processes approach; Also, the use of interviews and presentation as secondary techniques. The appropriate time of undertaking PR is on a monthly and at the end of stages so as to minimise the loss of knowledge without an impact on the demanding work. PR output is regarded as practical and can be reused when documented in short and précised structure (checklist and instructions) and should be displayed in live pages on the system.

8.2.5 Research Objective 5: Framework development

The data gathered from the literature and the interview was used in developing the framework. The induction method was adopted in constructing the framework using the revealed casual mapping.

PR was regarded as the key method used for knowledge capture. In order to implement an effective knowledge capture approach, two scenarios can be applied; capture solutions found knowledge filtration via a discussion board. The model erected for PR comprises three components; checklist, brainstorming technique and the three processes approach with each performing a specific function. The study shows that PR should be carried out monthly, given that the reviews are conducted at the end of every stage and after the completion of the project. The output of PR should be included in instructions or in checklist format and also in short and precise report structure. The knowledge base system must include four components, projects (to manage project knowledge), expert directory, e-mail client, and skills network (for knowledge sharing). A decision support model was designed to assist in retrieving project knowledge. Knowledge can be recovered from the project insight into the system by navigating to the exact work insight. The search engine could also be used in instances when the exact place of the work insight was not known. Expert directory, colleagues from the immediate team, and members of the organisation (community of practice) are alternative places to look for the desired knowledge, considering there is a precise order for approach.

8.2.6 Research Objective 6: Framework Validation

The proposed framework was validated in this stage. Since a handful of cases were used to formulate the framework, the suitability and the efficiency of the framework were measured using ten construction experts and ten academic experts making it a total of twenty validation participants. The

purpose was to compare the results gathered from the study with good practice. The outcome of the framework validation indicates that the framework is suitable and efficient.

8.3 Limitation of the Study

In spite of the valuable results obtained from this study, it is also faced with a few limitations. The constraints of the framework are as follows;

- The framework is constrained to knowledge capture and recovery. Therefore, the emphasis is on other KM processes solely for comprehending the context.
- The projects referred to in the study are to WLC practice in construction project. Therefore, projects out of the context of WLC practice are not valid.
- The framework is project-based; therefore, it is incapable of managing organisational knowledge.
- The data gathered from a handful of firms in UK construction was used to formulate the framework. Therefore, adopting the framework outside the UK may be unsuccessful due to the techniques, organisational structure, culture, organisational resources, etc. the outcomes could vary from country to country.

8.4 Contribution to Knowledge

The findings from this study have made several contributions to the current literature. These contributions include the following:

- Developing a framework for knowledge capture and recovery during a construction project, minimising the loss of WLC knowledge. It is the first framework/model that has considered both the capture and recovery of WLC knowledge in the construction industry. Other research studied either knowledge capture alone or in tandem with knowledge application, and the focus of previous research has been on the application of KM at the organisational level. This framework adds to a growing body of literature on project KM.
- Typical research carried out in the discipline of construction management limits the gathering of data only to the building sector, which is used to develop a theory that can only be applicable to that sector. Apart from the primary data collected from the construction industry, this study is enriched with concepts and ideas adopted in other sectors.
- Further procedures have been undertaken to ensure the applicability of the data collected by the industry.
- This study has provided an in-depth comprehension of the practical tools and techniques utilised in knowledge capture alongside its availability and efficiency. The popularity of the

KM techniques is also identified. This has improved the comprehension KM existing practice in the context of WLC practice.

- Although the different kinds of PR adopted in the entire industry is documented in the literature, Nevertheless, the method's popularity, the reason for adoption, the management of time was not precisely uncovered. The comprehension of the existing practice of PR has been strengthened by this study and has established a clearer picture to add to the findings from existing practice.

8.5 Recommendations for Further Research

The recommendation for further research in this study can be classed into two: recommendations for practitioners and recommendation for academics. A few are put forward as follows:

8.5.1 Recommendations for practitioners

The following recommendations could be considered by construction firms which can act as a guideline to assist firms to manage the initiative of knowledge capture and recovery.

- It is indisputable that the capture and recovery of knowledge have a significant influence in improving organisational performance on the use of WLC practice in a construction project. As such, UK RICS, being a recognised body is enhancing the careers of practitioners in the construction sector. It is vital that opportunities are provided to construction firms and registered practitioners by RICS, so the awareness and the importance of knowledge capture and recovery are published alongside training programmes for a practitioner in the aspect of KM. The training recommended a focus on the utilisation of ICT as a tool for the capture and recovery of knowledge that could be very expensive and also individual-based approaches to wholly use the potentials of formal and informal approaches to knowledge capture and recovery.

- A conceptual framework construction together with other key variables that influence the effective implementation of an approach for capturing and retrieving knowledge will enable a proactive approach to be adopted by the project team when capturing and retrieving knowledge in a firm. Nevertheless, there is a need for the framework testing in reality with construction firms and in other countries so the framework application and validity can be established.

- A key role is played by management in supporting the strategies for knowledge capture and recovery. It is very important that the strategies for knowledge capture and recovery get full visible support from the management. In order for a firm to improve its performance, consideration should be given to the objectives and strategies of capturing and recovery of

knowledge and design top management directives that classify what knowledge is to be captured.

- Many barriers exist regarding the successful implementation of knowledge capture and recovery strategies in construction firms. It is vital that the kind of culture, the structure of the organisation, workspace design and social network in a firm be considered because it could have an effect on the way in which employees share knowledge.

8.5.2 Recommendation for academics

- Only a handful of organisations with experience of WLC in construction projects situated in a single country (the UK) are examined in this study. Hence, the results presented in this study may only reflect a handful of a construction firms and a country with specific characteristics. Because of this, the results from this study might not be generalised to other construction companies and countries.

- In an attempt to have a clearer picture of capturing and retrieving knowledge in WLC practice. The data gathered were obtained from a handful of private construction firms. Nevertheless, a distorted result may be achieved due to the variation in the nature of the tasks being carried out by public construction firms. Additional practical work is required so as to test the generalisation of the findings in other businesses/sectors

- A considerable amount of work is needed to show the relationship between social network analysis and the factors influencing social networking in projects. The connection between the two interrelated areas proposes a break for the resulting exploration of social network analysis in a given situation and also make a comparison of them with the identified factors influencing social networking. A suggestion on the utilisation of a combined approach for two-phase investigation; firstly, to conduct interviews to determine the factors. Secondly, the utilisation of case studies in analysing both the social networks (utilising the model that has previously been identified) and recognising the factors available. Doing this may result in identifying critical factors that make the difference with regards to the solidification project social networks.

The accomplishment in each of the chapters in this thesis has been outlined and summarised in this chapter. The research aim and objectives were attained, and the research has contributed significantly to the participating construction organisations and also to KM discipline. The research limitation encountered when the research was undertaken was also highlighted which can be used as a guideline for undertaking future studies in the enhancement of the knowledge capture and recovery approach.

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APPENDIX A
CONSENT LETTER TO THE SENIOR PROJECT MANAGER/ LINE MANAGER

The Scott Sutherland School of
Architecture and Built Environment
The School of Built Environment
The Robert Gordon University
Garthdee Road
Aberdeen
L3 3AF
Email: n.y.tobin@rgu.ac.uk
The Human Res
Company Address
Dear……,

I am currently undertaking a PhD entitled "A framework development for knowledge capture and recovery in whole life costing practice". My research focuses developing an approach that could support knowledge capture and recovery.

The second stage of the work necessitates a semi-structured interview with mid-level practitioners so as to establish the existing and good practice of knowledge capture and recovery in whole life costing practice. The main research objective focuses on identifying strategies and practices which contribute to knowledge capture and recovery. It is my belief that ascertaining the existing and good practice from mid-level practitioners such as project managers, quantity surveyors, building surveyors who are directly involved with whole life costing practice in projects, will greatly assist in the provision of the most appropriate framework for knowledge capture and recovery. The decision to choose your organisation was based on the excellent background your company has had on whole life costing practice.

As a PhD research student at Robert Gordon University, I have a growing interest in finding out how mid-level practitioners capture and recovery knowledge in whole life costing practice. The participation of your practitioners in this project will eventually help to enhance the understanding of value enhancing practices in whole life costing projects. You are assured of confidentiality and that any identifying information will be destroyed at the data processing stage of the research. Please be assured that the identity of your experts and organisation shall remain strictly confidential.

Hopefully the research will provide a comprehensive review of how knowledge can be captured and recovered in whole life costing practice in construction project. If you would like a summary of the research findings I should be pleased to forward a copy on completion of the interview.
If you have any further questions or would like a discussion with me prior to making up your mind please contact me on **[deleted]** or leave a message to call you back as soon as possible. Your assistance and co-operation in this research will be welcome and gratefully received; I hope you will be able to assist in furthering my research studies.

Yours sincerely,

Ndibarafinia Young Tobin
PhD research student

I hereby agree/not agree for my organisation to participate in this study. I understand that all information gathered during the study will be treated as strictly confidential.
Name:

Date:
Telephone:
Address:

If you do not wish to participate in the study, I would be grateful if you would sign above and please feel free to write down the reasons for refusing.

APPENDIX B
Semi-structured interview questions to participants

Background: This research is part of a PhD study conducted in order to increase understanding in the area of knowledge management, and to define existing and best practices that organisations use in knowledge capture and recovery in whole life costing practice in a construction project. Please be aware that your responses will be confidential. All personal information obtained through this research will remain confidential.

1. Brief background:

1. Describe your role and responsibility in the organisation?
2. What type of project do you work on?
3. What is your experience and involvement in whole life costing practice?

2. What is the most commonly used IT tools in your organisation when carrying out whole life costing practice?

1. What is the purpose and how efficient is the identified IT tools?

3. What is the most commonly used KM technique in your organisation when carrying out whole life costing practice?

1. What is the purpose and how efficient is the identified KM techniques?

4. What kind if KM system is available in your organisation?

1. What components make up the system?
2. Access to the system?

5. How is project review conducted in your organisation?

1. What is the purpose of project review?
2. What are the methods of conducting project review?
3. Who are the keys actors when conducting project review?
4. What is the time frame set for carrying out project review?

6. How is the knowledge from project review codified?

7. How is knowledge recovered from the system?

8. What is the hierarchy of your organisation?

APPENDIX C
Framework Validation: Letter of Invitation

Dear [Name],

I am presently preparing a thesis on the capture and recovery of knowledge from whole life costing practice as part of my PhD research in construction management.

In this research, a framework for knowledge capture and recovery for whole life costing practice has been designed. A crucial part of the study is to validate the proposed framework.

As an expert in the industry, you are invited to watch a presentation, which can be found in drop box. Please find link and login details below to access the presentation.

https://www.dropbox.com/login?&_tk=sem_b_goog&_camp=sem-b-goog-uk-eng-top-exact&_kw=dropbox|e&_ad=160711325480|1t1|c&gclid=CjwKEAjw4vzKBRCt9Zmg8f2blgESJADN5fDgHv668ovpc14_8WNVcFP4yV-K9Kdee1gvSEvnPgaeXRoCmfHw_wcB

Email: tobin_ndibara@yahoo.com

Password: Letmein2016

You are then invited to give your opinion regarding the framework by filling in the questionnaire in this link: http://www.surveymonkey.com/s.aspx?sm=Ygwlr0Y1vHzTgtpfNqewz3tOcghTyVZKGOOO91niZkA_3d

The presentation is about 20 minutes long, and the questionnaire is estimated to take less than 3 minutes to complete.

Your assistance and cooperation is highly appreciated.

Yours faithfully

Ndibarafinia Young Tobin

Please note: If you do not wish to receive further emails, please click the link below. http://www.surveymonkey.com/optout.aspx

APPENDIX D
Sample Questionnaire for the Framework Validation

1. You name ?

2. Job title ?

3. Years of experience?

4. Business of your organisation

- ◯ Contractor
- ◯ Educational Institution
- ◯ Consultancy

Other (please specify)

5. Size of your organisation

6. Would you like your name and your organisation's name to remain confidential ?

- ◯ Yes
- ◯ No

7. Please indicate your rating for the suitability of the following approaches , Where 1 = unsuitable and 5 = Suitable

	1	2	3	4	5	Unsure
Knowledge Capture Approach	○	○	○	○	○	○
Knowledge Recovery Approach	○	○	○	○	○	○
Knowledge Structure	○	○	○	○	○	○
Knowledge Base Strucutre	○	○	○	○	○	○

8. Please indicate your rating for the efficency of following approaches , Where 1 = Inefficent 5 = Efficent

	1	2	3	4	5	Unsure
Knowledge Capture Approach	○	○	○	○	○	○
Knowledge Recovery Approach	○	○	○	○	○	○
Knowledge Structure	○	○	○	○	○	○
Knowledge Base Structure	○	○	○	○	○	○

9. Could you please express your opinion on the framework in terms of effectiveness, applicability, advantages and shortcoming

10. In your own opinion, how can the framework be improved ?

11. Would you like to receive a report of the research result by email, once it is completed ?

○ Yes

○ No

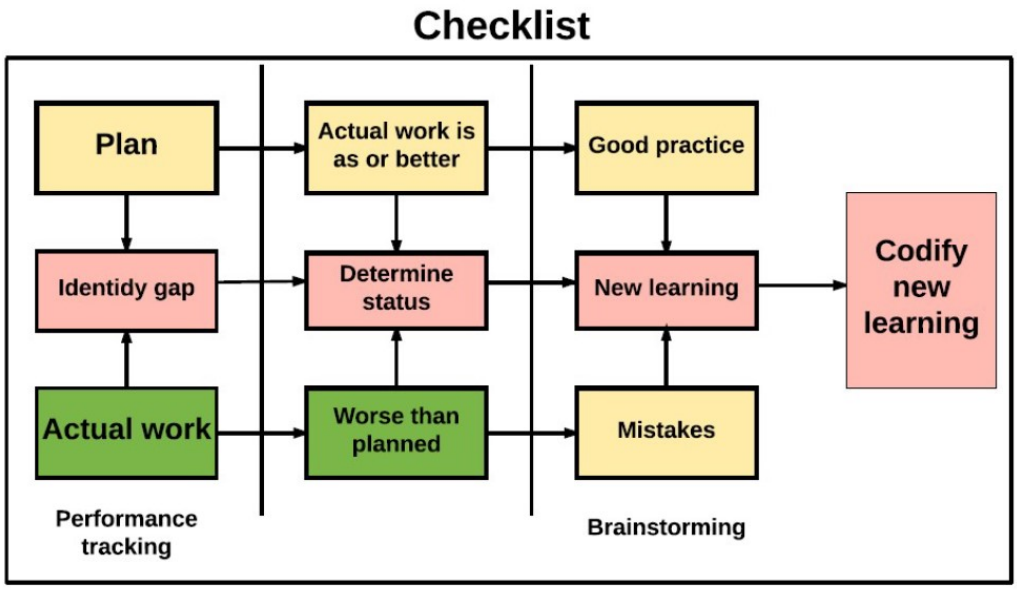
APPENDIX E
Framework Presentation for Validation

ROBERT GORDON UNIVERSITY•ABERDEEN

A Framework for Knowledge Capture and Recovery in Whole Life Costing

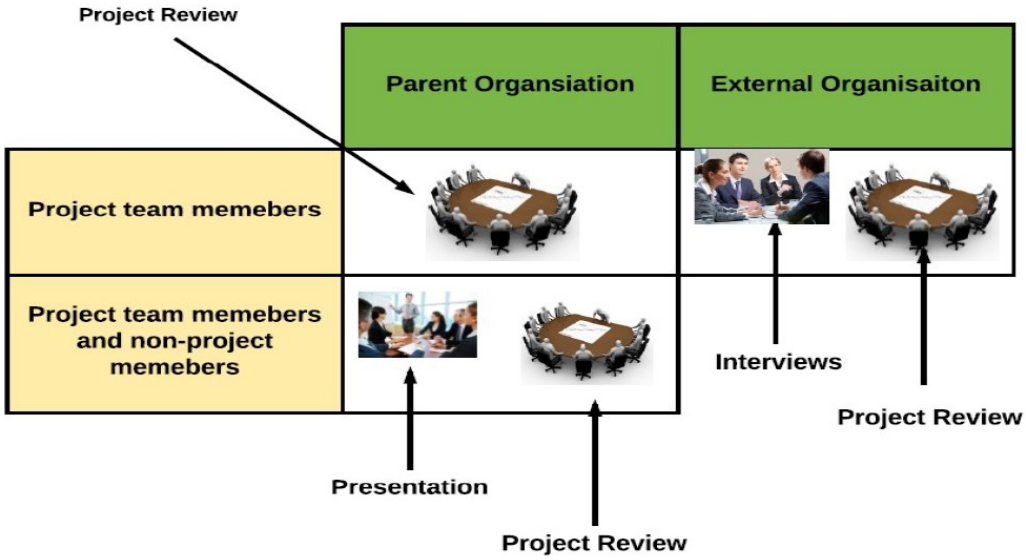
Research Student: Ndibarafinia Tobin
Supervisor: Professor Simon Burnett

Project Review



ROBERT GORDON UNIVERSITY•ABERDEEN

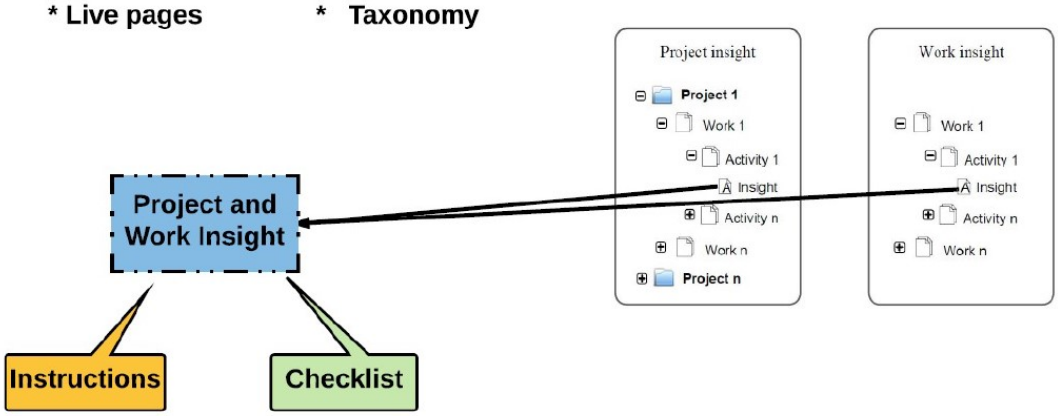
Project Review Participant



ROBERT GORDON UNIVERSITY•ABERDEEN

Knowledge Structure

* Short
* Forms
* Live pages
* Taxonomy



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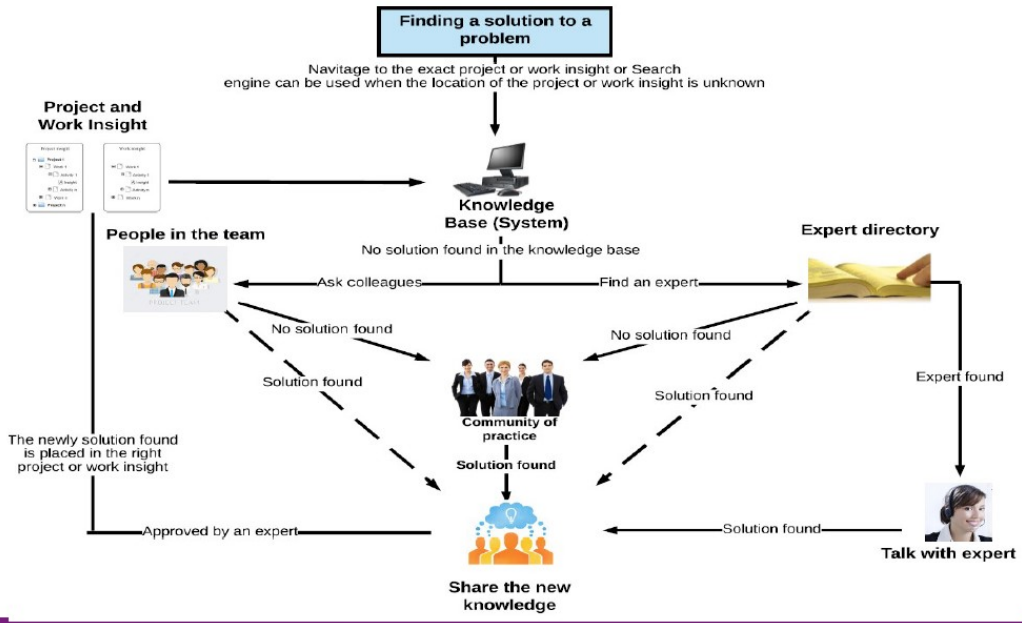
Knowledge Base

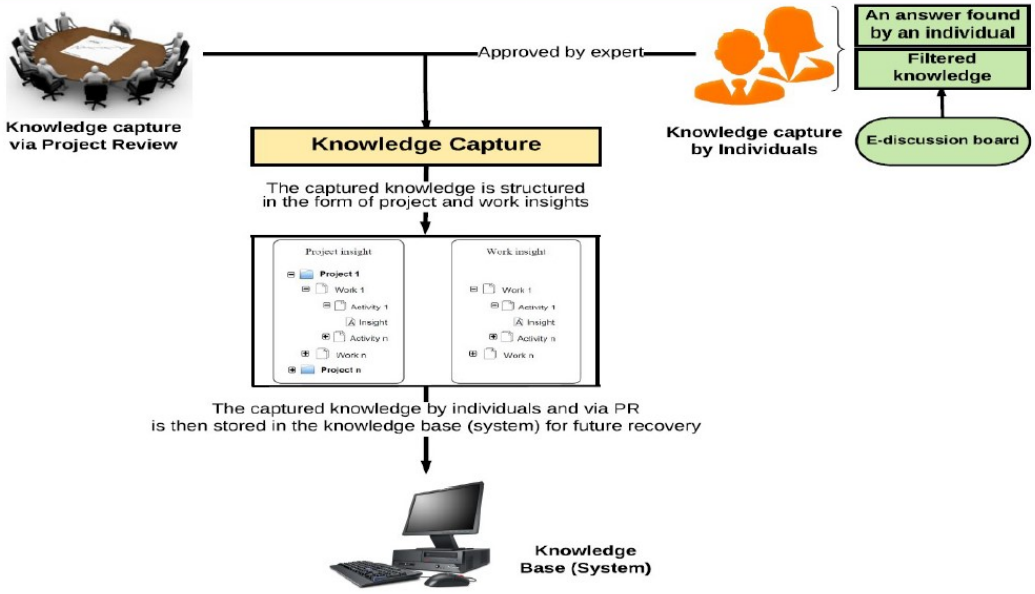
- Environment
- Access
- Components
  - Projects
  - Experts
  - Skills Network
  - E-mail Client

Knowledge Recovery



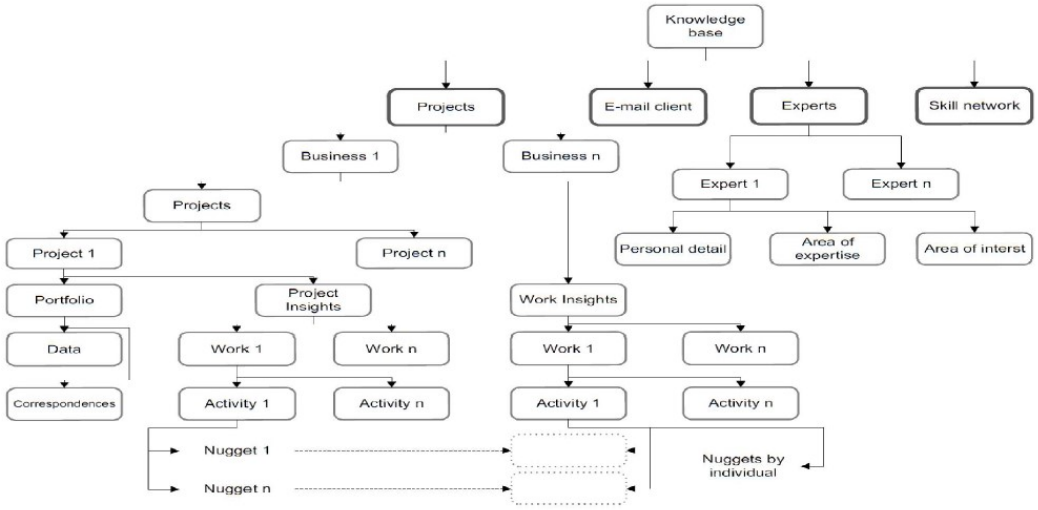
ROBERT GORDON UNIVERSITY•ABERDEEN

Knowledge Capture



ROBERT GORDON UNIVERSITY•ABERDEEN

Knowledge Base Structure



ROBERT GORDON UNIVERSITY•ABERDEEN