Knowledge Capture and Retrieval in Construction Projects

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ABSTRACT

The value of project knowledge to the management of a current project is considered crucial to successful project delivery. However, knowledge capture and retrieval suffers from a number of deficiencies, which may result in the loss of huge amount of knowledge and difficulties in retrieving captured knowledge. This study aims to develop a reliable framework for the capture and retrieval of organisational knowledge for use in construction projects.

Adopting an empiricist methodology, it includes a survey conducted to investigate the current practice, and semi-structured interviews to explore best practice. The results obtained are used as a foundation for a framework that can assist construction companies to avoid the loss of project knowledge and increase performance and innovation in projects.

The findings indicate that project review (PR) is the most appropriate method for achieving knowledge capture; in addition, this should be conducted in a systematic and precise way and results should be presented in the form of instructions or in a checklist format, forming short and precise insights. For quick and efficient retrieval knowledge must be categorised based on project management processes and activities, using an IT system with components designed to manage knowledge and locate experts. Nevertheless; the framework developed suggested that regardless of the effectiveness of the approach to knowledge capture and retrieval, without a knowledge-sharing environment the application will not benefit from these methods. Open culture and resources are critical for providing a knowledge-sharing environment and that leadership has to sustain project knowledge capture and retrieval, providing full support for its application. The framework has been evaluated by academics and practitioners who are experts in their field. The results have indicated that the framework and its components are both applicable and effective.

DEDICATION

To

My Family

In particular to my mother Khatma Al-Safi, my father Idris Falqi and my wife Aisha Falqi; for their support, encouragement and patience throughout the PhD period.

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CHAPTER ONE: INTRODUCTION

1.1. **Introduction**

This chapter introduces the topic of research. It provides a background to the research, and explains the problem which the research emerged from. The aim and objective are outlined along with the questions that the research intends to answer. The chapter also describes the research design in the form of a scenario, and presents the structure of the thesis.

1.2. **Context**

The management of construction projects is often linked with poor performance. One of the main solutions identified to enhance project performance is improved knowledge management (KM) processes. Today's construction organisations consider KM as a key success factor for enhancing project performance, but also for innovation. The processes of KM can be grouped into four major processes based on various theories (e.g. Wiig 1993; O'Dell 1996; Blair 2002b; Alavi and Leidner 2001): knowledge creation, capture, disseminating & sharing, and retrieval & application.

During construction projects, which can be highly knowledge-intensive (Woo *et al.* 2004; Hari *et al.* 2005), knowledge creation takes place. The new created knowledge will be imbedded in people's heads. Unless captured this knowledge is often lost, since only a small amount of this information makes its way into project documentation (Fruchter 2002). Therefore, all the knowledge gained on a construction project is lost if those involved are not given the opportunity to feed it back into future projects (Barlow and Jashapara 1998). When project knowledge is captured, rationale and decisions are made explicit in project archives (Fruchter and Demian 2005), and knowledge can then be transferred between different project life cycles, and can also be transferred within and between every phase of a construction project life (Kamara *et al*. 2005).

In practice when knowledge is captured, it is limited to formal knowledge (e.g. documents). Contextual or informal knowledge, such as the rationale behind decisions or interaction between team members, is often lost. This captured information cannot be retrieved for valid usage in future projects (Fruchter 2002). An effective approach to knowledge capture depends on the mechanism and technologies that facilitate the conversion of tacit knowledge into an explicit form (externalisation), or the conversion of explicit knowledge into a tacit form (internalisation). The development of models or prototypes and the articulation of best practices or lessons learned are some examples of mechanisms that enable externalisation. Learning by doing, on-the-job training, learning by observation, and face-to-face meetings are some of the mechanisms that facilitate internalisation (Becerra-Fernandez and Sabherwal 2006).

However, many companies have captured huge amounts of information that nobody looks at (Wenger 2000). Information overload is one of the major problems in construction KM (Liston *et al*. 2000). This recalls Eliot's question: "Where is the knowledge we have lost in information?" (Eliot 1963: p.161). Accordingly, randomly capturing knowledge is not enough; knowledge has to be refined and appropriate methods and tools should be established to enable project members to retrieve what they need quick and simply. As stated by Teece, "Knowledge, which is trapped inside the minds of key employees, in filing drawers and databases, is of little value if it is not supplied to the right people at the right time" (Teece 2001: p.128). An effective knowledge retrieval method assists people to understand their knowledge assets, and enables them to find the desired knowledge fast.

One of the dilemmas associated with the application of KM in construction projects is the uniqueness of a construction project. It is true that every construction project is unique in that it is formed by a unique set of characteristics (specifications, resources, site, project team, conditions, culture and environment). However, despite that construction projects are always regarded with uniqueness, the uniqueness of each construction project does not act as a barrier in the capture and retrieval of project knowledge because the processes, structure of teams, tools, skills in project development are similar although the projects are unique in terms of the characteristics set (Hughes 1991; Love *et al.* 1999; Kamara *et al.* 2003). The management of knowledge in an environment where works are frequently repeated, as done in construction management, is much more beneficial than managing knowledge of a work that is rarely or only once conducted. Since projects are best conducted when done in modelled processes (Frigenti and Comninos 2002; Kerzner 2009), a number of process models have been developed to improve the management of design and construction such as The RIBA Outline Plan of Work (RIBA 2007), Process Protocol by the University of Salford (Cooper *et al.* 1998), Project Management process model by Project Management Institute (PMI 1996), the British Property Federation model (BPF 1983), and the model of Construct IT Centre of Excellence (1995). Many studies shows that numerous UK construction organisations are using process models by respected professional bodies or using their own process model or process maps in a meaningful structure (for example, Aouad *et al*. 1999; Kamara *et al*. 2000; Tzortzopoulos and Sexton 2007). The existence of project management models by respected professional bodies and the increasing use of modelled processes is one of the major motivations for having a beneficial and applicable framework that captures and retrieves project history.

There is a lack of studies which explore in depth the current practice of KM in the UK construction industry. However a small number of studies indicated that most of the UK construction industry is still at an early stage of KM (Robinson *et al.* 2005), and KM is practiced but in an informal way (Herrington 2000; Egbu and Botterill 2001; Egbu *et al.* 2003). Nonetheless, a number of construction organisations have seriously attempted to establish formal methods for managing their knowledge such as Atelier Ten, Arup, Edward Cullinan architects, WSB group, Penoyre & Prasad and Broadway Malyan. The IT construction forum (see www.itconstructionforum.org.uk/publications /casestudies.asp) which is managed by construction excellence and founded by the Department of Trade and Industry (DTI), has supplied over 12 case studies on KM practice in the UK construction industry. These case studies revealed that there is a well understood approach that has been adapted in several organisations in order to capture, share and reuse knowledge. In a nutshell, the UK construction industry has begun to recognise KM as a central task in its organisations since many of them have already established strategies for managing the intellectual capital. However, “Most construction companies are still at the stage of building their awareness or understanding of KM” (CIRIA 2005). On the other hand, there is a lack of studies which explore in depth the KM processes are actually used in practice.

1.3. **Call for Changes**

Today knowledge is the only meaningful economic resource (Drucker 1995), and is considered to be a company’s greatest competitive advantage (Davenport and Prusak 1997). Knowledge-based theory of the firm (Grant 1996) suggested that knowledge is the primary and most important resource of the firm. In the same way, the construction industry is highly knowledge-intensive (Hari *et al*. 2005) which means the services and the products (e.g. construction project management) the construction firm provides greatly rely on the knowledge about the processes of delivering those products and services. Despite all the efforts that have been put into improving construction management, and despite all the tools and systems developed to allow successful project delivery, the record of construction projects' performance is disappointing (NEDO 1983; Assaf et al. 1995; Ogunlana and Promkuntong 1996). However, in the last two decades the UK construction industry has witnessed an exceptional level of demand for improvement. This change was called for in the Latham (1994) and Egan (1998) reports. Both reports criticised the performance of the industry and called for improvement. They demonstrated the lack of learning from previous projects' best practice as a fundamental barrier which needs to be overcome if construction performance is to improve and become more cost effective. The report by Egan (2004) dealt with KM practice and emphasised the need for capturing lessons learned and the culture of lifelong learning. The government response to the Egan review was the report from the Office of the Deputy Prime Minister (ODPM 2004), which again showed support for KM practices to be used in the industry. It expressed the willingness of the government to aid the current programmes with more learning and development programmes. To highlight the performance of the UK construction industry, nCRISP (2003) published the Pearce report (2003). One of the emphasised points in the report was the significance of knowledge capital, the need for a better trained and educated labour force, and keeping pace with technological change. In this report the author identified human capital as the skills, knowledge and education embodied in individuals. Wider emphasis on the significance of KM as a major element in improving construction management is clearly underlined in the publication '*A strategy for the future*' by Constructing Excellence (2004). This publication identified four complementary and integrated programmes of activity to be applied in their strategy in order to enhance the construction industry's performance. One of these programmes addressed best practice knowledge and called for the area of creating continuous improvement through the exchange of best practice.

1.4. **Statement of the Problem**

There is no need to waste time and money by reinventing existing good practice in construction projects (Egan 2004). Different barriers prevent current practice from capturing all project knowledge needed and ensuring its easy retrieval. The problem centres on the gap between the learning event and the time of knowledge capture, the absence of the project-related personnel and the final format of the project knowledge. The studies that have been previously carried out to tackle these issues have attempted to develop radical solutions, but have not attempted to improve the current situation of project KM. Furthermore, no study has been carried out to deal particularly with the knowledge of ‘project management’.

While much attention has been paid to the implementation of KM in project-based organisations, little effort has been made to address the management of knowledge in the projects themselves. The methods of project knowledge capturing offered can be classified in terms of the timing of when they are conducted into three types: (1) post project-based, (2) stage-based, and (3) activity-based. The post project-based method (e.g. post project review and post implementation review) is effective in that it represents the experiences and lessons learned from a wide angle that views the whole project. In addition, it provides a good opportunity for reviewers to judge project performance after a product (e.g. building) has been delivered and occupied. However, due to the time it takes to conduct the review (usually two years after the project) a huge amount of project knowledge could possibly be lost (Fruchter 2002; Kamara *et al.* 2003). Similarly, there would be a danger that relevant significant people would have moved to other projects (Orange *et al.* 1999; Kasvi *et al.* 2003).

The stage-based method (e.g. project review and project audit) of capturing project knowledge partly overcomes the problems related to the absence of relevant people indicated above. Yet in practice some parties or project members are involved in part of a stage and then leave the project (Kasvi *et al.* 2003). Moreover, the time between the start and completion of a stage might be so long to the extent that part of the knowledge would be lost, particularly in complex projects where large amounts of learning events can occur.

Quite a few attempts have been made to overcome the problems associated with post project-based, stage-based approaches. Those attempts established what can be called the activity-based approach. Tserng and Lin (2004) developed an activity-based KM system for contractors during the construction phase and Kamara *et al*. (2005) built up a conceptual framework for the live capture and reuse of project knowledge which dispends on capturing learning directly when detecting any learning events. It is asserted that these concepts can solve all identified problems as long as both of them are based on capturing knowledge instantly after the learning event occurs or after every activity in a project. However, visualising how many activities or how many potential learning events are in a construction project, may lead to considering a very large number of activities and even more learning events. Applying any of the above approaches could be very demanding and might have an impact on the project's activities.

In the case of capturing knowledge after every activity, there might be an assigned time for capturing knowledge, as a project's activities are supposed to be known in the project schedule; however the authors of this approach did not consider how it would be guaranteed that the participants in the activities will contribute in capturing knowledge. Conversely, Kamara *et al.* (2005) identified that a project knowledge file should be set up which is agreed on at the outset of a project, with all parties required to contribute to its compilation. Nonetheless, it is difficult (if not impossible) to know when and where all the learning events will occur. Accordingly, there will be no assigned time for capturing knowledge and that will lead us to state again that capturing knowledge via this framework will have a negative impact on project activities. In addition those approaches established a radical solution to the problem by adding new demanding tasks to the development processes of construction projects. On the other hand, the lack of time formally set aside for the learning process seemed to be the major problem due to the pressures of the organisational environment and construction programme (Boyd and Robson 1996). Construction projects are complex and adding additional tasks makes it more demanding and complex. Therefore improving available processes or techniques (such as project review) may save time and effort in construction projects.

Project review is considered to be an appropriate and popular technique for knowledge capture in construction projects (Orange *et al.* 1999; Winch and Carr 2001; Tan *et al.* 2005). However, project review suffers from the problems in post project-based and stage-based approaches. In addition, the primary goal of the project review report is not to capture project knowledge (Schindler and Eppler 2003), and the format of the report (CIOB 1998) indicates it is for project performance tracking and it is not to be retrieved in future projects. Yet it is widely known in practice that project reviews should be carried out by an external party (Prencipe and Tell 2001; Schindler and Eppler 2003; OGC 2003b) who is not involved in the project. The external party may not realise the knowledge obtained from the project as much as people who have participated in the project. To illustrate this point: why has it been very difficult for other vehicle companies to copy the Toyota Production System (TPS), despite the fact that Toyota produced books explaining in detail the process of production in addition to giving tours of its manufacturing facilities? Because “the TPS techniques that visitors see on their tours … represent the surface of TPS but not its soul” (Pfeffer 1998). Therefore, no one can express the know-how as well as the people who were involved in the project processes.

Further, more studies which considered knowledge capture either considered it alone (Fruchter 2002; Kamara *et al.* 2003; Hari *et al.* 2005; Suresh and Egbu 2006) or with knowledge use (Udeaja *et al.* 2008). There is a lack of studies that tackled both project capture and retrieval. This is despite the fact that knowledge retrieval is mainly affected by the way knowledge is captured, and the captured knowledge cannot be used unless it is retrieved.

Finally and most importantly, some studies have considered the significance of either the knowledge of particular construction phases or the knowledge of the overall project in general. The focus in both cases was either on the product-oriented knowledge (Fruchter 1996; Koch and Thuesen 2002; i.e. Brandon *et al.* 2005; and Fruchter and Demian 2005) or the project knowledge in general (Maqsood *et al.* 2003; Maqsood *et al.* 2004; Mohamed and Anumba 2004). Nevertheless, no study has been carried out to particularly tackle the knowledge of project management in construction.

1.5. **Theory of Research**

Research is usually built upon existing theories (excluding grounded theory research). Various principles have been used as a base for this study. In this study knowledge capture and retrieval is part of four major processes of knowledge management (e.g. Wiig 1993; O'Dell 1996; Blair 2002b; Alavi and Leidner 2001) (see section 4.1). Based on the conceptual model of KM factors in project-based environments suggested by Egbu *et al.* (2001a) which consists of a core and three rings, the study focuses on the core factors (people, processes, content and technology). In addition, it pays attention to some extent to the first (organisational factors) and second (deals with knowledge taxonomy and knowledge cycle) rings (see section 3.6). Furthermore, the research adopts Plato’s theory of knowledge which stated that Knowledge is ‘justified true belief’ (Tredennick and Tarrant

1969). However the truthfulness is not absolute and it is from the human view to knowledge (Nonaka *et al.* 2000). The project knowledge considered here is the procedural knowledge identified by Kasvi *et al*. (2003), which is part of the collective organisational knowledge. It is the knowledge concerning the management of delivering the project (see section 4.5). In addition, the research accepts and adopts the theory of knowledge creation, in which tacit knowledge can be transformed into explicit knowledge and knowledge is created through the conversion of four modes of knowledge in a continuous move spiral (section 2.8). Finally this study adopts the theory of construction modelling (BPF 1983; Construct IT Report 1995; Cooper *et al.* 1998; RIBA 2007), in which a construction project can be viewed as new product development (NPD) that consists of structured processes (section 3.3).

1.6. **Aim and Objectives**

The aim of the research is to develop a reliable framework for capturing and retrieving organisational project knowledge in construction companies.

It is important to know the current practice of KM, and that helps in establishing three major ground rules: Whether the current practice necessitates the need for developing a solution for knowledge capture and retrieval or not. The second point is to discover the major elements of KM available in current practice therefore the suggested solution can make use of already available elements. The third point is to examine the literature claim in which the project review is considered an appropriate method for knowledge capture.

1.6.1. Investigating the current practice of KM. This is done by determining the KM maturity stage amongst UK construction companies (based on existing organisation maturity metrics), and by defining the popular and efficient techniques applied to KM in general, project knowledge capture, capability of retrieval, and the practice of project review in current practice (Survey).

This research is built on the empiricism philosophy in which knowledge is gained by experience. Therefore best practice is the major source of theory. Studying the practice of knowledge capture and retrieval in the companies who have been proven to be at an advanced level of KM will lead to building a reliable framework.

1.6.2. Exploring in detail the advanced practice of both knowledge capture and retrieval strategies and their underlying processes in construction projects. (Reporting case studies by interviewing a number of carefully selected firms).

1.6.3. Building a framework of organisational project knowledge capture and retrieval (OPKCT) based on the results obtained from both objectives 1.6.1 and 1.6.2.

The proposed framework is mainly constructed based on the best practice of a small number of companies. Therefore the framework may or may not work for other construction companies. To tackle this issue, a validation process has to take place.

1.6.4. Ensuring that the framework is valid in terms of applicability and effectiveness throughout the process of evaluation by academics and expert practitioners.

1.7. **Research Questions**

To sufficiently address the identified aim and objectives, the study would need to answer the following questions:

- What is the current practice of KM in UK construction companies? (Objective 1).
    - What is the KM maturity stage of UK construction companies?
    - What are the KM techniques and tools available in construction organisations, and how efficient are they?
    - What is the current practice of project review?
- How is organisational project knowledge captured and retrieved effectively in advanced practice? (Objective 2).

1.8. **Research Area and Limitations**

The area of research is fundamentally about two facets of KM: capturing and retrieving knowledge. The study centres on the application of these two facets in the construction project environment. However, other important aspects of KM also need to be tackled as they are inter-related with capturing and retrieving organisational project knowledge. These areas include information technology and the management of individuals who possess the desired knowledge in addition to the organisational factors. Another significant factor is the study of the methods of developing a construction project, so that efforts can be made to integrate the project processes with the knowledge capture and retrieval processes.

The research is limited to the capture and retrieval of organisational project knowledge. The knowledge considered is the knowledge of project management processes, which can be converted into explicit knowledge. The projects are limited to the construction sector.

1.9. **Research Design and Scenario**

The main challenge in planning the research is for the student to consider and explicitly state the overall design of the study (Remenyi *et al.* 1998). The research used different methods and techniques in different stages as can be seen in Figure 1.1. Nevertheless, the general philosophy of this study is ontologically realist and epistemologically subjectivist (see section 5.2.3). In terms of research method, the study uses both quantitative and qualitative methods but the major theme of the research is qualitative. Empiricism philosophy and the qualitative method are appropriate since the study mainly concerns the '*how'* or the method of capturing and retrieving project knowledge (see section 5.3).

The research started by conducting a comprehensive literature review (Stage 1 – see section 5.5.1) on KM in general management (task A: chapter 2), KM in construction and project environments (task B: chapter 3), and knowledge capture and retrieval in construction and project environments (task C: chapter 4). At the end of stage 1, a gap was found, thus in stage 2 (chapter 5) the problem was defined (task D), and the research objective and questions were formed (task E). The research objectives and questions led to the design of the research philosophy and method (task F). One of the research objectives is to examine the current practice of KM in construction companies, particularly the level of organisation maturity in KM, and the popularity and efficiency of KM techniques and tools mainly the project review technique. In order to achieve this objective, a survey based on a close ended questionnaire was conducted (Stage 3: chapter 6 – see section 5.5.3). The gap found in the literature was then confirmed as construction companies were found to be still at an early level of KM, and it was also reported that project review is the most popular and efficient technique for KM. This in turn provided a solid ground and strong justification for an existing problem that need to be tackled. Therefore stage 4 (chapter 7 – see section 5.5.4) was to investigate the best practice of project knowledge capture and retrieval by conducting interviews with the appropriate experts of companies who have been proved to be at an advanced level of KM. The collected data from interviews has been analysed, taking into account the primary data collected in stage 3 and the secondary data from literature review in stage 1. The result of the analysis was then used to build a conceptual framework (Stage 5: chapter 8 – see section 5.5.5). The framework was sent to a number of practitioners and academics to examine whether it is efficient and applicable or not (Stage 6: chapter 9 – see section 5.5.6). The validation stage revealed that out of 5 the framework scored 4 in effectiveness and applicability. Accordingly the framework is considered to be valid and could be use to benefit construction companies in capturing and retrieving knowledge of project management processes efficiently. The validation stage suggested that no further development is needed before using the framework, and the only way improve the framework is by trial and errors in the application. Finally, stage 7 (chapter 10) draws a conclusion of the research results, and recommended to further investigate.

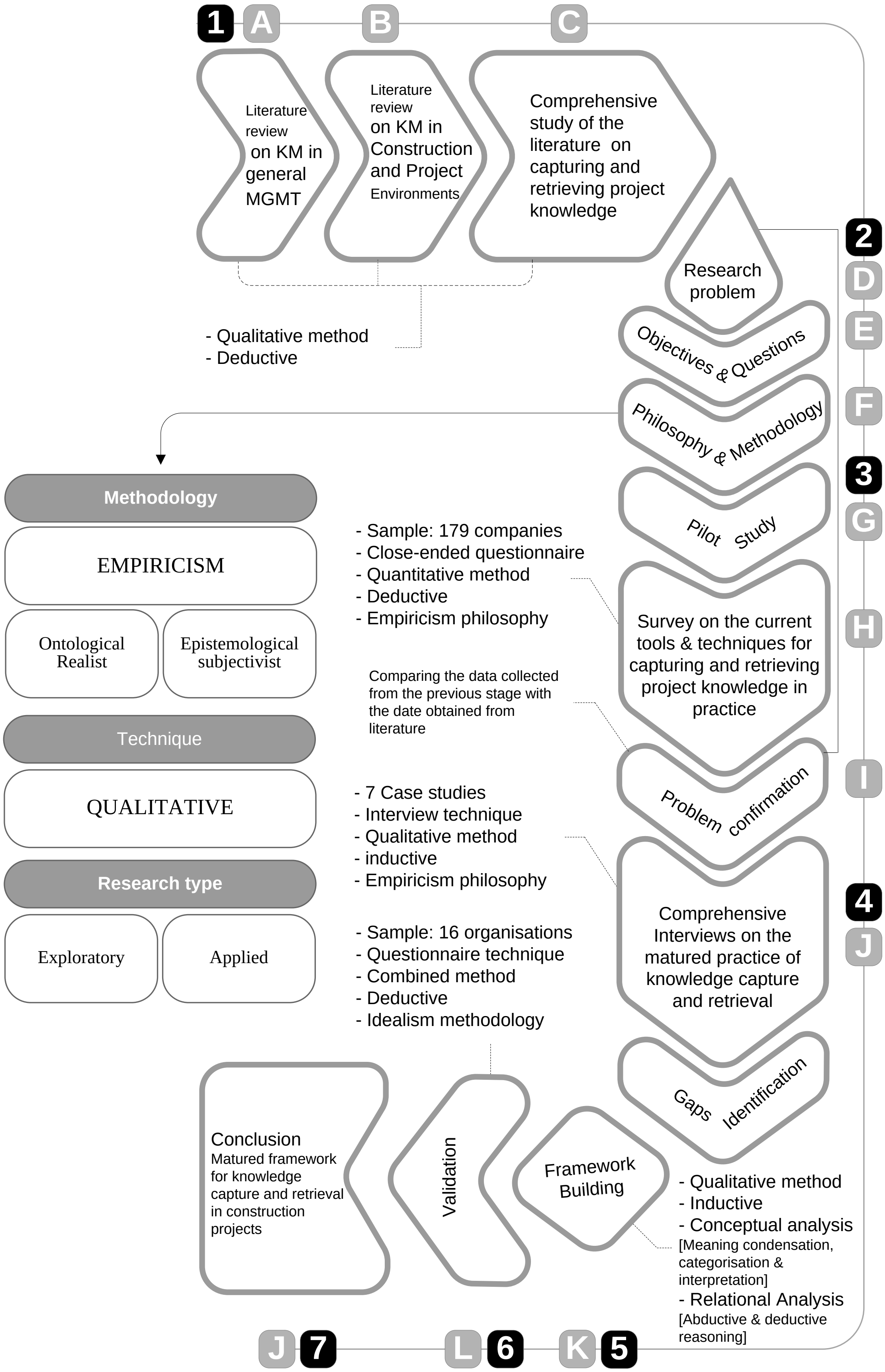


Figure 1.1 The overall design of the research

1.10. **Thesis Structure**

The thesis comprises seven sections which are represented in 10 chapters. A brief introduction of each chapter is given in this section in order to outline the logical progression of the thesis.

Chapter 1 introduces the topic and provides a brief overview of the thesis, including a background to the subject, the research problem, objectives and questions, and the research design.

Chapter 2, 3, and 4 forms the literature review**.** Chapter 2 provides an in-depth review of the literature of KM. The chapter reviews the theories on knowledge, KM, and highlights the major perspectives, techniques and tools of KM. Chapter 3 summarises the efforts that have been done on the models of the construction management processes, gives a glimpse into the current situation of KM practice in the UK construction industry, and discusses the major perspectives to KM in construction. Chapter 4 explores the theories of knowledge capture and retrieval in construction and project-based environments. In this chapter knowledge capture and retrieval are presented within the context of KM processes. In addition, the chapter discusses a number of studies concerned with the core subject of this research.

Chapter 5 outlines the method adopted in this research and explains the rationale of this method. The chapter presents the stages of data collection and explains the method of collecting and analysing those data.

Chapter 6 presents and discusses the findings from the questionnaire survey on the current practice of KM.

Chapter 7 analyses and discusses the findings of the interviews. This is to illustrate the strategies and method of knowledge capture and retrieval in the advanced practice.

Chapter 8 constructs and explains the framework based on the results obtained from the interviews and survey.

Chapter 9 presents and discusses the framework validity derived from a survey conducted for this purpose.

Chapter 10 summarises the results and major findings of the research, highlights the contribution to knowledge and suggests particular areas for future research.

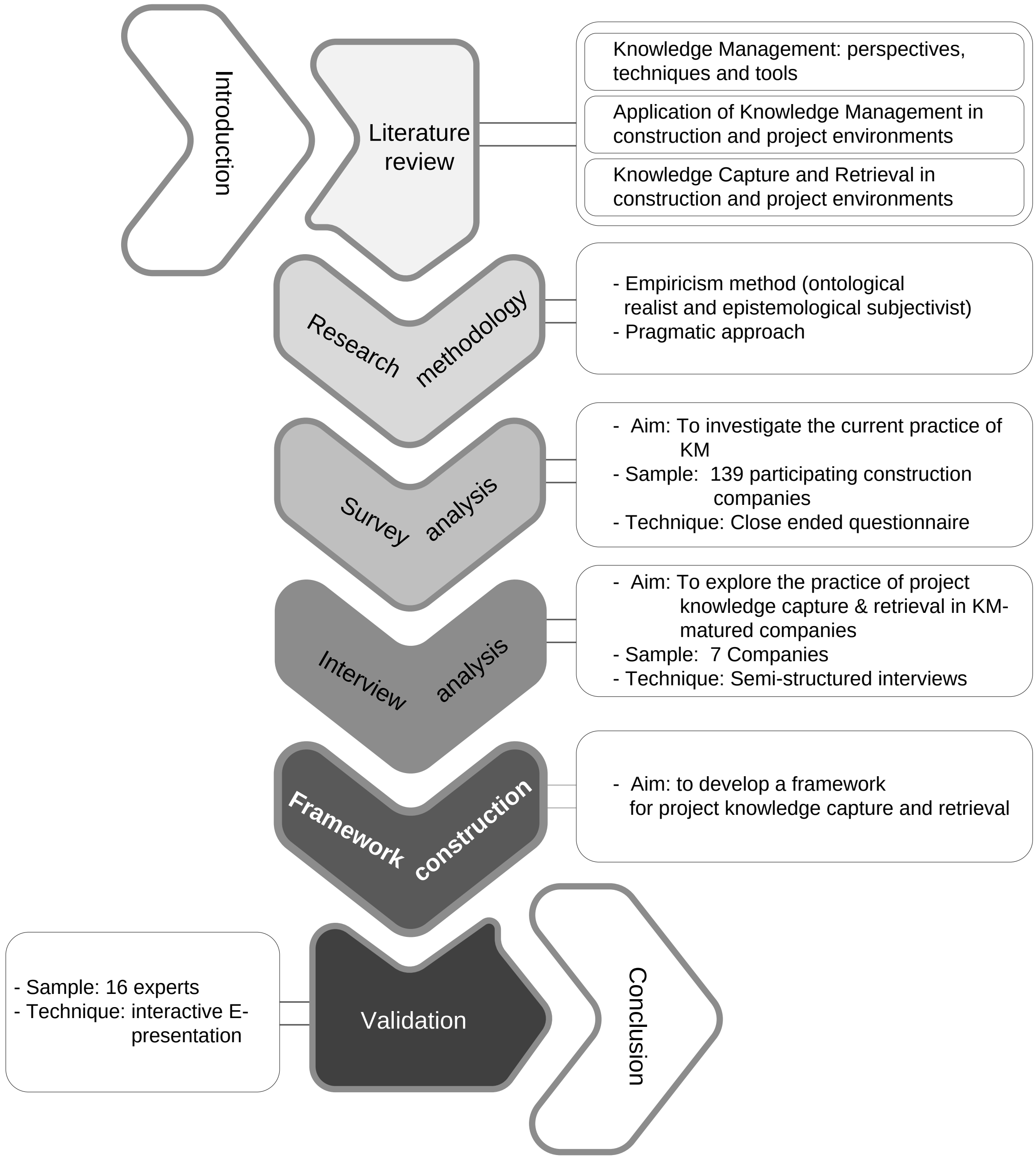
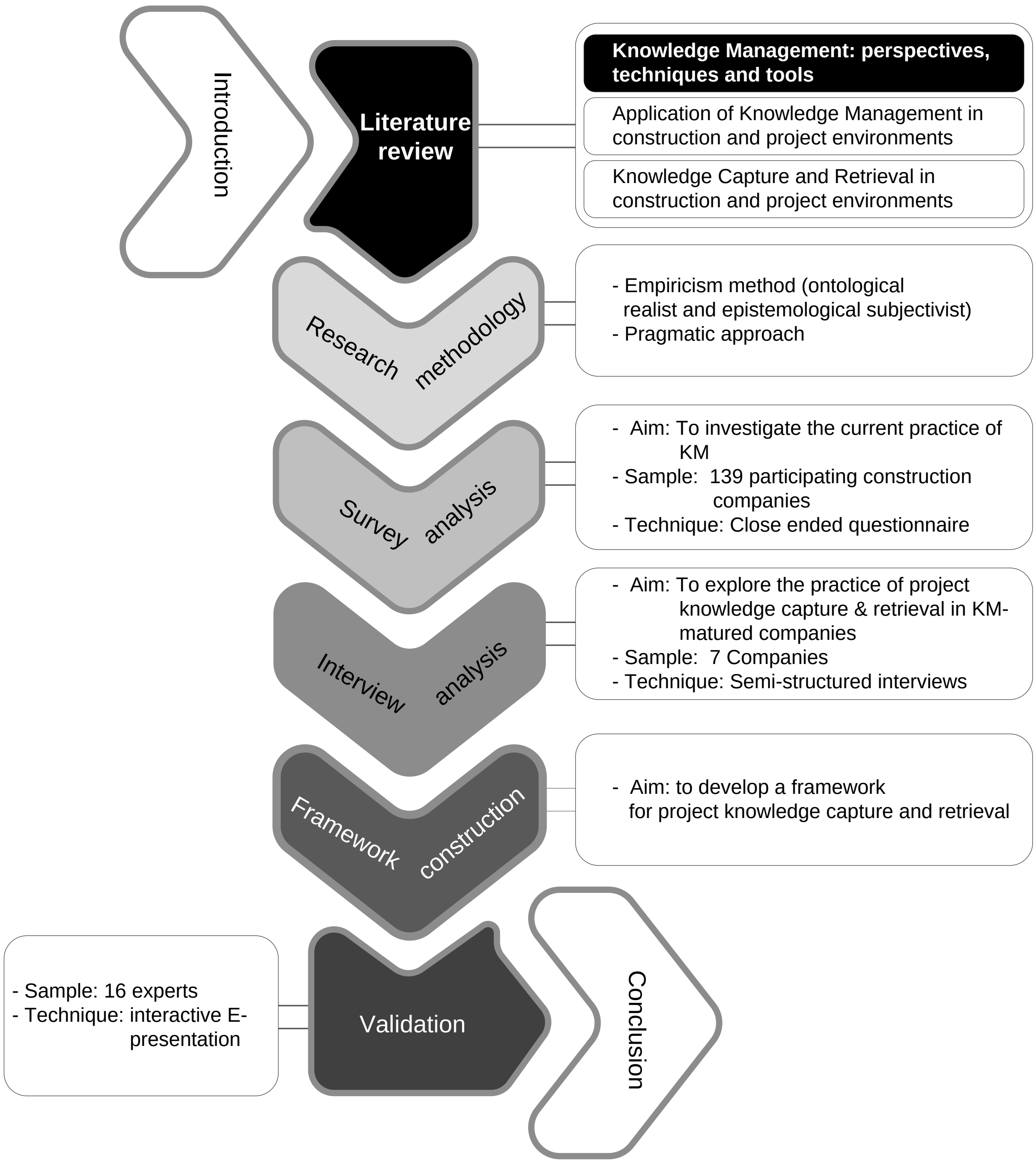


Figure 1.2: Thesis Structure

CHAPTER TWO: KNOWLEDGE MANAGEMENT: PERSPECTIVES, TECHNIQUES AND TOOLS



2.1. **Introduction**

KM is an increasingly important area as the number of studies tackling different aspects of KM has been gradually increasing since the mid 90s. This chapter seeks to provide an in-depth review of the literature and begins by presenting different definitions of knowledge and looking at its explicit and tacit dimensions. It will then go on to define KM, providing an historical overview. The drivers for KM are then presented, followed by the dimensions. Several perspectives of KM are available in the literature; this chapter will highlight and discuss the major ones. The techniques and tools of KM are then considered.

2.2. **Knowledge**

It is clear that we cannot manage anything unless we know what we are managing. Researchers who have defined knowledge have provided two perceptions of it. The first group who have disseminated the common perception of knowledge identifies knowledge as an advanced stage in the information hierarchy: information is formatted data, knowledge is analysed information, and data is the real seed of knowledge (Machlup 1980; Dretske 1981; Turban 1992; Alter 1996; Tobin 1996; Beckman 1997; Van der Spek and Spijkervet 1997). An example of a definition belonging to the first group is that proposed by Turban (1992), which views knowledge as information that has been organised and analysed to make it understandable and applicable to problem solving or decision making. In contrast, Tuomi (1999), establishing the theory of reversed hierarchy of knowledge, argues that knowledge is not created from data and information; instead data and information are a result of knowledge. In support of this argument, Fahey and Prusak (1998) criticised the way knowledge is equated with information and viewed as a stock rather than as a flow. This mistake, in the opinion of Fahey and Prusak (1998), caused the other eleven deadly sins of KM. Fahey and Prusak (1998) believed that knowledge cannot be treated as an object separated from knowledge carrier (the knower). In principle, indications can be extracted to form a consistent view with the two perspectives of knowledge. The following quotations explain this further:

‘‘Even though some argue knowledge can be acquired, stored and used outside of the human brain, knowledge cannot exist outside of the human brain and that only information and data can exist outside of the brain’’ (Beveren 2002: p. 19)

“Information is converted to knowledge once it is processed in the mind of individuals and knowledge becomes information once it is articulated” (Alavi and Leidner 2001: p. 109)

The quotes above argue that considering codified knowledge as knowledge or information is relatively associated with and depends on the individual dealing with that codified knowledge/information. However, the distinction between knowledge and information is still debatable; the next section pays more attention to this relationship. Returning to knowledge definition, here is a definition that may establish a common ground for both groups. In this definition knowledge is “the whole set of insights, experiences, and procedures that are considered correct and true and that therefore guide the thoughts, behaviours, and communications of people” (Van der Spek and Spijkervet 1997: p.13). In addition, Plato’s theory of knowledge suggested that Knowledge is ‘justified true belief’ (Tredennick and Tarrant 1969). This means that it must be believed to be true, and the belief must be justified. However the truthfulness is not absolute and it is form the human view to knowledge (Nonaka *et al*. 2000).

2.3. **Knowledge Dimensions**

Based on Polanyi’s (1966) concept of tacit knowledge, Nonaka and Takeuchi (1995) divided knowledge into explicit and tacit knowledge. Explicit knowledge is knowledge that has been codified or fixed in some format, i.e., explained, recorded, or documented, and it can, therefore, be disseminated and shared between users. Explicit knowledge might be presented in different formats, such as manuals, written procedures, business records, journal articles, books, web pages, databases, intranets, e-mails, notes, graphic representations, or audio and visual materials (McInerney 2002). The focus of this study is on the capture and retrieval of knowledge that can be codified; that is explicit knowledge. On the other hand, tacit knowledge is the knowledge that is gained by an individual and has not been articulated, spoken or expressed. It is "the stuff between people’s ears, the know-how, the little tricks, the intuition, the judgment, the stuff that makes things work" (Stamps 1999, p. 40). Tacit knowledge cannot be shared unless it is converted into explicit knowledge. Many authors (Stamps 1999; Rumizen 2002; O'Dell and Leavitt 2004) estimate that 80 percent of the important knowledge is tacit knowledge.

Peter Druker seems not to believe in the concept of tacit and explicit knowledge, because he thinks that knowledge cannot be codified: “Knowledge is not impersonal, like money. Knowledge does not reside in a book, a databank, a software program - these contain only information. Knowledge is always, embodied in a person; carried by a person; created, augmented, or improved by a person, applied by a person; taught and passed on by a person, used or misused by a person.” (Druker 1993:p.191). When knowledge is codified, does it become explicit knowledge or information? Alavi and Leidner (2001) state clearly that “information is converted to knowledge once it is processed in the minds of individuals and knowledge becomes information once it is articulated” (Alavi and Leidner 2001: p.109). However, it could be said that codified knowledge could be explicit knowledge or information, depending on the knowledge background of the reader, listener, or viewer. For example, instructions about how to remove a tooth could be considered to be information for non-dentists, whereas it could be knowledge for dentists. So codified knowledge is, by itself, information, but can be knowledge to a reader with a sufficient amount of tacit knowledge in the same field that enables him or her to perceive this information as knowledge. In this study, codified knowledge is referred to as knowledge, because knowledge here is that related to construction management activities/processes and to people who are working on those activities/processes. That is supported by the theories that view companies as knowledge based, rather than information based, organisations (Davis and Botkin 1994; Nonaka and Takeuchi 1995; Grant 1996), since members of a company don’t simply deal with information objectively, instead perceiving and interpreting it consciously or unconsciously within the accumulative experience and skills they gain. Knowledge can also be viewed in terms of mode 1 and mode 2 knowledge production (Gibbons *et al.* 1994). In mode 1, knowledge is disciplinary and largely academic; while in mode 2, knowledge is trans-disciplinary and conducted in the context of an application. This study focuses on mode 2 knowledge production, as the knowledge desired for capture is work-based.

2.4. **Definition of Knowledge Management**

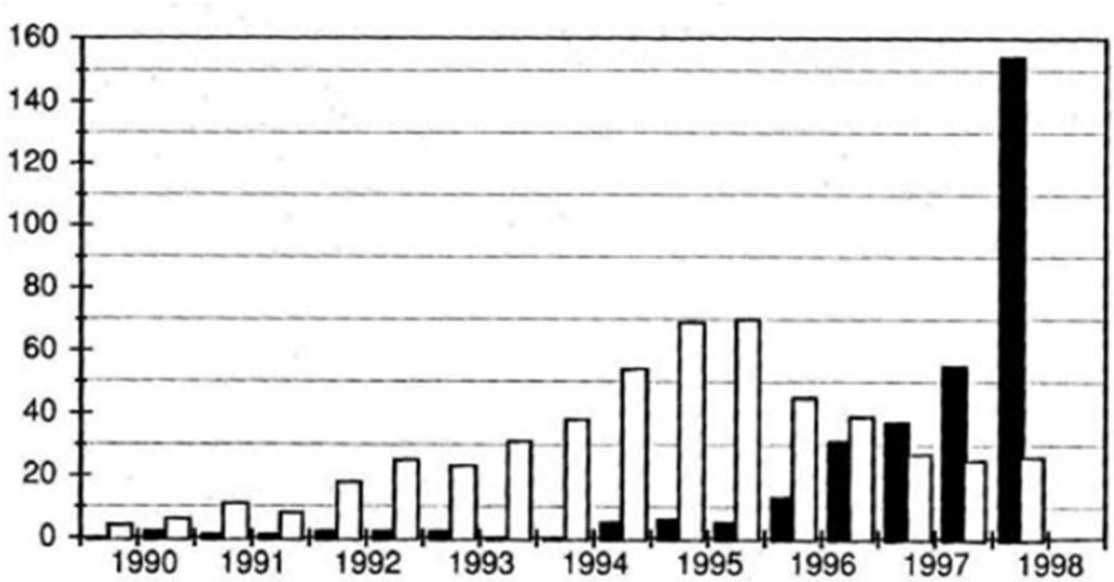
Knowledge management has been one of the most hyped phrases over the first years of the twenty-first century (Brian *et al.* 2003). Many in KM prefer to avoid defining it as it is difficult to express what the real work of KM is (Firestone and McElroy 2003). It is generally accepted that Karl Wiig is the one who coined the concept of KM in 1986 (Beckman 1999; Haav and Kalja 2002; Firestone and McElroy 2003). To emphasize the importance of KM it has been described as "Powerful environmental forces … reshaping the world of the manager of the 21st century. These forces call for a fundamental shift in organisation process and human resource strategy. This is knowledge management" (McAdam and Reid 2001: p.231). However, because KM is related to more than one field and is an emerging discipline, it somehow becomes hard to have an agreeable definition. Quintas *et al*. (1997) highlighted this problem: "Our work to date highlights both the importance and difficulty of scoping and defining this emergent and disparate field, and of understanding the processes involved..." (Quintas *et al*. 1997: p.390). Over 90 definitions of knowledge management have been found in the literature. In those definitions, knowledge management is seen from different perspectives. KM in literature is seen in various forms, as activities, techniques, tools, strategy, principles, or concept. Dubey (2003) defined KM as the "the process of capturing organisational collective expertise wherever it resides in databases, on paper, or in people's head and distributing it to wherever it can help produce the biggest payoffs" (Cited in Singh 2007: p.173). A similar definition is offered by Petrash (1996): KM is getting the right knowledge to the right people at the right time so that they can make the best decision. Furthermore, Holsapple and Joshi (2000) suggested that the aim of KM initiatives is to make the right knowledge available to the right processors (human or computer) at the right times in the right presentation for the right costs.

However, those previous definitions assume that knowledge exists and the role of KM is to make it available to the right people at the right time. Other definitions seem to disagree with this concept of KM, suggesting that knowledge does not always exist in the organisation, and the role of KM is to create new knowledge. For example, Beckman (1997) recognises KM as the formalisation of, and access to, experience, knowledge and expertise that create new capabilities, enable superior performance, encourage innovation, and enhance customer value. Brooking (1997) also views KM as an activity that is concerned with strategy and tactics to manage human centred assets. However, some other concepts connected the role of KM to make the right knowledge available when needed, with the other role that focuses on the creation of knowledge. Macintosh (1996) suggested that KM involves the identification and analysis of available and required knowledge, and the subsequent planning and control of actions to develop knowledge assets so as to fulfil organisation objectives. On the same route Davenport and Prusak (1997) found that KM projects will have at least one of these three aims: (i) to make knowledge available and accessible, and to emphasise the role of knowledge in the organisation by mapping knowledge, and using yellow pages and hypertext tools; (2) to build up a knowledge-intensive culture by encouraging and aggregating behaviours such as knowledge sharing and proactively seeking and offering knowledge; (3) to develop a knowledge infrastructure, not only a technical system, but a web of connections among people given space, time, tools, and encouragement to interact and collaborate.

2.5. **Historical Background of Knowledge Management**

The practice of KM is not new, as knowledge has always been captured and shared. What is new is the consideration of KM as a central task in an organisation. That concept was brought forward during the last fifteen years in the literature by authors such as Nonaka and Takeuchi (1995), and Leonard-Barton (1995). Evidence of change in a number of organisations adapting KM strategies has been increasing since the mid nineties (Westelius and Mårtensson 2004).

The number of publications, conferences, and events related to KM has been increasing since the mid-1990s. Nevertheless, some related events took place before that. As reported by Beckman (1999), in 1989 large management consulting firms started internal efforts to formally manage knowledge. In the same year the large accountants and business consultants company, Price Waterhouse, integrated KM into its business strategy. Two years later (1991) one of the first journal articles on KM (Harvard Business Review) was published by Nonaka and Takeuchi. In 1993 Karl Wiig published one of the first books on KM (Knowledge Management Foundation). Later, in 1994, the first conference on KM (knowledge management network) was held; and also in that year, for the first time, large consulting firms began to offer KM services to clients.



Knowledge Management Learning Organisation

Figure 2.1: ProQuest references to "KM" and the "LO" (Swan et al. 1999b)

Since 1995 there has been a sudden increase in the number of publications, conferences and events related to KM. As illustrated in Figure 2.1, Swan *et al*. (1999b) found increasing attention has been paid to KM since 1996, with a concomitant fall in learning organisation references in the ProQuest database. Another study, conducted by Ponzi and Koenig (2002), showed that journal articles related to KM took off from 1996 as indicated in Figure 2.2. More recently a study conducted by Scarbrough *et al.* (1999) analysed the content of journal databases (BIDS, ISI, and ProQuest Direct) and found that the number of KM references have gradually increased from one reference in 1993 to 32 references in 1998. According to Quintas (2005), during the years 1996 and 1997 there were over 30 conferences on KM in the USA and Europe, and an estimated £816 million of KM consulting revenue was being spent annually.

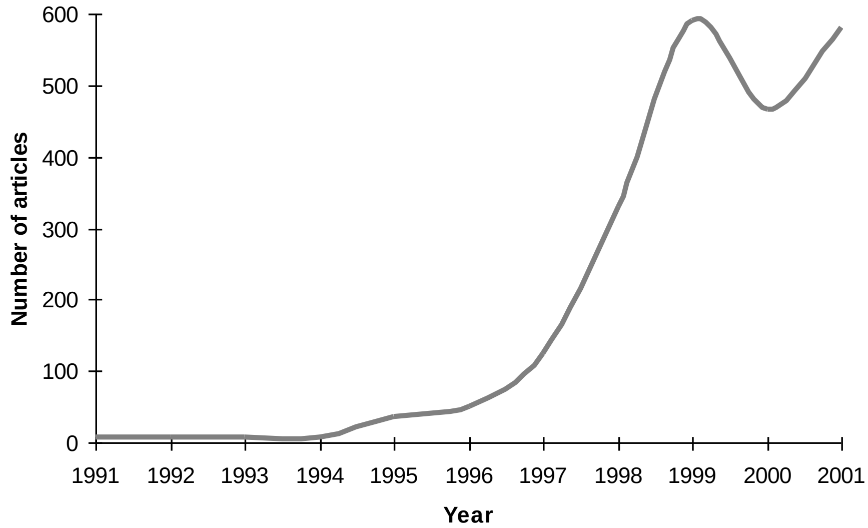


Figure 2.2: The number of KM articles 1991-2001 (Ponzi and Koenig 2002)

2.6. **Drivers for Knowledge Management**

KM now acts as a principal managerial component and key enabler for successful organisations. A leader in business management thinking, namely, Peter Drucker (1969) argued that knowledge had become the central capital, the main cost centre and crucial resource of the economy. DiMattia and Oder (1997) attributed the tremendous increase of attention paid to KM to two fundamental shifts: downsizing (redundancy) and technological development. Downsizing means decreasing the number of employees for the sake of increasing profit. As employees leave, companies experience the loss of their knowledge, which leaves with them.

The rapidly growing interests in KM by academicians, organisations and governments, led Sanchez (2001) to question why managing knowledge is now a central concern and must become a basic skill of the modern manager? In response to this question, Quintas (2005) identified the following drivers of KM:

- Wealth being demonstrably and increasingly generated from knowledge and intangible assets

- The discovery that people are the locus of much organisational knowledge

- Accelerating change in markets, competition and technology, making continuous learning essential

- The recognition that innovation is the key to competitiveness, and that it depends on knowledge creation and application

- The growing importance of cross-boundary knowledge transactions

- Technology limits and potentials: the limits of information technology, and potentials of communications and knowledge technologies

Jennex (2008) gave some other reasons to justify the need for KM: "We need KM because we need a formal process to help organisations identify, capture, store, and retrieve critical knowledge. We need KM processes to help organisations deal with changing storage strategies. We need KM to help us deal with the transience of knowledge workers. We need KM processes to help organizations manage a glut of knowledge. Ultimately, we need KM to help organizations make sense of what they know, to know what they know, and to effectively use what they know" (Jennex 2008: p.4)

In his study, Wijnhoven (2006) identified three sources feeding and enriching the discipline of KM: (1) Suppliers of information technology and academics in this field have developed systems and software for supporting knowledge re-use and knowledge creation. (2) Organisation and human relations professionals and academics have recognized the need for academically challenging jobs and for using the opportunities of an increasingly highly educated work force in modern societies. (3) Strategic management has recognized that the optimal use of intellectual capabilities may be the best source for sustaining competitiveness in our global economy.

In a nutshell, "the need for sharing knowledge hasn't changed but working environments have" (BSI 2003), and the future might witness more need for managing knowledge as the rapid change is expected to continue in working environments.

2.7. **Dimensions of Knowledge Management**

Like any other discipline, without an accepted unifying theory a variety of perspectives will emerge, each based on what can be observed or implemented from practices relating to other disciplines, (Kuhn 1996). As a result, a range of perspectives on the main constituents that construct KM are offered in literature. Quintas (1997) indicated that KM has four diminutions: 1) organisational structure and culture, 2) human resource, 3) processes and 4) technology. On the other hand, Blair (2002a) suggested that KM has two parts: (1) the management of data and information and (2) the management of individuals who possess specific expertise, abilities, or knowledge. Roy (2001) examined KM in terms of the strategic and tactical perspective and suggested that KM consists of two levels:

- Micro scale KM: focuses on the capture, structuring and use of knowledge at local level.

- Macro scale KM: is very sensitive to company strategic plans, and requires strong senior and top management commitment and support.

With a view similar to that of Roy (2001), Wijnhoven (2006) grouped the general management concepts and put forward the following category of KM levels:

- *Strategic knowledge management*: Knowledge management at this level is the definition of the organization's knowledge architecture

- *Tactical knowledge management*: Tactical management is concerned with the acquisition of resources, determination of plant locations, new product initiation, and establishment and monitoring of budgets.

- *Operational knowledge management*: Operational management is concerned with the effective and efficient use of existing facilities and resources within given budget constraints.

In his book, 'the Encyclopaedia of KM', David Schwartz (2006) conceptualised an holistic view of KM and its foundations, introducing a layered approach to the discipline. As shown in Figure 2.3 the approach consists of four layers. *Philosophies* (core layer), the *KM processes* (second layer). These processes address and deal with *managerial, social and organizational needs* (third layer). Finally *information technologies* (fourth layer) support and implement KM processes.

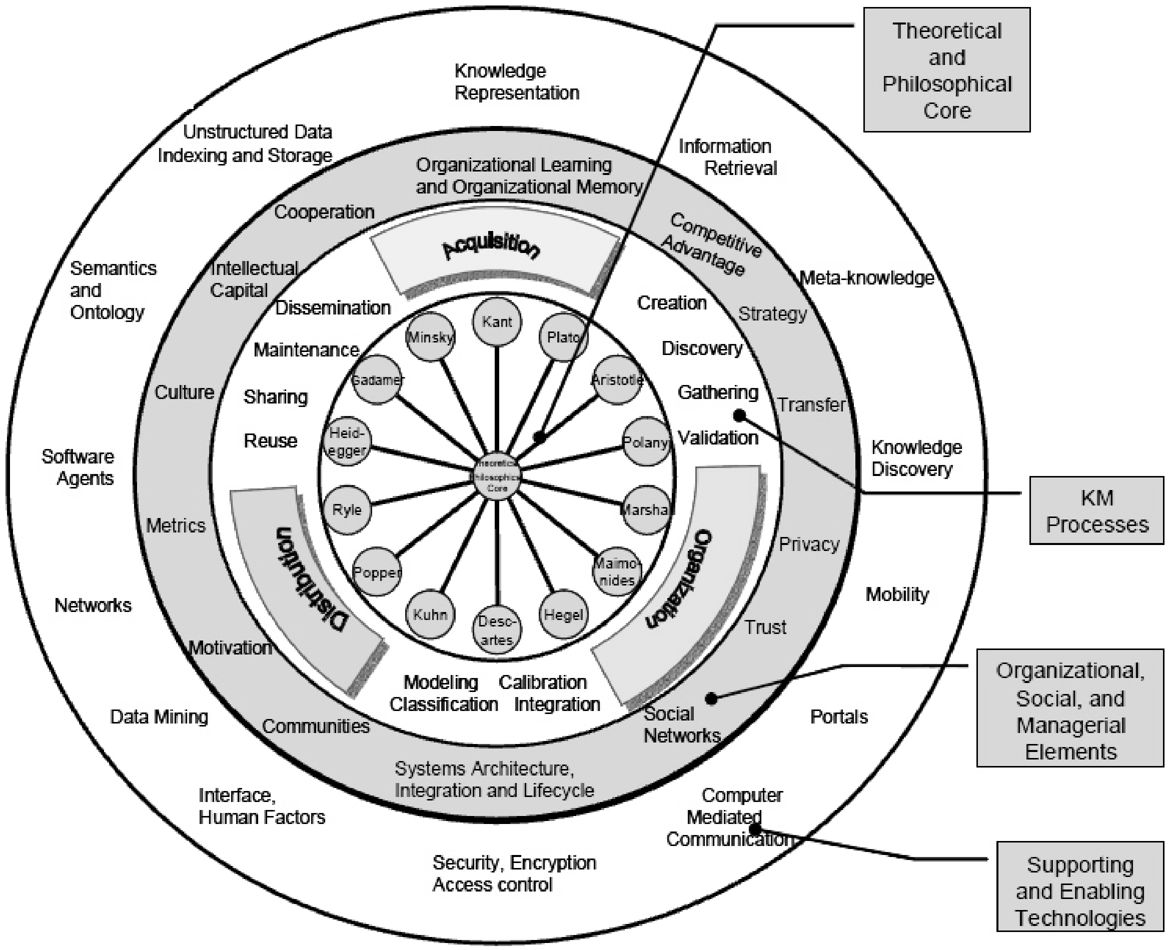


Figure 2.3: Layers of KM   Schwartz (2006)

2.8. **Perspectives of Knowledge Management**

A considerable amount of literature has been published on KM. A broad search and investigation of those studies indicated that there is a variety of perspectives on KM, due mainly to the different views on the nature and definition of knowledge. In a major study examining, in depth, the classifications and models of KM, McAdam and McCreedy (1999) identified three main perspectives. Three broad classifications of models were identified. Firstly, *knowledge category models* made reference to social processes for transforming knowledge; however the categorisation of knowledge in these models was somewhat mechanistic. Secondly, the *intellectual capital models* were found to be more mechanistic, assuming that knowledge can be treated similarly to other assets. Thirdly, *socially constructed models* were found to give a more balanced approach between the scientific and social approaches to KM. (McAdam and McCreedy 1999). The classifications of KM models by McAdam and McCreedy (1999) provided thorough views of the approaches to KM and focussed on an evaluative framework. However, the names of the first and second categories were based on the classification of knowledge, while the name of the third category was based on the way knowledge is treated. On the other hand, Wiig (1997) identified three notions of KM. The first one focused on knowledge acquired from people, in computer knowledge bases, knowledge-based systems, and knowledge made available over technology-based networks using e-mail, groupware and other tools. A second notion focused on management of 'intellectual capital' in the forms of structural capital and human capital. A third notion for managing knowledge had a broader focus to include all relevant knowledge-related aspects that affect the enterprise's viability and success (Wiig 1997).

Several authors suggest different approaches for the management of knowledge, however, the framework by Wiig (1993) gained more consideration as it reflects high-level guidance for KM.

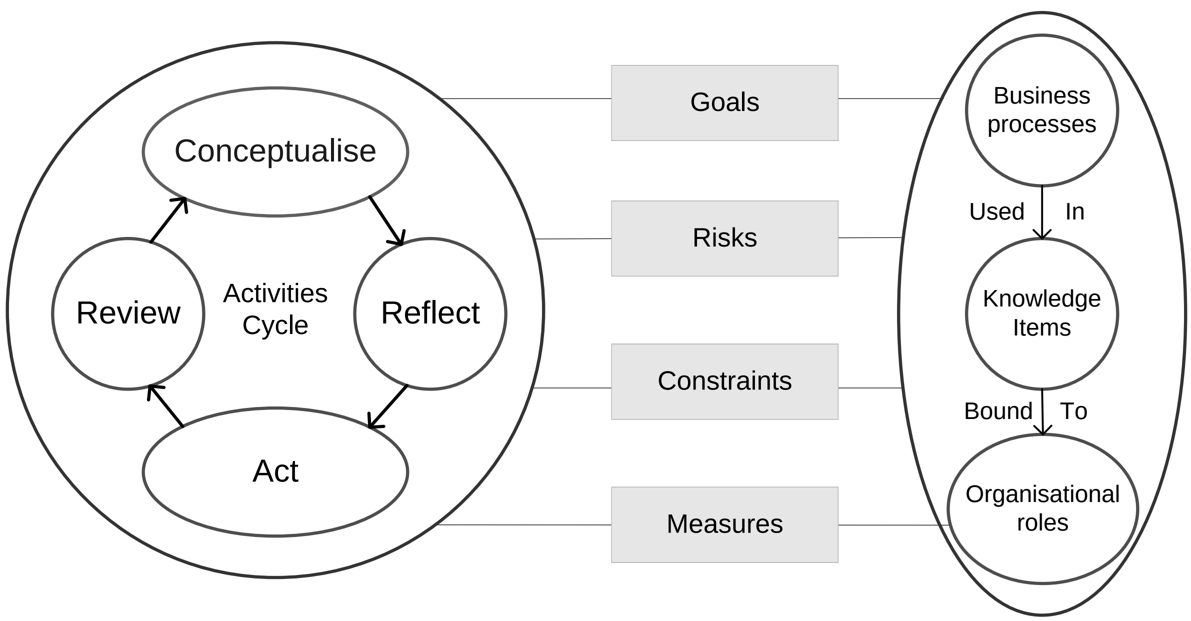


Figure 2.4: Wiig's KM framework. source: (Liebowitz and Megbolugbe 2003)

Wiig's framework, shown in Figure 2.4 represents three levels. The activities on the left-hand cycle represent the KM level. It begins with conceptualising knowledge, then evaluating knowledge (reflect), followed by applying knowledge (act). The review activity means assessing the action in terms of the achievement, then the cycle continues again. On the right-hand side of the figure is the knowledge object level through which business processes are used in knowledge items that are bound to organizational roles. The elements in the middle (goals, risks, constraints and measures) are supporters.

On the other hand, other authors went into more detail in terms of KM processes and activities. Seven steps for managing knowledge were identified by O'Dell (1996) as follows:

1 Identify	2 Collect	3 Adapt	4 Organise
5 Apply	6 Share	7 Create	

The terms "Tacit knowledge" and "explicit knowledge" were firstly introduced by Michael Polanyi (1966). But then Nonaka and Takeuchi (1995), the two professors in the knowledge field, distinguished between the eastern and western perceptions of knowledge in their poplar book "*The Knowledge-Creating Company*". Nonaka and Takeuchi (1995) believed that westerners focus on explicit knowledge while easterners focus on tacit knowledge. However, Nonaka and Takeuchi (1995) claim that tacit and explicit knowledge are not “totally separate”, and explained the interaction between them in four modes of knowledge conversion (Figure 2.5):

- Socialisation: from tacit knowledge to tacit knowledge, through observation, imitation, and practice,
- Externalisation: from tacit knowledge to explicit knowledge, taking the shapes of metaphors, analogies, concepts, hypotheses, or models,
- Combination: from explicit knowledge to explicit knowledge, through different bodies of explicit knowledge, such as exchange and combine knowledge through media, as documents, meetings, telephone conversations or computerised communication networks. Or by sorting, adding, combining, and categorising of explicit knowledge.
- Internalization: from explicit knowledge to tacit knowledge. It is associated with learning by practice.

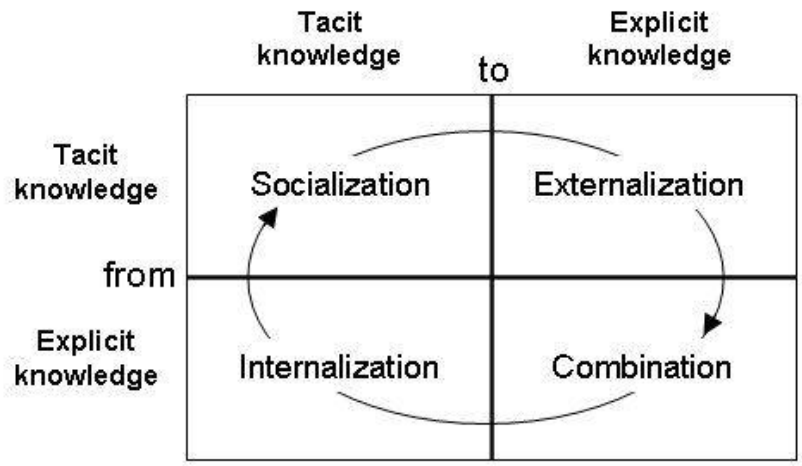


Figure 2.5: Knowledge conversion processes (Nonaka and Takeuchi 1995)

The conversion of four modes of knowledge in a continuous spiral move, leads to organisational knowledge creation. This can also be viewed as a spiral process as shown in Figure 2.6. The epistemological dimension (the vertical axis in the figure) shows the nature of knowledge (tacit or explicit) during the conversion process. On the other hand, the ontological dimension (the horizontal axis in the figure) shows that knowledge created by individuals is transformed into knowledge at group and organisational levels.

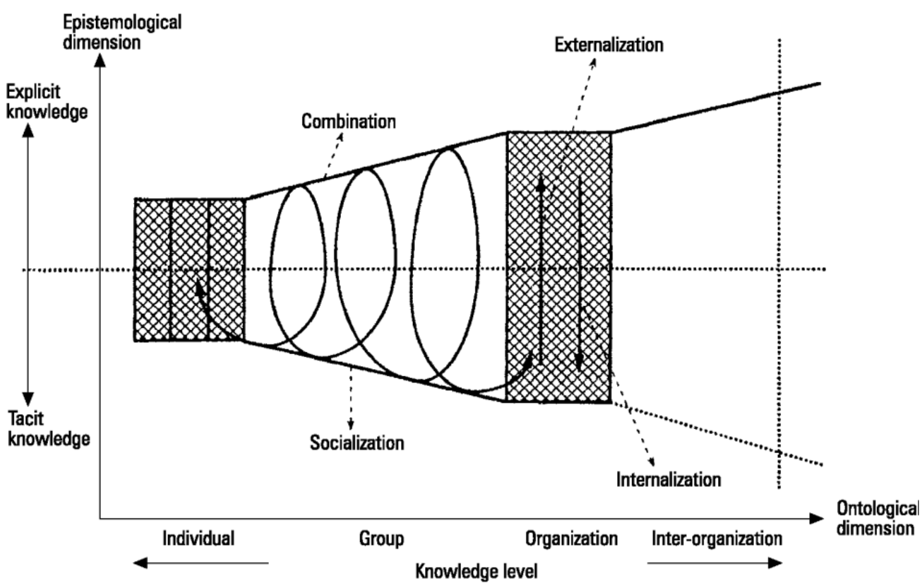


Figure 2.6: Spiral of organisational knowledge creation - (Nonaka and Takeuchi 1995)

Wiig (1999) introduced the concept of personal knowledge evolution cycle. The concept is comprised of five stages. According to Wiig, knowledge of a particular thing can be gradually improved through these five stages, as shown in Figure 2.7.

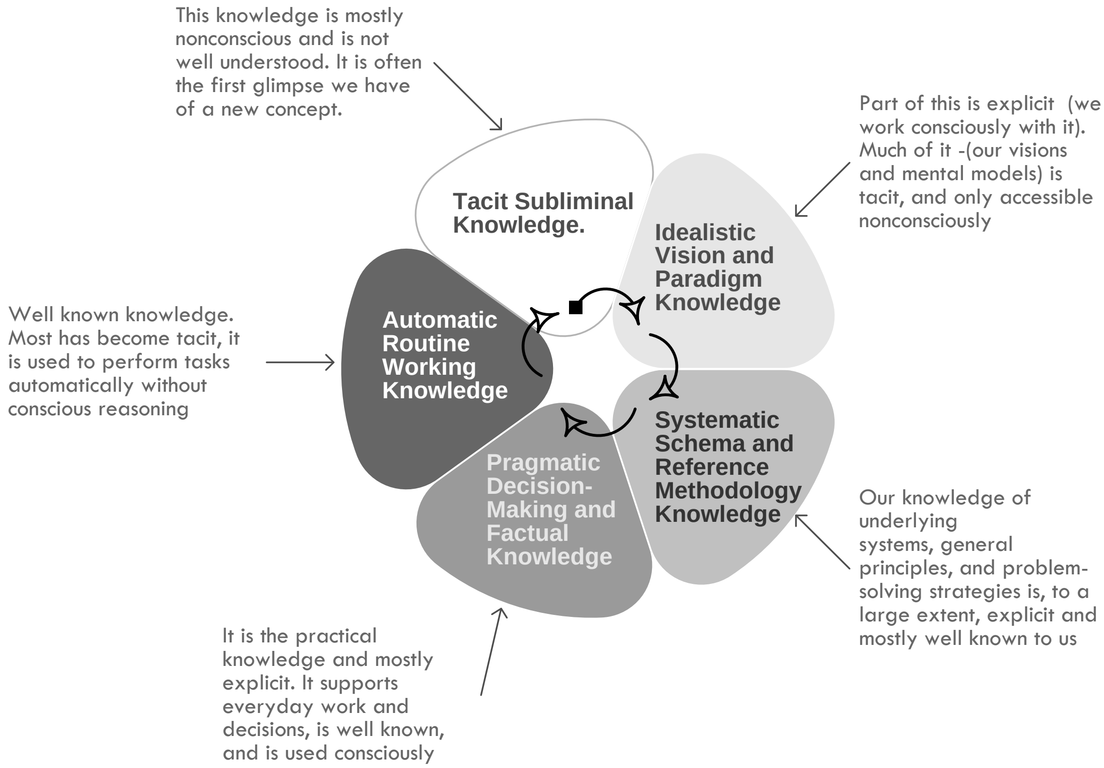


Figure 2.7: Personal Knowledge Evolution Cycle. (Wiig 1999)

Another approach for KM is provided by Ruggles (1997a). This approach is processes-based and consists of three processes: Knowledge generation, knowledge codification, and knowledge transfer. Slightly similar to Ruggles (1997a), a model developed by McElroy (2000) emphasizes the idea of the second generation of KM by focusing on knowledge production (demand-side thinking) without discounting the importance of first generation KM codification and sharing (supply-side thinking).

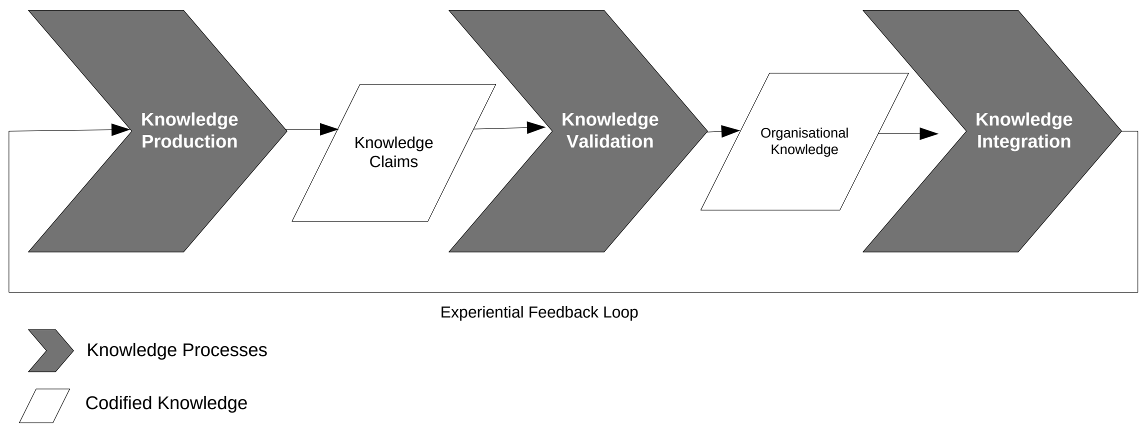


Figure 2.8: McElroy's KM Life Cycle *McElroy (2000)*

In McElroy's (2000) second generation KM (Figure 2.8), life cycles of KM are seen as continuums of natural knowledge processes. These processes are *natural* in the sense that they lie behind the production of all knowledge in living systems, including human organizations. The lifecycle is composed of three processes; knowledge production, knowledge validation, and knowledge integration with a series of feedback loops (McElroy 2000).

2.9. **KM Techniques**

KM has a broad range of instruments at its disposal that can be applied when acting to bring about improvements (Van der Spek and Spijkervet 1997). Many techniques have been developed to assist in managing knowledge. Tools that can help in enabling the application of KM include knowledge recording/codification, external sources of knowledge, training, reassignment of people, research collaboration, preparation of standard details, knowledge team, knowledge manager, mentoring, apprenticeship, discussion groups, storyboards, project review (Tan *et al.* 2005). The following sections consider some of those techniques:

2.9.1. ***Communities of Practice (CoP)***

CoP is KM technique developed by Lave and Wenger (1991). It has been defined as groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly (Wenger 1998). Unlike teams and workgroups, they are not bound by a fixed project, agenda, or set of deliverables (Hasanali *et al.* 2002). CoP could be naturally created or it could be formed for a specific goal. In addition, today CoP are more popular online in the form of discussion boards, online social networks (such as Facebook and Ning), and news groups.

2.9.2. ***Apprenticeship***

Apprenticeship means "young apprentices work with old master craftsmen, thereby acquiring technical skills through observation, imitation, and practice" (Nonaka *et al.* 1996 p: 205). Since the concept of KM has appeared, apprenticeship has been associated more with transferring tacit knowledge. Polanyi (1966), the pioneer of tacit knowledge, indicated that tacit knowledge cannot be fully explicated even by experts, and can only be transferred by long apprenticeship. The importance of apprenticeship becomes clear when it comes to transferring tacit knowledge. Nonaka and Takeuchi (1995) suggested apprenticeship as a technique of socialisation (in their ESCE modes) which can transfer tacit knowledge from one person to another.

2.9.3. ***Mentorship***

Murray (2001) defines mentoring as the deliberate pairing of a more skilled or experienced person with someone with less skill or experience with a mutually agreed goal of having the less skilled person grow and develop specific competencies. The aim of mentoring is the exchange of knowledge, so the mentor provides the information and instructions that the mentee needs. Mentoring is also considered as a method of transferring knowledge from an old generation to a new generation. Klasen and Clutterbuck (2001) categorise the mentoring methods into three main types as follows:

- **One-to-one mentoring:** a mentor is allocated to one mentee; here the relationship is likely to be very strong, and this is the most prevalent type of mentoring.

- **Circle mentoring**: more than one mentee are assigned to one mentor; this method is used when the number of mentors is fewer than the mentees.

- **Needs-based mentoring**: A number of mentors are available for individuals to call on when assistance is required.

2.10. **KM System**

Traditionally, organisations have addressed KM from either a management or a technological point of view. It was found that effective KM requires a hybrid solution that involves both people and technology (Abecker *et al.* 1999). Technology is an important enabler (Egbu 2004), and the use of technology in the management of knowledge will certainly accelerate and facilitate learning in organisations by capturing knowledge and reusing the existing codified knowledge (Damodaran and Olphert 2000). Two of the three aims of the KM project identified by Davenport and Prusak (1997) are associated with KM systems, namely: 1) making knowledge available and accessible and emphasising the role of knowledge in the organisation, by mapping knowledge, and using yellow pages and hypertext tools; (2) developing a knowledge infrastructure; not only a technical system, but a web of connections among people given space, time, tools, and encouragement to interact and collaborate, (Davenport and Prusak 1997). Simply, without adapting advanced IT for competitive advantage, organisations cannot exist long term in the global market (Lee and Hong 2002). More emphasis on the IT role in KM is articulated by Koulopoulos and Frappaolo (1999):

"If the smart manager knows one thing, it is that knowledge management is not just about technology. But, if the smart manager knows two things, the second is that in today's age of technology-driven communication and information production, the role technology can play to facilitate knowledge management should be examined", (Koulopoulos and Frappaolo 1999: p.67)

However, numerous authors argued that IT is just an enabler for KM and is not the core part of KM. A study conducted for the purpose of examining the role of IT in KM, concluded that IT tools play a critical enabling role. However, although IT tools are necessary, they are not sufficient for enabling collective sense-making within organisations (Junnarkar and Brown 1997). In contrast, and in answer to the question, 'is technology just an enabler or does it also add value?' Mitchell and Unitec (2003) point out that technology is usually regarded in literature as an enabler rather than a value adder. Yet continual movement and development in technological progress clearly enhances business operation and adds value.

To conclude, the implementation of KM without IT is extremely challenging, but IT, of itself, does not guarantee the success of KM (Lu *et al*. 2007). IT offers environments and tools that enable and enrich knowledge capture, dissemination, sharing and retrieval. There are many KM tools, such as portal/content management system, custom-designed software, expert directory/yellow pages, e-mail, website, electronic file manager, electronic forum, groupware, electronic instant messaging system, and project extranet. The flowing sections shed light on tools related to this study.

2.10.1. ***System Network***

Electronic systems are built on a network, and there are three types of networks: intranet, extranet and internet.

2.10.2. ***Intranet***

Intranet can be defined as any private network (TCP/IP) that supports Internet application—primarily web (HTTP), but also other applications, such as file transfer protocol (Ji and Salvendy 2001). It is like a miniature local version of internet designed solely for the use of a company and its employees. It uses the same technology that built the World Wide Web (WWW), (Sofroniou 1998). Intranets are quickly becoming a standard communication and information-sharing tool within organisations (Cohen 1998). Access to intranet is limited to organisational members.

2.10.3. ***Extranet***

An extranet is an intranet that uses Internet protocols and the public telecommunications system to work with selected external users (Rumizen 2002). Its purpose is to extend intranets and enable companies to communicate with other parties outside the firm (Chan and Davis 2000). Extranet provides access to both organisational members and external parties, but access by external parties is limited to certain areas of the system.

2.10.4. ***Internet***

The internet is an interconnection of a variety of networks, all of which use sharable databases, programs and files (Hura and Singhal 2001). It is always considered to be a wide area network (WAN), and it links millions of people worldwide through their computers (Lathrop 1999). The internet has existed since the early 1 970s (Larsen and McGuire 1998) and provides an appropriate environment for sharing information between people worldwide.

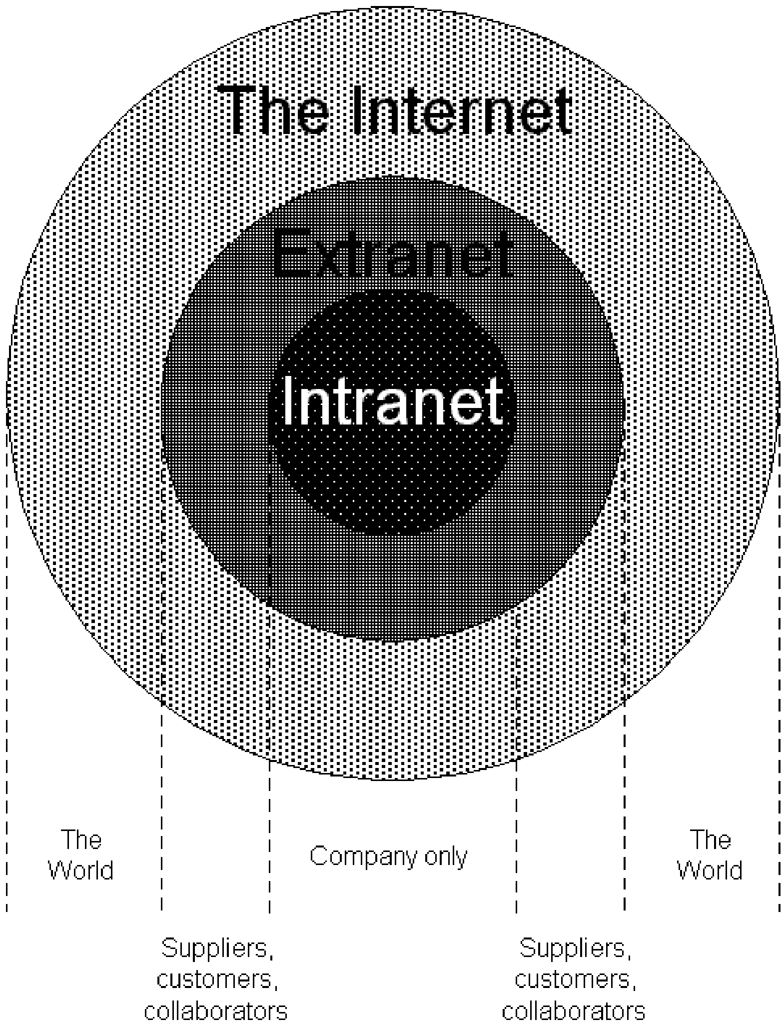


Figure 2.9: The relationship between intranets, extranets and the Internet (Chaffey et al. 2009)

2.10.5. ***Electronic discussion board***

According to vBulletin Solutions, the producer of the most popular script for discussion board, discussion board is an online discussion site. It's sometimes also called a 'discussion message' or 'forum'. It may contain several categories, consisting of forums, threads and individual posts (vBulletin Solutions 2009). Today many companies use discussion boards (Honebein 1997) as a media for knowledge sharing. It allows a member to post a comment, idea, or question online. Other members read that post and respond, over time, with their own remarks and ideas. Discussion boards have historical value because they provide the context for the original digital communities (Zaphiris and Ang 2009), and are considered by many authors (e.g. Sharratt and Usoro 2003; Ardichvili *et al.* 2006; Kimble *et al.* 2008) as a tool for a virtual community of practice.

2.10.6. ***Expert Directory***

Typically, expert directory contains static data for organizational staff, such as people's names, telephone numbers and e-mail addresses (Frid 2000). Unfortunately, KM requires a better directory system. One can rarely identify information attributes such as a person's name or e-mail address from the context of need. What is more likely to be extracted from the person context is the subject area and type of knowledge being sought, (Malinconico 2009). However, a better expert directory was found to include details about people's skills, knowledge, experience, and expertise (McNabb 2006). The Robust expert directory helps in finding the right person to approach for advice and best practice (Anumba *et al.* 2005a). Sometimes it is called 'skill directory' or 'yellow pages'. As far as 90 per cent of an organisation's knowledge is embedded in people's heads (Grant 1996; Wah 1999), access to know-who knowledge will always be important and will save time and effort. Gamble and Blackwell (2001) emphasised five uses for the expert directory system:

- Develops awareness of the background of others in the company
- Increases awareness of what is going on by revealing which groups people belong to, and which activities they are associated with.
- Helps members tailor their response to people they have not met, by understanding their position in the company.
- Plays a role in creating an efficient internal labour market. It becomes easier to assemble project teams more efficiently.
- Acts as an important communication tool, not only by keeping people in touch with each other, but also by providing the sort of social network that takes place in face-to-face environments.

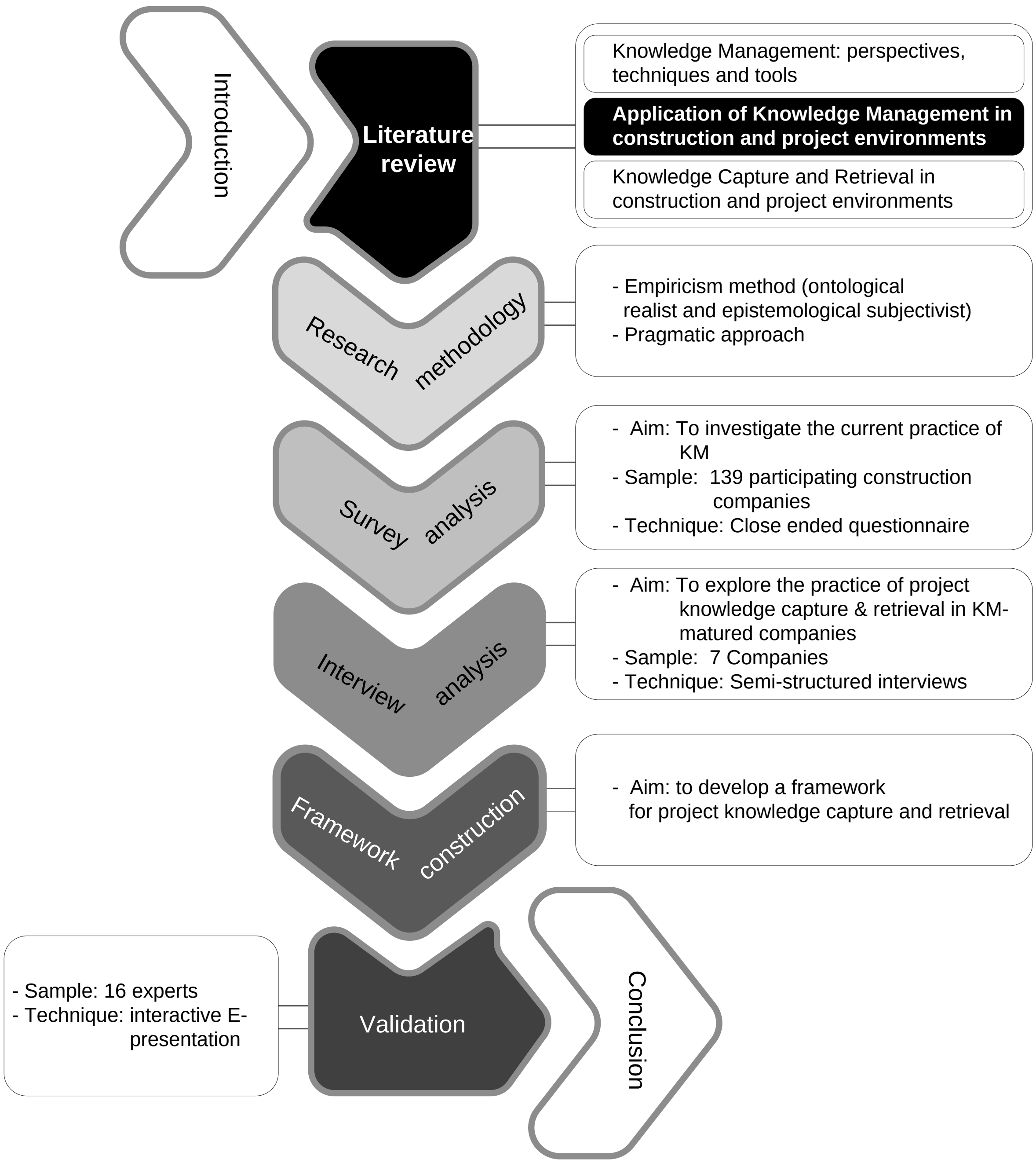
2.11. **Conclusion**

This chapter has investigated perspectives on knowledge and KM, and discussed a number of widely-known frameworks of KM. The roles of technologies and the available techniques and tools of KM were also emphasised in this chapter.

Some authors view knowledge as an object that can be directly managed without considering the knowledge carrier. In contrast, others believe that knowledge is socially constructed. These different views of knowledge led to a range of definitions, perspectives, and frameworks of KM.

A variety of tools and resources may help in managing project knowledge, such as workshops, communities of practice, and project review. The use of information technology is also an important factor as it can facilitate communication even between geographically distant parties. Different types of applications can be used in project KM, for example, groupware, e-forums, live discussions, instant messaging systems, file manager, and content management systems. These tools can be applied in different system networks. It can be used on the intranet or extranet which enables the involvement of other project parties.

CHAPTER THREE: KNOWLEDGE MANAGEMENT IN CONSTRUCTION AND PROJECT ENVIRONMENTS



3.1. **Introduction**

The management of knowledge in an environment where jobs are frequently repeated is much more beneficial than managing knowledge of a task that is only undertaken once or on rare occasions. Despite the uniqueness usually attributed to a construction project, projects go through similar steps in their development. This chapter sets out to illustrate the extent to which construction projects are unique and similar, and how that affects KM application. The chapter then provides an overview of the phases and processes of construction projects, summarising the efforts that have been made in modelling the processes of project management, in particular, construction projects. After that the current practice of KM is presented, based on the previous studies, showing what the current practice of KM in the construction industry looks like. Next the chapter presents and discusses the main perspectives on KM in construction. Finally, some of the major studies will be demonstrated, proposing approaches or frameworks for managing knowledge in construction.

3.2. **The Uniqueness and Similarity of Construction Projects**

Every construction project is unique in the way in which it is formed by a particular set of characteristics (specifications, resources, site, project team, conditions, culture and environment). Therefore, it may become impossible to construct the same project with the same set of characteristics twice. In addition, construction projects are always regarded as being complex and unique. However, the uniqueness of each construction project does not act as a barrier in the capture and retrieval of knowledge because "it is often argued that the processes involved in delivering the final outcome are similar even though a project is unique" (Love *et al*. 1999: p.xiii). All construction projects involve similar steps in their evolution in terms of stages of work (Hughes 1991), and the structure of teams, processes, tools, skills, etc. used in these projects are also similar (Kamara *et al.* 2003). The information set associated with a given project may have as much as a 70 percent overlap with the information set of another project (Le and Brønn 2007). If the project processes are, to some degree, repetitive, and the information used in one project forms a high percentage of the information used in another, then knowledge capture becomes essential to avoid reinventing the wheel in future projects. Failure to re-use knowledge or capture existing experiences and solutions may result in having to deal with every problem in a project from scratch.

This situation has led many construction organisations (e.g. Arup, Edward Cullinan architects, WSB group, Penoyre & Prasad) to establish a strategy for managing their knowledge. Simultaneously, many authors in the field have considered KM in their studies. While much attention has been paid to the implementation of KM in project-based organisations, little effort has been made to address the management of knowledge in the projects themselves.

3.3. **Construction Process**

Projects are composed of phases. A project phase is a collection of activities carried out within several processes to create a product (e.g. project plan). These phases differ from project to project, however, a typical construction project consists of eight phases, namely (Marchman 2003):

- Feasibility Study
- Conceptual Design
- Detailed Design
- Bidding
- Construction
- Commissioning
- Closeout
- Maintenance

Construction processes are the functional stages of each phase of the project. They involve designing and implementing a building project from the conception of the project in a client's mind to its completion for commissioning and use, (CIB W65 1985 Cited in; Karhu *et al*. 1997). It is generally considered that projects are most successful when constructed from a modelled process or method. The first point of Kerzner's (2009) 16 points to project management maturity is: "Adopt a project management methodology and use it consistently", (Kerzner 2009: p. ii). The methodology of modelling construction projects is usually built on, or seen from, a process perspective. Frigenti and Comninos (2002) indicated that project management is most effective when applied in a consistent and repetitive manner in the form of a process. Furthermore, Love *et al* (1999) highlighted that the processes of projects are similar, and Hughes (1991) points out that construction projects involve similar steps (Hughes 1991). In addition, the structure of teams, processes, tools, skills, etc. used in these projects is also similar (Kamara *et al.* 2003). Kamara *et al.* (2003) distinguished between the macro and macro perspectives and indicated that construction projects are usually unique in macro terms (such as site, context, client requirements) but similar in a micro context. Despite a complication in the relationships between stakeholders, the fundamental generic process is largely consistent (Kagioglou *et al.* 1998)

Several studies have developed process models in order to improve the performance of construction projects. The RIBA Outline Plan of Work was first published in 1964 and since this first attempt the model has improved gradually (Figure 3.1). The aim of this model is to organise the process of design management in building projects and administering building contracts into a number of key work stages.

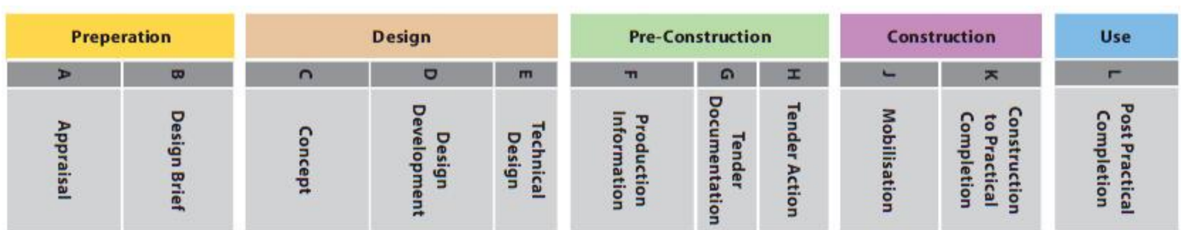


Figure 3.1: RIBA Work Stages   (RIBA 2007)

The RIBA has also identified different sequences for completion of work stages for various procurement/contract methods, for example PPP, design and build, partnering, management contracting. The sequence of work stages may vary or they may overlap to suit the procurement method. An example of the sequence of work stages for management contracting is shown in Figure 3.2, however, the RIBA outline plan of work appears, mainly, to reflect an architect's perspective.

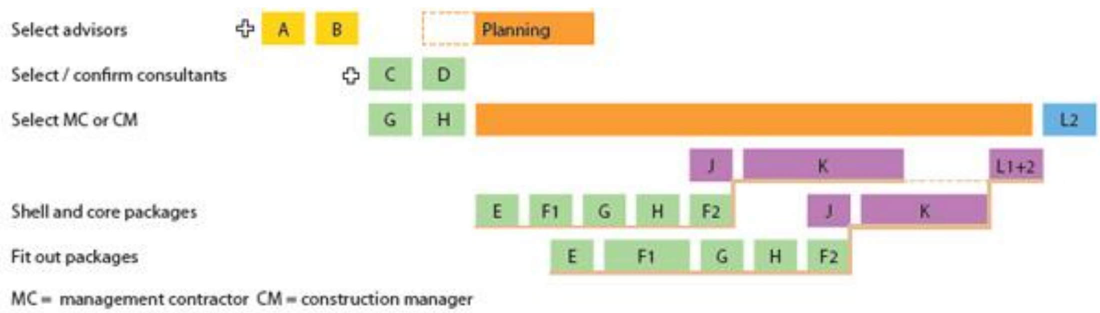


Figure 3.2: The sequence of work stages in management contract/construction management (RIBA 2007)

Based on the belief that they can deliver an agreed set of processes and procedures for construction projects, the University of Salford developed a 'generic design and construction process protocol' (GDCPP - the short name is Process Protocol). The aim of the Process Protocol is to create an improved design and construction Process Protocol by considering construction as a manufacturing process. It consists of 10 phases: (Cooper *et al.* March 1998 and www.processprotocol.com).

- Phase 0: Demonstrating the Need
- Phase 1: Conception of Need
- Phase 2: Outline Feasibility
- Phase 3: Substantive Feasibility Study & Outline Financial Authority
- Phase 4: Outline Conceptual Design
- Phase 5: Full Conceptual Design
- Phase 6: Coordinated Design, Procurement & Full Financial Authority
- Phase 7: Production Information
- Phase 8: Construction
- Phase 9: Operation & Maintenance

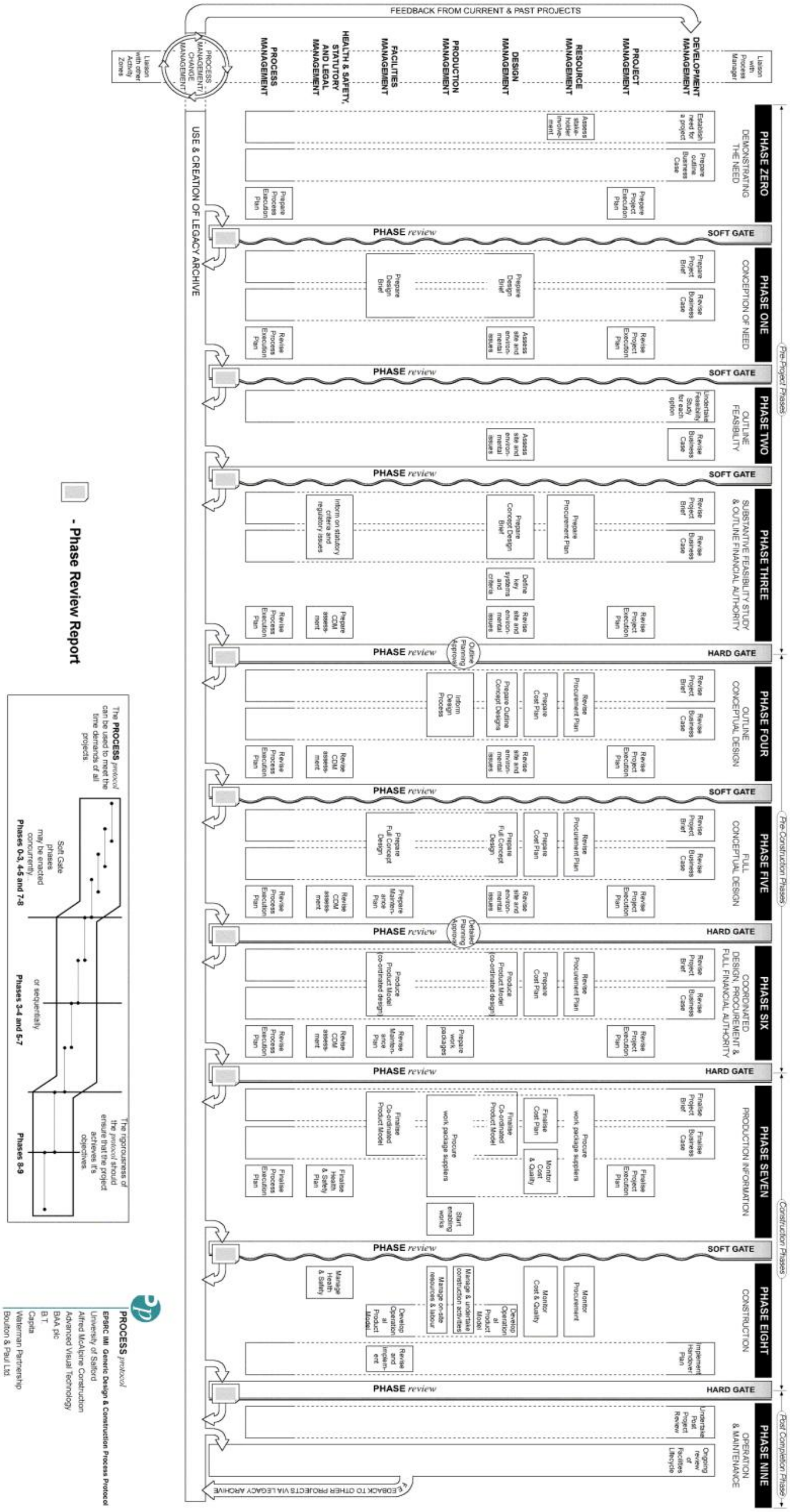


Figure 3.3: The Generic Design and Construction Process Protocol Model (Cooper et al. March 1998).

Another approach has been developed for the management of projects (regardless of the project type) by the Project Management Institute (PMI 1996). In this model PMI identified five main processes: *initiating, planning, executing, controlling and closing processes;* and nine project management knowledge areas (PMI 1996):

- Project Integration Management
- Project Scope Management
- Project Time Management
- Project Cost Management
- Project Quality Management
- Project Human Resource Management
- Project Communications Management
- Project Risk Management
- Project Procurement Management
-

The areas of project management knowledge are composed of processes distributed in the five processes of project management. Those processes are put together by Mulcahy Rita (2005), emphasising the parent area of knowledge in each process. For example, Figure 3.4 shows all the processes, highlighting those that belong to communications management.

Several other models for construction processes have been developed to improve the management of design and construction. The most popular are the British Property Federation (BPF 1983) model, and the Construct IT Centre of Excellence (1995) model.

Many studies show that numerous UK construction organisations are using either process models of respected professional bodies or their own process models or process maps in meaningful structures, (for example, Aouad *et al.* 1999; Kamara *et al.* 2000; Tzortzopoulos and Sexton 2007).

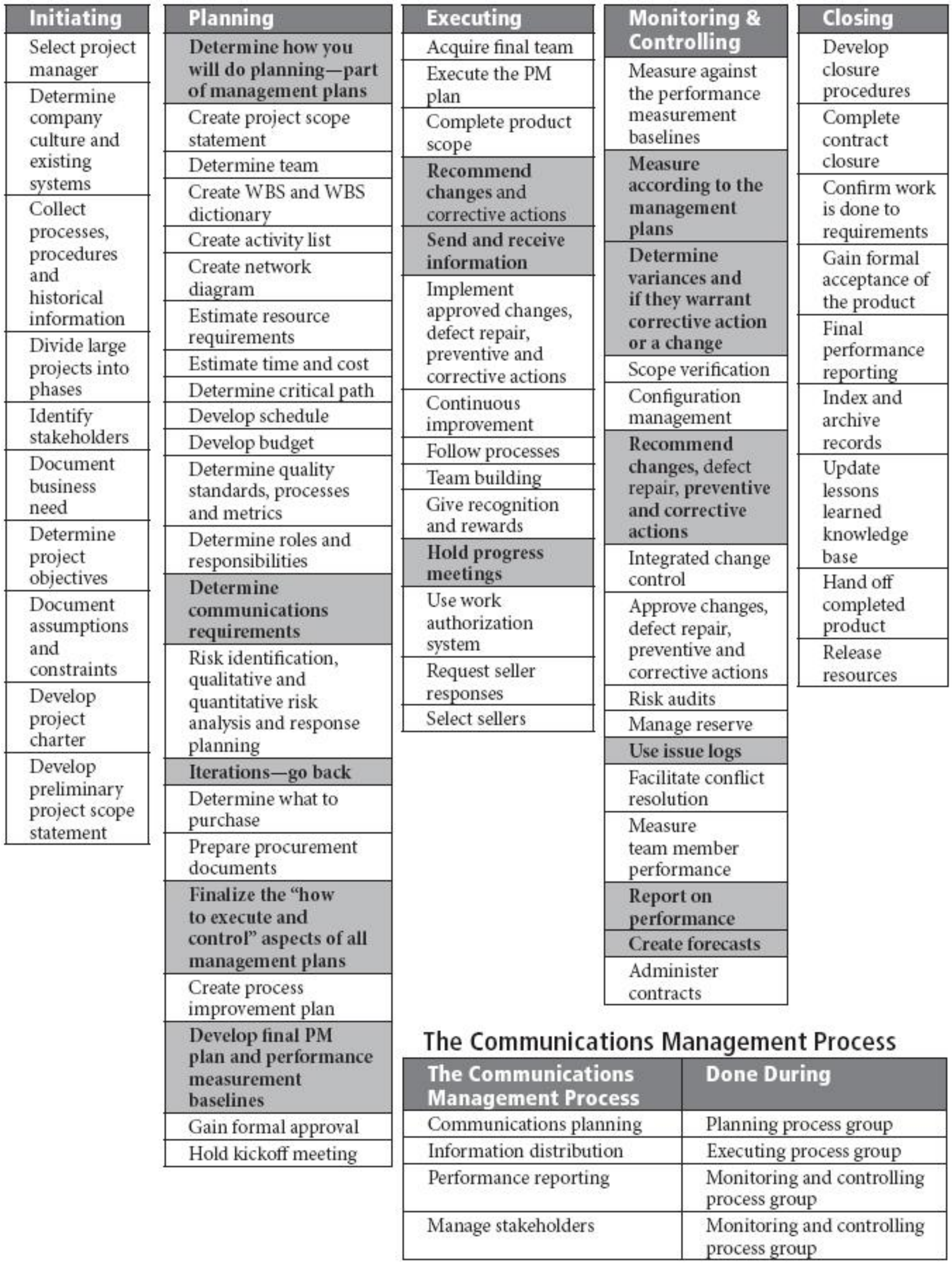


Figure 3.4: Rita's Process Chart - Communications Management (Mulcahy 2005)

3.4. **Current Practice of KM in Construction Industry**

Although there is a scarcity of studies that analyse and report on what organisations are doing in practice to capture and transfer knowledge (CIRIA 2004), some studies have been carried out to review the level of KM practice in the industry. Egbu (2000) conducted a study, based on previous projects and aimed at developing a prototype-training simulator that would provide experiential learning of the cultural aspects of the innovation process in organisations. The study involved four case studies from four innovative construction organisations and showed that KM is not just about the supply side (data and communication technologies). Instead, it was shown that it also involved the demand side (business goals, strategy, organisational structure and people issues). In addition, it demonstrated that a thorough consideration of the knowledge content, people, processes, culture, technology, and their interdependence - is vital in any coherent and robust strategy for managing organisational knowledge in construction. In the same year an MSc dissertation examined the current practices of KM in 12 of the largest 20 construction organisations in the UK, according to the business turnover. The study was conducted to develop an academic KM model based on current thinking. It was found that 50% of the organisations understood the meaning of KM, and 30% of them had some form of KM. However, it was generally found that the practice of KM applied in all of the participated organisations, but in an informal way (Herrington 2000). In another study by Egbu and Botterill (2001) 20 ethnographic interviews were conducted in six diverse project-based construction organisations. The study revealed that organisations could be said to be at different 'stages of maturity' in the management of knowledge and intellectual capital. The study also demonstrated that managing tacit knowledge was difficult and organisations employed different techniques (formal and informal) in their attempts to manage tacit knowledge. A separate empirically based study by Egbu *et al,* (2003) carried out an interview-based survey on 12 small and medium enterprises in order to review the current practices of KM. That study produced the same results as the previously cited work, as it concluded that some elements of KM are practised, but in an adhoc fashion. Another recent survey of construction organisations by Carrillo *et al,* (2003), showed that about 40% of the survey's respondents already had a KM strategy and another 41% planned to have a strategy within a year. About 80% also perceived KM as having the potential to provide benefits for their organisations, and some had already appointed a senior person, or group of people, to implement their KM strategy. Robinson *et al*., (2005) examined the current practice of KM in large construction organisations. In this study five KM maturity stages were developed to benchmark the organisation's KM maturity (Figure 3.5). The study results revealed large organisations still in the first three levels of maturity, and international organisations ahead of the national organisations. However, this study was based on four case studies and may not represent the level of KM maturity of large organisations in the UK construction industry.

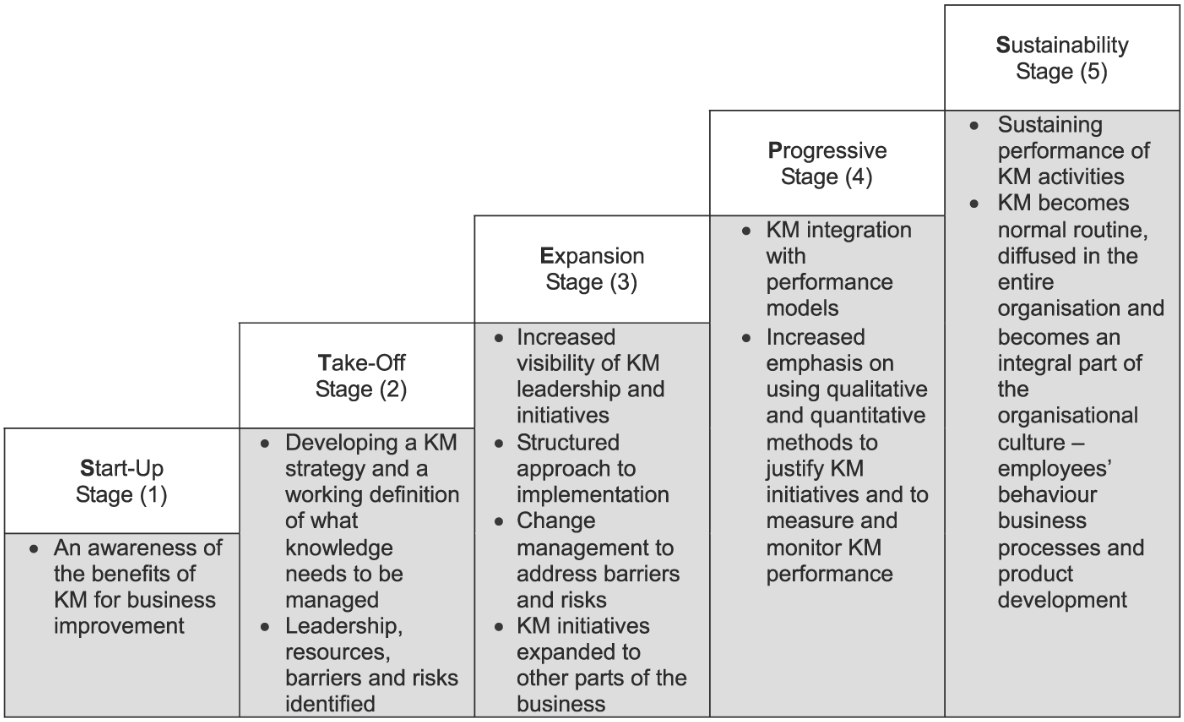


Figure 3.5: KM maturity stages (Robinson et al. 2005)

Nonetheless, a number of construction organisations have seriously attempted to establish formal methods for managing their knowledge, such as Atelier Ten, Arup, Edward Cullinan architects, WSB group, Penoyre & Prasad and Broadway Malyan. The IT construction forum (see www.itconstructionforum.org.uk/publications /casestudies.asp), which is managed by Construction Excellence and founded by the Department of Trade and Industry (DTI), has supplied over 12 case studies on KM practice in the UK construction industry. These case studies revealed that there is a well understood approach that has been adapted in several organisations in order to capture, share and re-use knowledge. Examples of that approach include a structural skills network, appraisal system, intranet system, KM group, regular CPD (Continuing Professional Development) sessions, knowledge bank, stage reports, mentoring, lessons learned..

In a nutshell, the UK construction industry has begun to recognise KM as a central task in its organisations since many of them have already established strategies for managing the intellectual capital. However, "Most construction companies are still at the stage of building their awareness or understanding of KM" (CIRIA 2005). On the other hand, there is a lack of studies that explore in depth the KM processes that are actually used in the practice.

3.5. **Perspective of managing knowledge in construction projects**

KM in construction can be defined as a process of acquiring, creating, sharing, utilizing and storing intellectual assets and other stimuli from the internal and external business environments that facilitates an organisation's performance successfully (Kuluganga and McCaffer 2001). The KM approach is likely to reflect the knowledge of individual organisations (context), and on the understanding of the meaning of knowledge (content) (Scarbrough *et al.* 1999). Therefore, two challenges can be expected in the practise of KM within construction; the challenges are at the firm and the project levels. The method of managing knowledge at the firm level will influence the project performance, since the firm and its projects are interrelated, (Anumba *et al.* 2005b). According to Kamara *et al* (2005) there are different levels of construction projects.

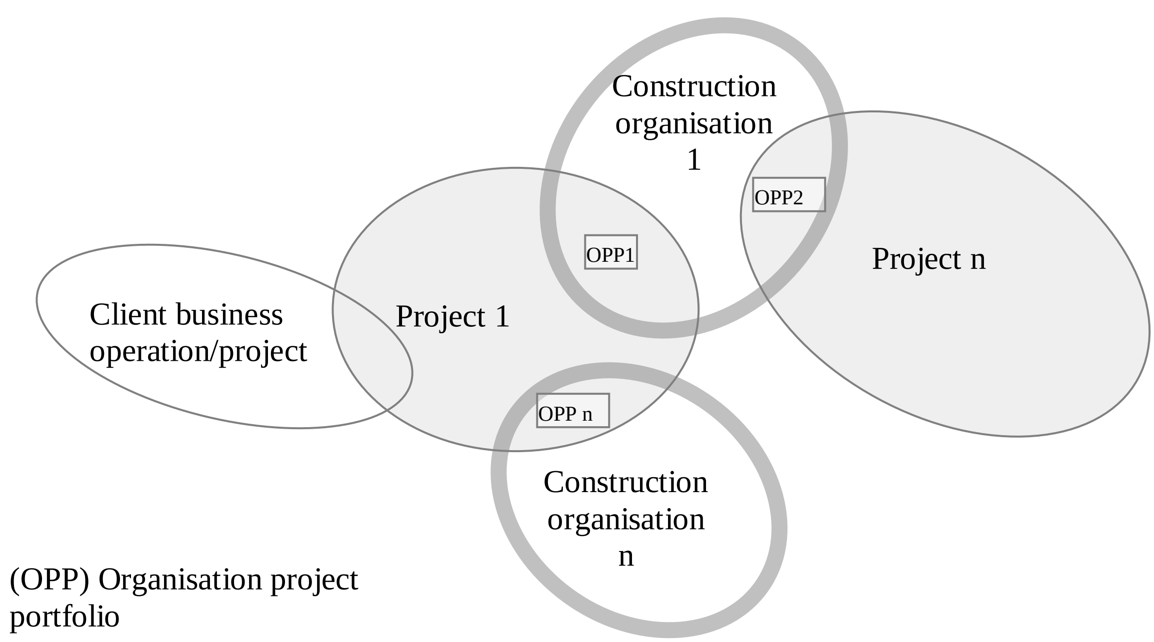


Figure 3.6: Linkages between projects in the construction industry (Kamara et al. 2005)

The 'main project' (construction project) is commissioned by a client and implemented by a number of organisation teams. Then, again, the work package, such as the design of a facility, is implemented by participating firms and is also a (mini) project from the perspective of the contributing organisation.

Accordingly, a construction firm (e.g. architects) may have projects that are, themselves, parts of different construction projects. On the other hand, a client views the construction project as part of their business operation. As illustrated in Figure 3.6 a construction project is a subset of a client business operation/project. A construction organisation project is a subset of a construction project. In addition, a construction organisation project is a subset of construction organisation portfolio (Kamara *et al*. 2005).

Construction organisations are likely to be successful in implementing KM if appropriate considerations are given to strategy formulation, implementation issues are addressed and the link between KM and business strategy is strengthened (Robinson *et al.* 2005). Anumba *et al,* (2005b) explained a framework for selecting an appropriate KM strategy, which was developed as part of the CLEVER (Cross-sectoral LEarning in the Virtual entERprise) research project at Loughborough University. In addition to providing an appropriate process to solve the identified KM problem, the framework helps to identify the level (project or/and firm) at which KM should be applied. The CLEVER framework involves four stages and can be summarised as follows:

- Defining the KM problem and linking it to business drivers/goals.
- Creating the desired characteristics of the KM solution.
- Identifying the critical migration paths for each specific problem.
- Selecting appropriate KM process(es) to use on those paths.

In terms of the relationship between a construction organisation and its projects, knowledge can be a transfer either between the project and the parent organisation, or between multiple projects and the parent organisation, or between multiple projects. As shown in Figure 3.7 the graph on the left-hand side illustrates a situation where an organisation has a one-off project. The knowledge existing in the parent organisation can be used in the project. After completion, knowledge from the project is fed back into the parent organisation knowledge base.

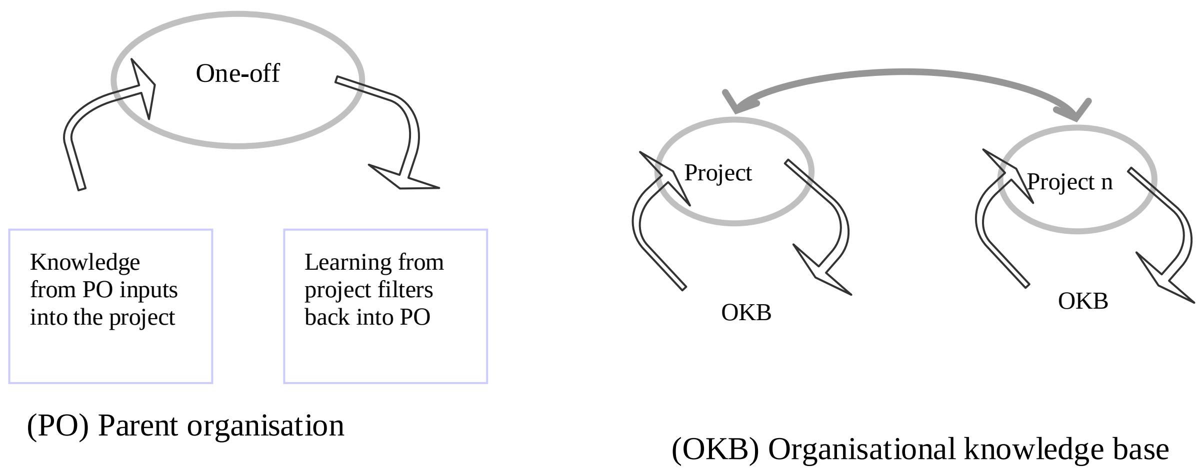


Figure 3.7: Relationships between projects and parent organisations (Kamara et al. 2005)

The right-hand side of Figure 3.7 shows a parent organisation with several projects. The knowledge is supposedly to be transferred and re-used between the projects and organisational knowledge base (OKB). In the case of transferring knowledge between projects that are running subsequently, knowledge will be transferred via OKB. Where projects are running at the same time, knowledge might be transferred between projects directly, (Kamara *et al*. 2005). However, a construction project typically involves multi-disciplinary firms as project tasks need the interaction between project parties to complete the project. Performing an activity in a construction project may require different aspects of knowledge. Hence, if the knowledge of a construction project needs to be accumulatively managed, all project parties have to participate in the project KM.

As discussed above, knowledge can be transferred between different project life cycles. However, principally, knowledge can also be transferred within and between every phase of a construction project's life. Figure 3.8 is a schematic representation of how knowledge could transfer between distinct phases of a construction project's life cycle, and the feedback link across projects (Le and Brønn 2007).

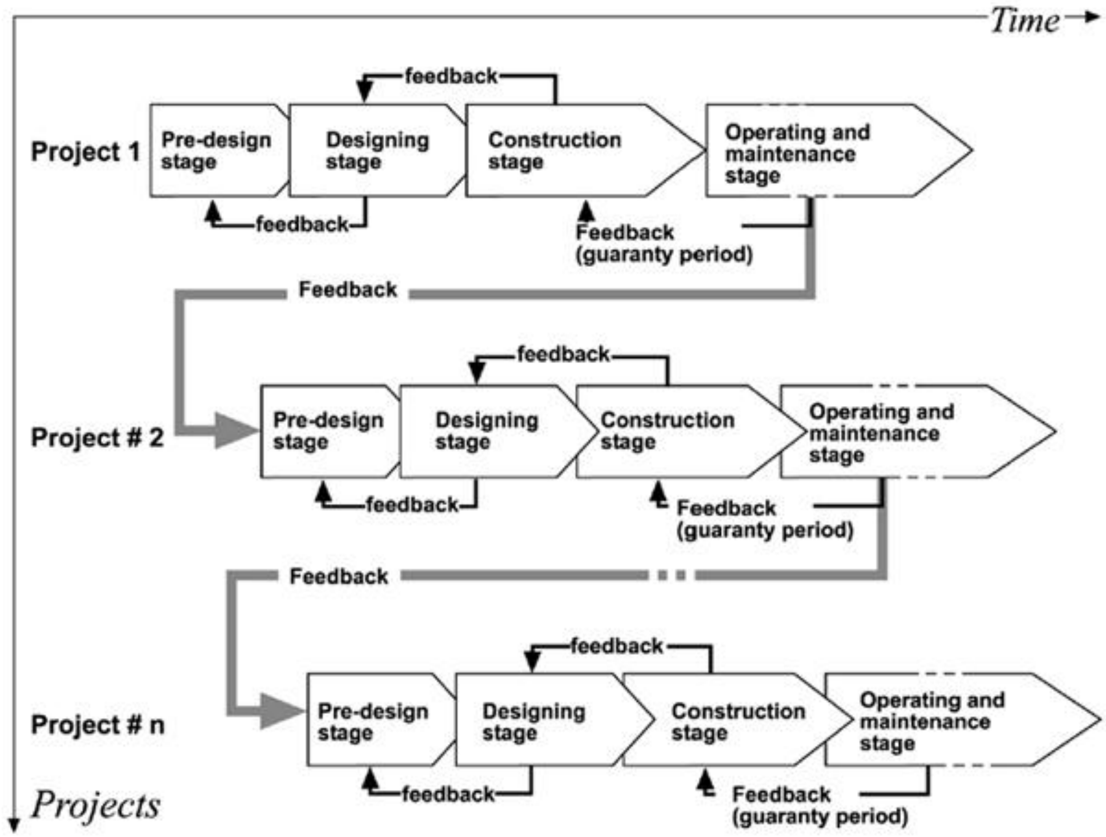


Figure 3.8: Principal feedback processes (Le and Brønn 2007)

3.6. Models and frameworks of KM in Construction Projects

A study conducted by Kasvi *et al*. (2003) to obtain lessons from one project and use them in another, concludes that in order to systematically manage knowledge created in a project, the projects themselves must be systematically managed. This result emphasises the importance of construction process modelling discussed in section (3.3). The result of Kasvi *et al*'s (2003) study is illustrated by the project learning model (see Figure 3.9), which relies on systematic repetition of project workshops. These workshops are to update the project plan and team contract. The project plan is the repository for project knowledge, such as project definition, activities and results. The Team Contract includes organisational knowledge (e.g. experiences and capitalisation of lessons learned). To secure learning from the project both the project plan and the team contract must be systematically managed.

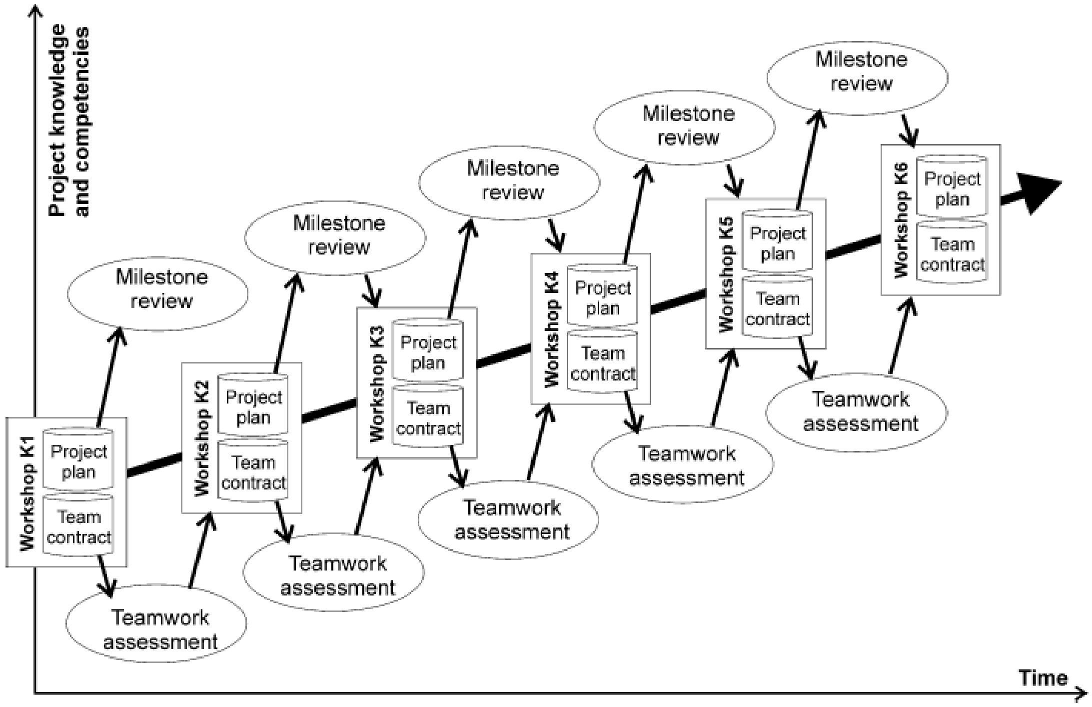


Figure 3.9: Project learning model includes two knowledge repositories, the project plan and the team contract. (Kasvi et al. 2003)

Another study focuses on the social practices and the management of knowledge in project environments. Bresnen *et al.*, (2003) pointed out that the processes of capturing and transferring knowledge in project-based environments broadly depends on practices and processes, and social patterns. This result may indicate the challenges and limitations of attempting to capture and codify project-based learning via the use of IT. They also demonstrate the importance of developing mechanisms for knowledge dissemination that are able to replicate the social nature and dynamics of KM and learning processes (Bresnen *et al.* 2003). Maqsood *et al*, (2004) found that repositories containing the data from previous projects in the construction industry are often poorly designed, implemented, managed and applied. They argued that a major cause for this poor practice is the lack of top management support and the disintegration of project histories into the strategy of the company. This led Maqsood *et al*. (2004) to develop a solution based on a matured practice of a construction company (see Figure 3.10). This is articulated as a model of human activity where there are eight high-level key activities necessary to achieve the transformation of project histories.

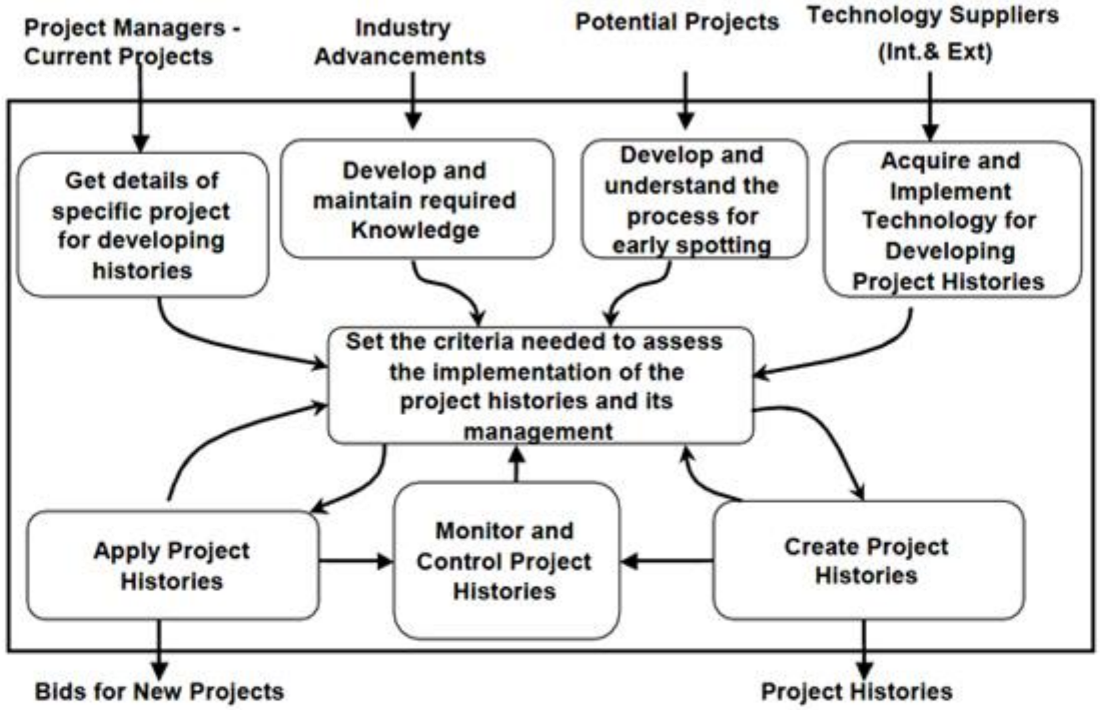


Figure 3.10: Conceptual model of project histories (Maqsood et al. 2004)

Egbu *et al*. (2001a) developed a conceptual model of the main factors associated with knowledge management in project-based environments. This model acts as a road map for developing frameworks and models, since it charts the major factors of KM in project environments and the relationships between those factors. As illustrated in Figure 3.11, those factors centre around people, processes, content and technology, which are the major factors considered in this PhD research. However, providing that the model consists of four major categories, the core and three rings, the factors included in the first and second rings are also associated, to some extent, with this research.

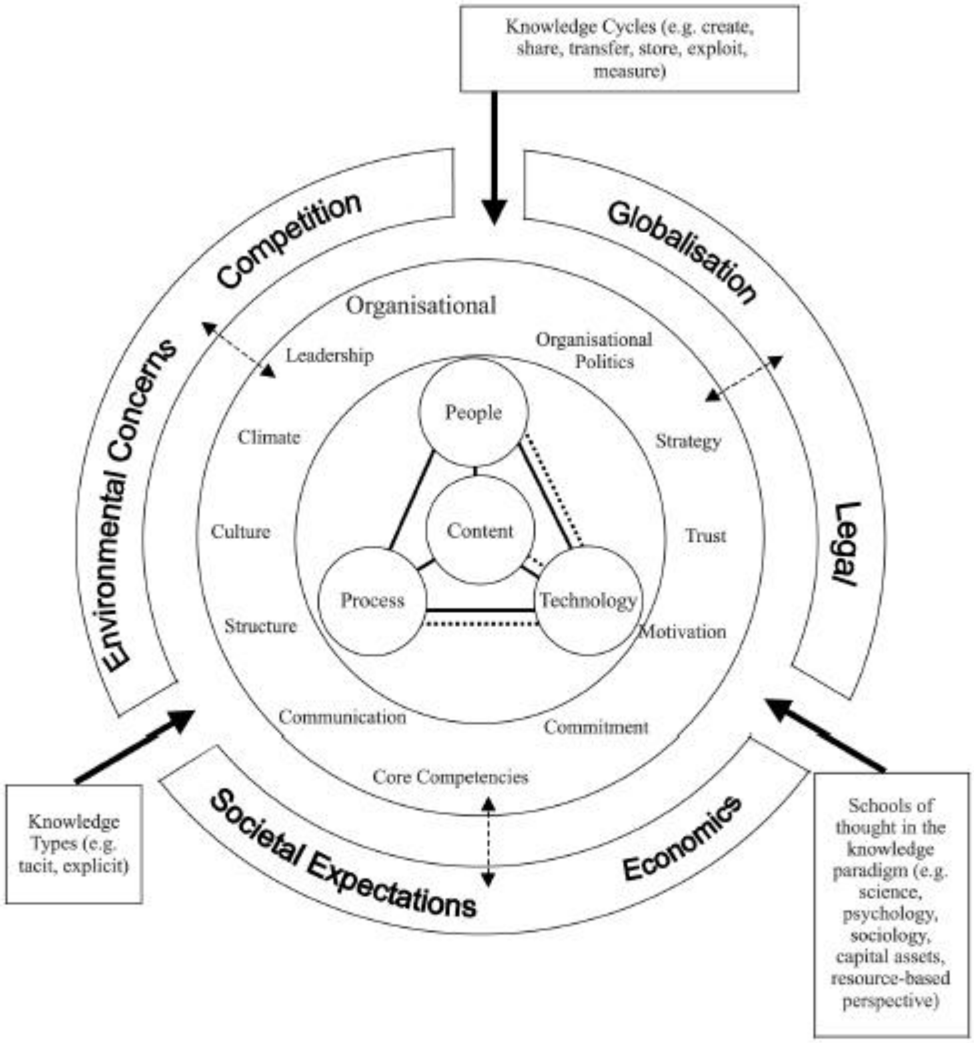


Figure 3.11: A conceptual model of the main factors associated with knowledge management in project-based environments (Egbu et al. 2001a)

In another study, conducted on two large-scale construction projects, to explore the fundamental processes of knowledge creation, Fong (2003) developed a model composed of five processes of knowledge creation, as shown in Figure 3.12. The model starts with the pre-requisite boundary-crossing process, which then leads to the three knowledge processes of knowledge-sharing, knowledge generation and knowledge integration. Collective project learning is central to the three knowledge processes. This shows that the knowledge creation processes within multidisciplinary teams are not linear. Instead, they are interwoven, occurring throughout the projects.

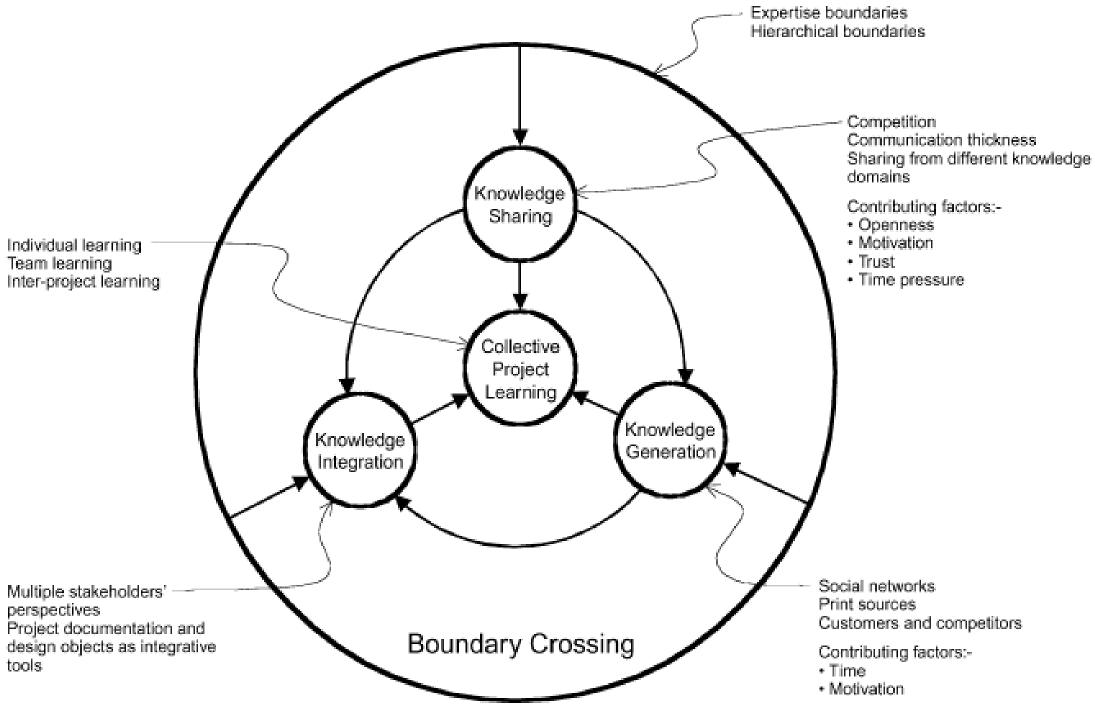


Figure 3.12: The interrelationships between multidisciplinary knowledge creation processes. (Fong 2003)

Recently Gasik (2011) developed a project knowledge management (PKM) model considering both the organisational micro and macro levels (Figure 3.13). The macro level includes three phases: informal phase, implementation phase and exploitation and improvement phase. In the informal phase the practice of PKM is developed informally and this activity is assisted with the emergence of informal communities of practice. When a company becomes aware of the benefits of project knowledge, the implementation phase takes place. This phase includes the processes of: definition of the goals for PKM, description of current practices, definition of the target state of knowledge management, implementation plan development and implementation plan execution. The final phase involves ongoing improvements to the system; aiming to obtain higher levels of maturity in PKM by mastering the ways of implementing the project knowledge management and improving the system.

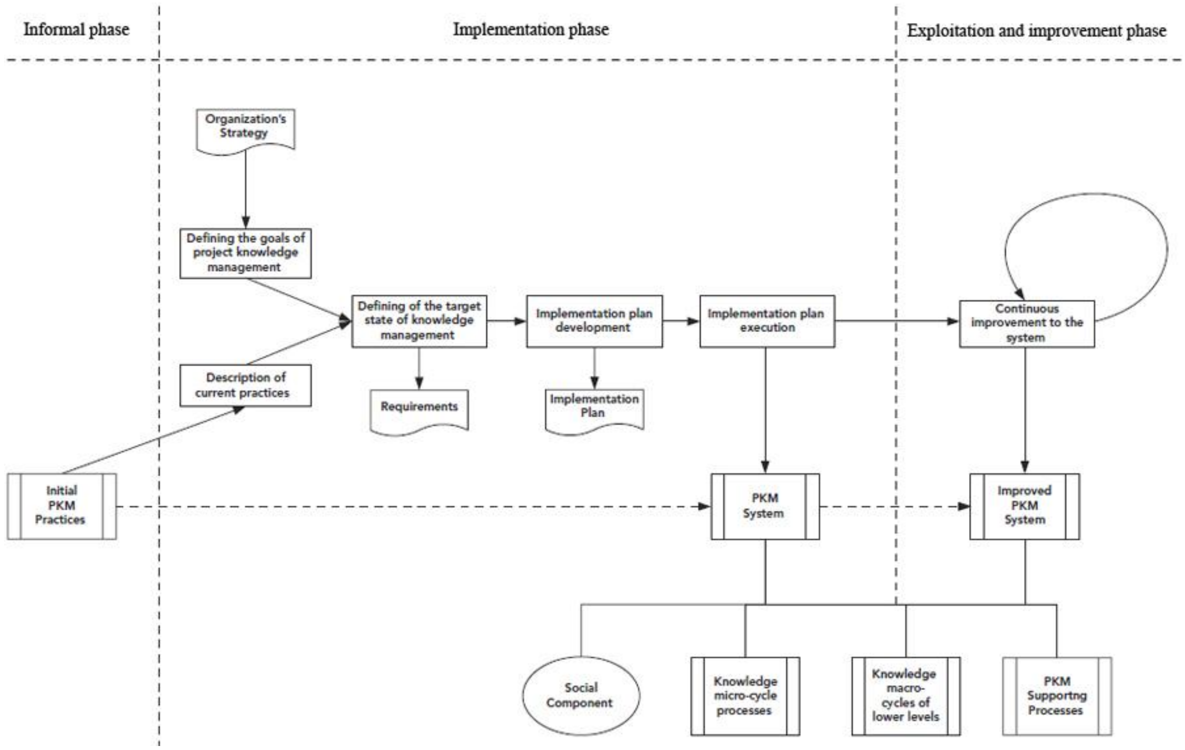
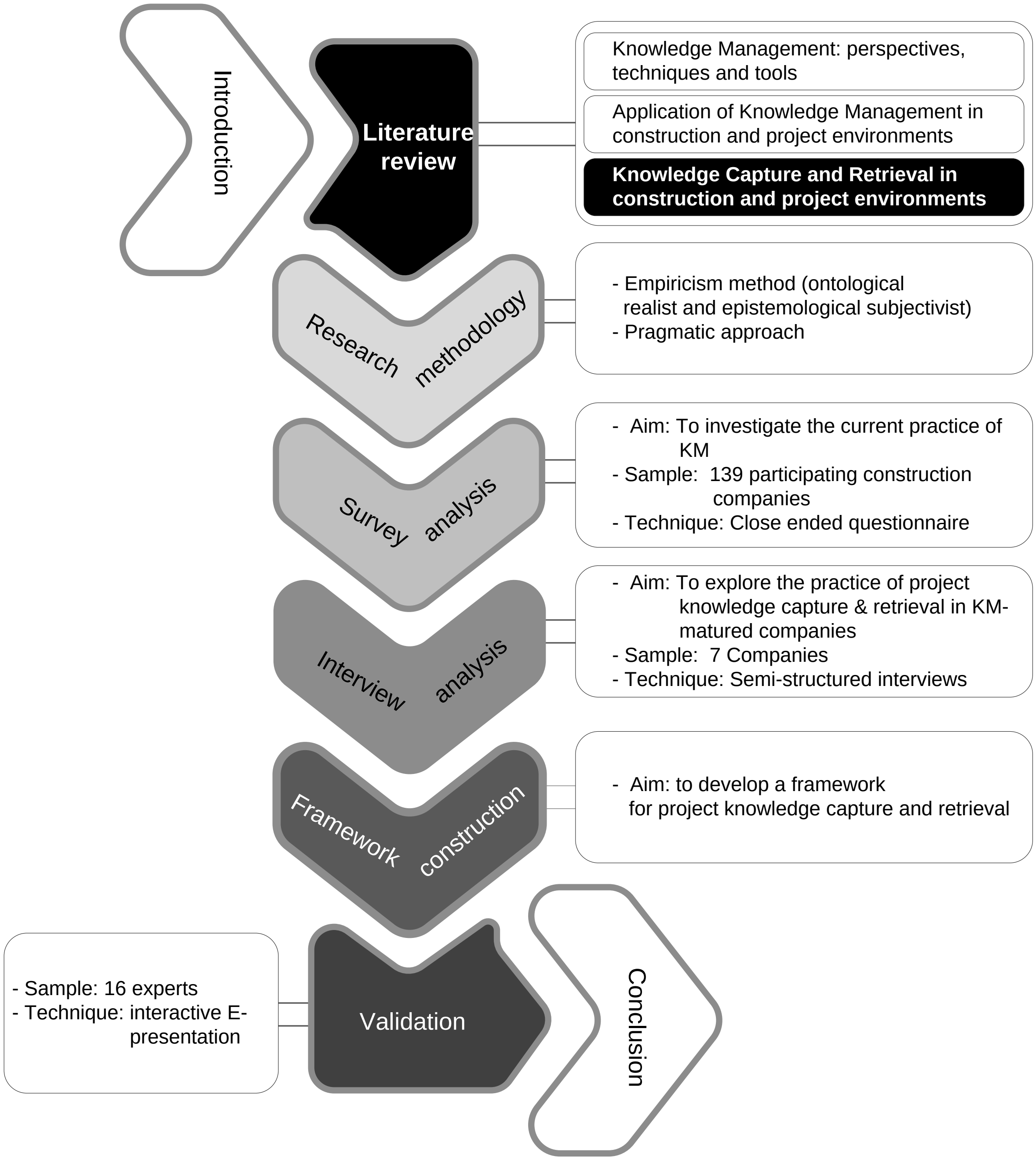


Figure 3.13: Organisation-level macro-knowledge life cycle. (Gasik 2011)

3.7. **Conclusion**

Construction projects go through similar steps in their development, although they are unique in terms of the characteristics set (specifications, resources, site, project team, conditions, culture and environment). Because of the fact that projects are most successful when conducted in a modelled process or method, a number of process models have been developed to improve the management of design and construction. As a result numerous construction organisations have been using either the process models of respected professional bodies or their own process models or process maps in a meaningful structure. There is a lack of studies that explore in depth the KM processes that are actually used in practice. However, a small number of studies indicated that most of the UK construction industry is still at an early stage of KM. However, it was reported that some construction companies have already established strategies for managing intellectual capital. Knowledge can be transferred between different project life cycles, and can also be transferred within and between every phase of a construction project's life. Two levels of KM have to be considered; firm level and the project level. Diverse approaches and frameworks have been proposed to help understand the application of KM in project environments and construction projects. Those approaches facilitate and ease the cognition of how knowledge is managed and what underlying factors and processes are involved in construction KM.

CHAPTER FOUR: KNOWLEDGE CAPTURE AND RETRIEVAL IN CONSTRUCTION AND PROJECT ENVIRONMENTS



4.1. Introduction

During construction projects, which can be highly knowledge-intensive, a considerable amount of new knowledge is created and remains in people's heads. Unless it is captured and transformed into collective explicit knowledge it will be lost. Capturing project knowledge in order to retrieve and apply it in subsequent projects is considered to be a key significant factor in improving construction project performance. As shown in Table 4.1 the processes of KM can be grouped into four major processes based on various theories, those are: 1) knowledge creation, capture, disseminating & sharing, and retrieval & application. For the purposes of the present research, this chapter will review the literature related to knowledge capture and retrieval in construction projects, in which it is presented as part of the four KM processes. This provides an opportunity to show knowledge capture and retrieval within the whole picture of the KM lifecycle. First, the chapter provides a short description of the creation of project knowledge, continuing with an intensive review of the capture of newly created knowledge. Within the context of knowledge capture, the chapter considers the processes of knowledge capture, taxonomy of project knowledge, knowledge base, knowledge codification, and project review. Then providing a brief general overview of knowledge dissemination and sharing, also highlighting culture and organisational influences. Finally, the chapter presents and discusses a number of studies concerned with the core subject of this research.

Table 4.1: Knowledge Management Processes

	Create	**Capture**	**Disseminate & share**	**Retrieve & apply**
Wiig (1993)	• Creation	• Sourcing • Compilation	• Dissemination	• Application • value realisation
De Jarnett (1996)	• Creation	• Retention • Refinement	• knowledge dissemination	• Knowledge interpretation • Knowledge use
O'Dell (1996)	• Identify • Create	• Collect • Adapt • Organise	• Share	• Apply
(Quintas *et al*. 1997)	• Creating • Acquiring	• Capturing,	• Sharing	• Using
Beckman (1997)*	• Identify • Create	• Capture • Select • Store	• Share	• Apply • Sell
(Ruggles 1997a)	• Generating	• Codification	• Transfer	
Scarbrough *et al*.(1999)	• Acquiring	• Capturing,	• Sharing	• Using

	Create	Capture	Disseminate & share	Retrieve & apply
Alavi and Leidne (2001) *	• Creation	• Storage	• Transfer	• Retrieval • Application
Staab *et al*. (2001)	• Create &/or import	• Capture	•	• Retrieve/Access • Use
Grover and Davenport (2001)	• Generate	• Codification	• Transfer	• Realization
Blair (2002b)	• Identifying •	• Capturing, • Evaluating	• Sharing	• Retrieving,
		Theories in construction management research		
Kazi *et al*. (1999)		• Capture • Consolidation	• Dissemination	• Reuse
(Egbu and Botterill 2001)	• Creation	• Capturing,	• Sharing,	• Implementing • Exploitation
Tserng and Lin (2004)	• Creating	• Securing • Capturing • Coordinating • Combining	• Distributing	• Retrieving

** Order of processes is different from the source.*

4.2. Knowledge Creation

The processes of delivering a construction project can be viewed as processes of product development. Product development is essentially a knowledge creation process (Rozenfeld and Eversheim 2002). Knowledge creation engages developing new content or replacing existing content within the organization's tacit and explicit knowledge (Pentland 1995). Nonaka and Takeuchi (1995) demonstrated that new knowledge (either tacit or explicit) is created through the interaction between individuals, groups and organisations. This highlights the importance of collaboration between team members in construction projects for creating new knowledge. However, Suchman (1987) emphasised the need for specific context if knowledge is to be created. It is the time, space and interactions between individuals. In project environments, the interactions between project members occur during the course of the project. Nevertheless, the space of emerging relationships can be physical, virtual, or mental (Nonaka and Konno 1999). In construction projects and other environments, virtual space can be electronic forums, emails, groupware. According to Horvath *et al*.(1996) the project team is the constructed phenomenon that establishes links and interactions between the individuals and parties involved in the project, and therefore it is the fertile ground for knowledge creation. In every construction project a considerable amount of new knowledge is created, and this remains in people's heads unless it is captured and transformed into collective explicit knowledge. In relation to both information and communication technology (ICT), Berente *et al*. (2010) found that projects involving a joint ICT artefact rooted in practice are likely to require less frequent physical interaction during the knowledge creation process and will therefore result in larger amounts of information pooling. The next section expands the discussion with regards to capturing the new created knowledge in construction projects.

4.3. **Knowledge Capture**

There is no need to waste time and money by reinventing existing good practice in construction projects (Egan 2004). During construction projects, which can be highly knowledge-intensive (Woo *et al.* 2004; Hari *et al.* 2005), knowledge creation takes place. The new created knowledge will be impeded in people's heads. Realising that members of a construction organisation involved in a project possess new knowledge, provides the inspiration and encouragement to want to capture this knowledge. Unless captured this knowledge is often lost, since only a small amount of this information makes it into project documentation (Fruchter 2002). Therefore, all the knowledge gained on a construction project is lost if those involved are not given the opportunity to feed it back into future projects (Barlow and Jashapara 1998). When capturing knowledge of construction management activities, rationale and decisions are made explicit in project archives, so they can be shared and used in future projects (Fruchter and Demian 2005). It should be considered that knowledge capture can be distinguished from knowledge access, as knowledge capture is: "The process of eliciting knowledge that resides within people, artefacts, or organisational entities, and representing it in an electronic form such as a knowledge-based system for later reuse or retrieval" (Becerra-Fernandez and Sabherwal 2006: p. 235); while knowledge access refers to allowing authorised people to read, update, duplicate, and transfer previously codified knowledge in a convenient and prompt way (Schwartz 2006). On the other hand knowledge retrieval is recalling relevant past experience, which can be used to aid current decision making (Niu *et al.* 2009). The successful application of knowledge capture can be viewed as "turning personal knowledge into corporate knowledge that can be widely shared and properly applied throughout the organisation in such a way as to create competitive advantage to the organisation" (Hari *et al*. 2005: p. 535-36).

In practice, when knowledge is captured, it is limited to formal knowledge (e.g. documents). Contextual or informal knowledge, such as the rationale behind decisions, or interaction between team members, is often lost. This captured information cannot be retrieved to make a valid usage in future projects (Fruchter 2002). An effective approach to knowledge capture depends on the mechanism and technologies that facilitate the conversion of tacit knowledge into explicit form (externalisation), or the conversion of explicit knowledge into tacit form (internalisation). The development of models or prototypes and the articulation of best practices or lessons learned are some examples of mechanisms that enable externalisation. Learning by doing, on-the-job training, learning by observation, and face-to-face meetings are some of the mechanisms that facilitate internalization (Becerra-Fernandez and Sabherwal 2006)

Evidence has shown that most organisational knowledge is in people's heads and processes, and IT is not capable of capturing some tacit knowledge without losing its context (Robinson *et al*. 2005). In addition, knowledge repositories can only capture explicit aspects of knowledge. Therefore, part of project knowledge can be successfully captured and effectively used. However, a large part of knowledge will remain in people's heads (Wenger 2000). It is clear that part of project knowledge can be transformed into explicit knowledge – externalisation (Nonaka and Takeuchi 1995). However, it should be considered that not all project knowledge can be captured, because not all the tacit knowledge can be transformed into explicit knowledge; as indicated by Polanyi: "we know more than we can tell" (Polanyi 1966: p.4). However, some tacit knowledge (captured in people's heads) can be transferred by socialisation (Nonaka and Takeuchi 1995).

On the other hand, knowledge capture is not a project to be conducted only once. It is an investment programme that needs continuous consideration over a substantial period of time (Hari *et al*. 2005). The management of explicit knowledge utilises four primary resources (Zack 1999):

- Repositories of explicit knowledge;
- Refineries for accumulating, refining, managing, and distributing that knowledge;

- Organisation roles to execute and manage the refining process; and
- Information technologies to support those repositories and processes.

A number of techniques are identified in the literature as appropriate methods for capturing construction projects. Those include CoP (Anumba *et al.* 2005a), Post project reviews (Orange *et al.* 1999; Tan *et al.* 2005), manuals, storytelling, and information systems tools (Shapiro 1999).

4.4. **Knowledge Capture Process**

Several views on the processes of knowledge capture are available in the literature. For example, Phillips-Wren and Jain (2005) identified five processes of knowledge capture: identification, conceptualisation, formalisation, implementation, and testing. Another similar view from the construction industry by Hari *et al.* (2005) suggested seven processes: recognise, examine, implement, filter, bank, disseminate and update knowledge. However, both of these approaches interfere knowledge capture processes with the other processes of KM, such as knowledge disseminating, and application. Another dissimilar approach to knowledge capture is suggested by (Gruber and Russell (1991) and view knowledge capture as eliciting, recording, and organising project knowledge. Although this approach distinguishes between knowledge capture and the other processes of KM, it doesn't include the process of identifying the desired knowledge, which seems to be an important process of knowledge capture.

4.5. **Project Knowledge Taxonomy:**

It is generally accepted that knowledge can be categorised into four types: know what, know why, know how, and know who (Foray and Lundvall 1998; Egbu and Robinson 2005). Within the context of construction projects, Kasvi *et al.* (2003) identified three types of project knowledge:

- Technical knowledge: concerning the product, its parts and technologies.
- Procedural knowledge: concerning producing and using of the product and acting in a project.

- Organisational knowledge: concerning communication and collaboration.

Another broad view by Mead (1997), suggested that knowledge of construction projects could be grouped into four general categories: project, design, management, and financial information. On the other hand, Tserng and Lin (2004) divided project knowledge, based on the nature of knowledge, into tacit and explicit knowledge. Explicit knowledge includes specifications/contracts, reports, drawings, change orders and data; while tacit knowledge includes process records, problems faced, problems solved, expert suggestions, know-how, innovations and notes on experience. Kasvi *et al*. (2003), in some ways, provided the same idea of tacit and explicit knowledge, however, it was presented in other terms, i.e. project plan and the team contract:

- Project plan: a repository for 'hard' project knowledge including project definition, activities and results.
- Team contract: includes organisational knowledge, like experiences and capitalisation of lessons

In terms of the way knowledge is classified in the knowledge repository, there is a lack of studies that investigate this. However, Millie Kwan and Balasubramanian (2003) illustrated several studies showing that most knowledge repositories are classified by subject area, such as procurement, cost control and risk management. An alternative classification by Tserng and Lin (2004) categorised project knowledge based on the activities of the project.

4.6. **Knowledge Base**

Today, the practice of knowledge capture in many companies in the construction industry is limited to dealing with paper archives. Companies that use IT to capture knowledge in digital format are using documents and folders, which are difficult to explore and navigate (Fruchter and Demian 2005). The lack of an appropriate system is one of the most significant barriers for successful KM initiatives in projects (Ajmal *et al.* 2010). Information technologies can enhance the management of organisational and project memories (Alavi and Leidner 2001). The purpose of the knowledge base is to store the captured project knowledge, so it can be retrieved by project members during the course of the project. The challenge of knowledge base is to be able to collect knowledge created in ongoing processes of projects, to organise and store that learning, and then distribute it to members of the project who are likely to benefit from it (Grant 2000). In using a knowledge base, it is necessary to consider two issues: knowledge repositories can only capture explicit aspects of knowledge. Therefore part of project knowledge can be successfully captured and effectively used. However, a large part of that knowledge will remain in people’s heads. The second point is that many companies capture huge amount of information that nobody looks at (Wenger 2000). Ontology is another determinant for an effective knowledge base. Ontologies are specifications of discourse in the form of a shared vocabulary. They provide a structure for developing a knowledge base. At the highest level, ontologies define the components of a knowledge base, such as the best practice section. At lower levels, ontologies serve to define models in particular components (O’leary 1999). A knowledge base usually includes several sections or components: Yellow pages (Davenport *et al*. 1999), gives information about the members of the organisation, such as the contact details and areas of expertise. Another component of a knowledge base is file management (Bowman 2002). This is to categorise and store the knowledge online. An online discussion board (Alavi and Leidner 2001) is another tool that can help in sharing, disseminating, and capturing knowledge. Emailing the client is also considered a KM tool that facilitates communication and project correspondence (Woo *et al*. 2004).

4.7. **Knowledge Codification**

This is one of the most important, and challenging areas of knowledge management. Knowledge codification can be defined as “the process of converting knowledge into accessible and applicable format” (April *et al*. 2004: p 91). It is the process of putting knowledge in "various forms that can be leveraged and transferred" (Ruggles 1997b: p 6). The information required to develop a project knowledge map often already exists in organisations, but it is usually in fragmented and undocumented form. Every employee has a little piece of the map in his head (Davenport and Prusak 1997). The aim of knowledge codification in the project context is to make knowledge available for all members of project team so they can use it when needed. It is important to recognise that not all types of knowledge need to be codified, as that may lead to overload of information and make it difficult to retrieve the right knowledge. This is illustrated clearly in this statement: “In a world where attention is a major scarce resource, information may be an expensive luxury, for it may turn our attention from what is important to what is unimportant" (Simon 1978: p.13). Davenport and Prusak (2000) suggested four basic principles of knowledge codification:

- Managers must determine the business goals that the codified knowledge will serve.
- Managers must be able to identify knowledge existing in various forms appropriate to reaching those goals.
- Knowledge managers must evaluate knowledge for usefulness and appropriateness for codification.
- Codifiers must identify an appropriate medium for codification and distribution.

Despite knowledge codification having been covered in numerous studies, there is a lack of detail regarding the appropriate form and format of the codified knowledge.

4.8. **Project Review**

Project review is considered to be an appropriate and popular technique for knowledge capture in construction projects (Orange *et al.* 1999; Winch and Carr 2001; Tan *et al.* 2005). The emphasis of project review methods is on the assessment of project activities. It is conducted after key stages of the project, then lessons learned are gathered upon completion of the project. Alternatively, it can be carried out only once after the project completion. Process-based methods deal with information on what was, and what was not, performed well in terms of time, cost and quality.

Four different types of project review can be found in the literature. One of them is post project review (PPR also known as Post Project Appraisal PPA, Project Completion Review PCR, and Project Post-mortem PPM). It takes place after the completion of the project, sometimes two years after project completion. PPR involves the contribution of the project team and other parties engaged in the project, such as contractors, suppliers and specialists. PPR takes the form of checklists, or, in some cases, a survey distributed to the project participants and commenced before reviewing the project (Bolles 2002; DIR 2003). The aim of PPR is to group together the evaluations for the aspects they are involved with during the course of the project, and to facilitate discussion during a PPR meeting. The

CIOB (1998) identified four main elements that a typical PPR would contain, namely; project audit, cost and time study, human resource aspects, and performance study. It may also consider the lessons learned and documented in a lessons learned report. This review is carried out by an external project review unit (Gulliver 1987) or by a project homework group (Garvin 1993). Another type of project review is called project evaluation, which can be defined as an ongoing check of how well the project is performing. These reviews are carried out at gateways and other major decision points. The performance reflected in the project evaluation is based on the project team and the facility being constructed in terms of the desired benefits (OGC 2003a). In the PPR the aim of the project evaluation is to collect the knowledge of the project in order to enhance performance of future projects. The method is typically conducted through face to face meetings and is codified in the form of a report. The third type of project review is a post implementation review (PIR). Hallows (2001) considered the aim of the PIR technique to be unlike PPR and project evaluation as it is not intended to identify lessons learned or best practice. The only reason for conducting the PIR is to assess the quality of the implementation of the project product. In contrast, other authors, such as OGC (2003a) and Frigenti and Comninos (2002), pointed out that PIR is carried out to identify lessons that can be learned from the project experience in addition to measuring the project's quality performance. The after-action review (AAR) is the fourth type of project review. It was originally developed as an approach to learning by the US Army in the 1970s. It was designed to facilitate day-to-day learning from combat training exercises (Sheehan *et al*. 2005). AAR is conducted during the course of the project after each decision stage, in a form of discussion. A facilitator should be assigned to carry out these reviews and all members of the project team should contribute to the discussions. The discussion covers the answers to questions such as: What was supposed to happen? What actually happened? Why were there differences? and What can one learn from this experience? The codification of this review is conducted in the form of flip charts (Schindler and Eppler 2003; Ozorhon *et al.* 2005). A study by Schindler and Eppler (2003) identifying four types of project debriefing methods. Table 4.2 showed detailed practices of those methods.

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 4.2: Process-based methods to learn from experiences (Schindler and Eppler 2003)

Parameter	**Method**			
	Project Review/Project Audit	Postcontrol	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 into the project	Project manager (inclusion of project team not neglected)	Project team and third parties that are involved into 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 project's 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, check points 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

Parameter	Method			
	Project Review/Project Audit	Postcontrol	Post-Project Appraisal	After Action Review
		to identify relevant backgrounds of differences between estimated and actual effort		
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 goal (excluding predefined distribution lists)	Booklets as well as personalized	Flip charts

4.9. **Knowledge Dissemination and Sharing**

KM approaches can be categorised into two major approaches, the supply driven approach and the demand driven approach (Scarbrough *et al*. 1999). In terms of knowledge dissemination, supply driven approaches focus on making *codified* knowledge available to the right people at the right time. Therefore, project members can get the right knowledge during the course of the project. It is also claimed that codified knowledge can be transferred through networks - information systems - and is central for innovation (Choo 1996; Howells 2000). It might be arguable that codified knowledge transferred through networks leads to innovation and competitive advantage (Wolfe 1994). On the other hand, and from the perceptive of knowledge sharing, the demand driven approach pays more attention to innovation and motivation, providing that knowledge for innovation is socially constructed, and cannot simply be processed; instead it must be continuously recreated and reconstituted through dynamic, interactive and social networking activity (Swan *et al.* 1999a). Presuming that knowledge created through social activity is associated more with innovation (Swan *et al.* 1999a), part of tacit knowledge can be converted into explicit, and the continual dialogue between explicit and tacit knowledge drives the creation of knowledge (Nonaka 1994).

Those two approaches can indicate two kinds of knowledge sharing scenarios. Even if it is arguable that one is better than the other, there is certainly no arguable case found to indicate that either one of those approaches is not needed. As a result, it is important in the management of project knowledge to consider both; the objective (structural) perspective of knowledge sharing and the subjective (social) perspective. It is necessary to consider both codified (explicit) and tacit knowledge of projects through *networks* and *networking* in construction projects.

4.10. **Knowledge Retrieval**

For some 4000 years, information has been organised for later retrieval and usage. A typical example is the table of contents of a book (Baeza-Yates and Ribeiro-Neto 1999). Once knowledge has been created, captured, and stored, it will be available for members of an organisation to retrieve while involved in a project. The concepts of:

(1) most of what organisations know is not codified (Polanyi 1966),

(2) members of a project forget what they have learned (Darr *et al.* 1995), and

(3) knowledge is the most important asset for organisational competitive advantage (Etzioni 1964),

have led organisations to capture knowledge so they can retrieve it when needed. However, many companies have captured huge amounts of information that nobody looks at (Wenger 2000). Information overload is one of the major problem in construction KM (Liston *et al*. 2000). This recalls Eliot's question: "Where is the knowledge we have lost in information?" (Eliot 1963: p.161). Therefore, capturing knowledge is not enough; knowledge has to be refined, and appropriate methods and tools should be in place to enable project members to retrieve what they want in a quick and simple way. As stated by Teece, "Knowledge, which is trapped inside the minds of key employees, in filing drawers and databases, is of little value if it is not supplied to the right people at the right time" (Teece 2001: p.128).

An effective knowledge retrieval method assists people to understand their knowledge assets, and enables them to find the desired knowledge fast. A number of tools have been developed to enrich the method of information/knowledge retrieval. These tools include the search engine techniques, the automatic clustering or classification of documents, and user or expertise profiles (Geo and Kokossis 2004). It can be argued that searching and browsing are the two basic approaches for knowledge retrieval (Rollett (2003). However, the effectiveness of browsing or navigating methods mainly depends on how knowledge is formatted, structured, and classified.

Providing knowledge is either context-specific, or context-free (Myers *et al*. 1979), a knowledge worker will not only retrieve knowledge items, but will process them for further use in a specific context (Staab *et al*. 2001). Indeed, knowledge of design and construction process management is context-specific knowledge. It is associated with specific processes, and specific types of projects (i.e. construction projects), and is related to a particular area of knowledge. Therefore, a knowledge retriever needs to have a minimum amount of knowledge and experience in order to make a valid interpretation of codified knowledge.

4.11. **Organisational and Cultural Influence**

The concept that knowledge is socially constructed has inspired many studies to focus on organisational and cultural aspects, because that is the base for any successful application of KM. The emphasis of these studies is on social capital rather than the hard edge of KM. Social capital is identified as "goodwill that is engendered by the fabric of social relations and that can be mobilized to facilitate action" (Adler and Kwon 2002: p.17). In order to enhance social capital, Davenport *et al*. (1999) suggested the following three key indicators:

- people have a positive orientation to knowledge
- people are not inhibited in sharing knowledge
- the KM project fits with the existing culture

A study about learning capabilities by Styhre *et al*. (2004) shows that in the context of construction projects, organisational learning depends on personal contacts, communities of practice, and learning by doing instead of a technical and formal system. The weight has to be put on the management of project knowledge and carriers of project knowledge: the project team (Kamara *et al*. 2002). Because knowledge carriers are one of the two major elements of KM, it is essential to motivate them to share project knowledge (Bresnen *et al*. 2003). A study by Jeon *et al*. (2011) shows that both extrinsic motivational and intrinsic motivational factors can positively affect knowledge sharing behaviours, but intrinsic motivational factors were found to be more influential.

The effective implementation of KM depends on many factors, which include, leadership (Egbu *et al.* 2001b; Ajmal *et al.* 2009), organisational structure , people, the environment (Egbu *et al.* 2001b), culture (Egbu *et al.* 2001b; Ajmal *et al.* 2009; Lindner and Wald 2011), finance, technology (Egbu *et al.* 2005), incentives (Ajmal *et al.* 2010), social patterns, practices and processes, that highlight the value of implementing a community-based approach (Bresnen *et al*. 2003). Nevertheless, the support of top management and the existence of the right culture may be considered major factors affecting the processes of capturing, disseminating, and retrieving knowledge in the project environment (Suresh and Egbu 2006). The management of the project knowledge asset may seem easy; but it is not. It is an integrated and complex social process (Egbu *et al*. 2005).

4.12. **Related Studies**

While most of the studies considering KM in construction focused on the organisational perspective, a small number of studies considered the management of project knowledge, and knowledge capture and retrieval.

In a study by Hari *et al*. (2005), it was found that there is a lack of awareness of knowledge capture benefits and processes. The study pointed out that the application of knowledge capture largely depends on the vision of the organisational owner. It was also found that culture, structure, people, finance and technology are major factors affecting the implementation of knowledge capture. The study concluded that knowledge capture in SMEs is not an easy task and called for a coherent structured approach to utilise the existing tacit and explicit knowledge within organisations. Additional factors influencing knowledge capture in construction have been suggested in another study conducted by Suresh and Egbu (2006). The study suggested that construction organisations should adopt a holistic and integrated approach to knowledge capture. Top management, culture, processes, tools and training, at the core of their knowledge capture strategy, were found to be determinants for a successful application of knowledge capture. On the other hand, Kamara *et al*. (2003) developed a conceptual framework for knowledge capture (Figure 4.1). In this approach, when a learning event occurs during the course of a construction project, the integrated workflow system is triggered and this sets in motion a flow of actions to capture the learning at a particular point in time.

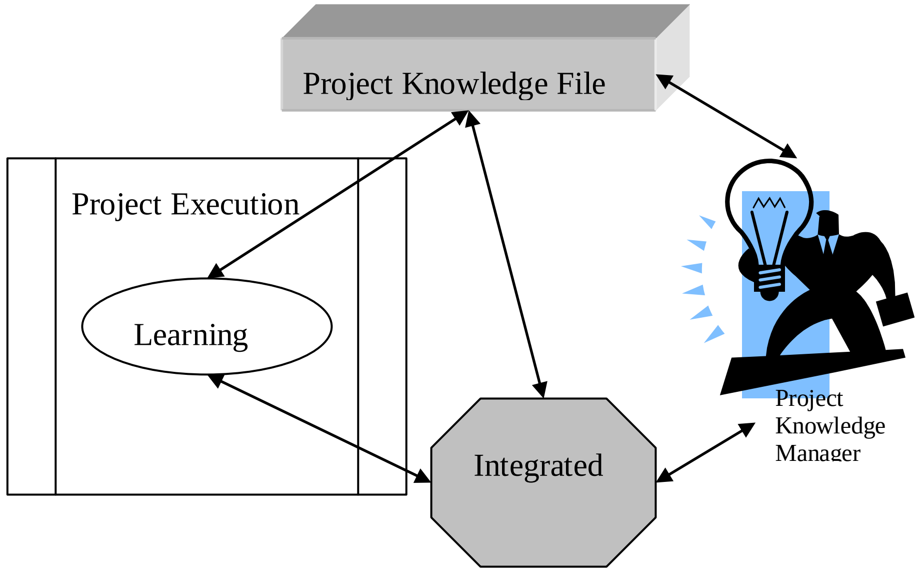


Figure 4.1: learning event-based knowledge capture system (Kamara et al. 2003)

Considering knowledge that related to all the parties involved in the project, Nitithamyong and Skibniewski (2004) identified web-based project management system (WPMS) as an appropriate method of knowledge capture (Figure 4.2). The system is built on the extranet network and is only accessible by project teams. It transmits information between parties involved in the project, and provides a centralised, commonly accessible means of transmitting and storing project information. Project information is stored on the server and is accessible through the Web browser.

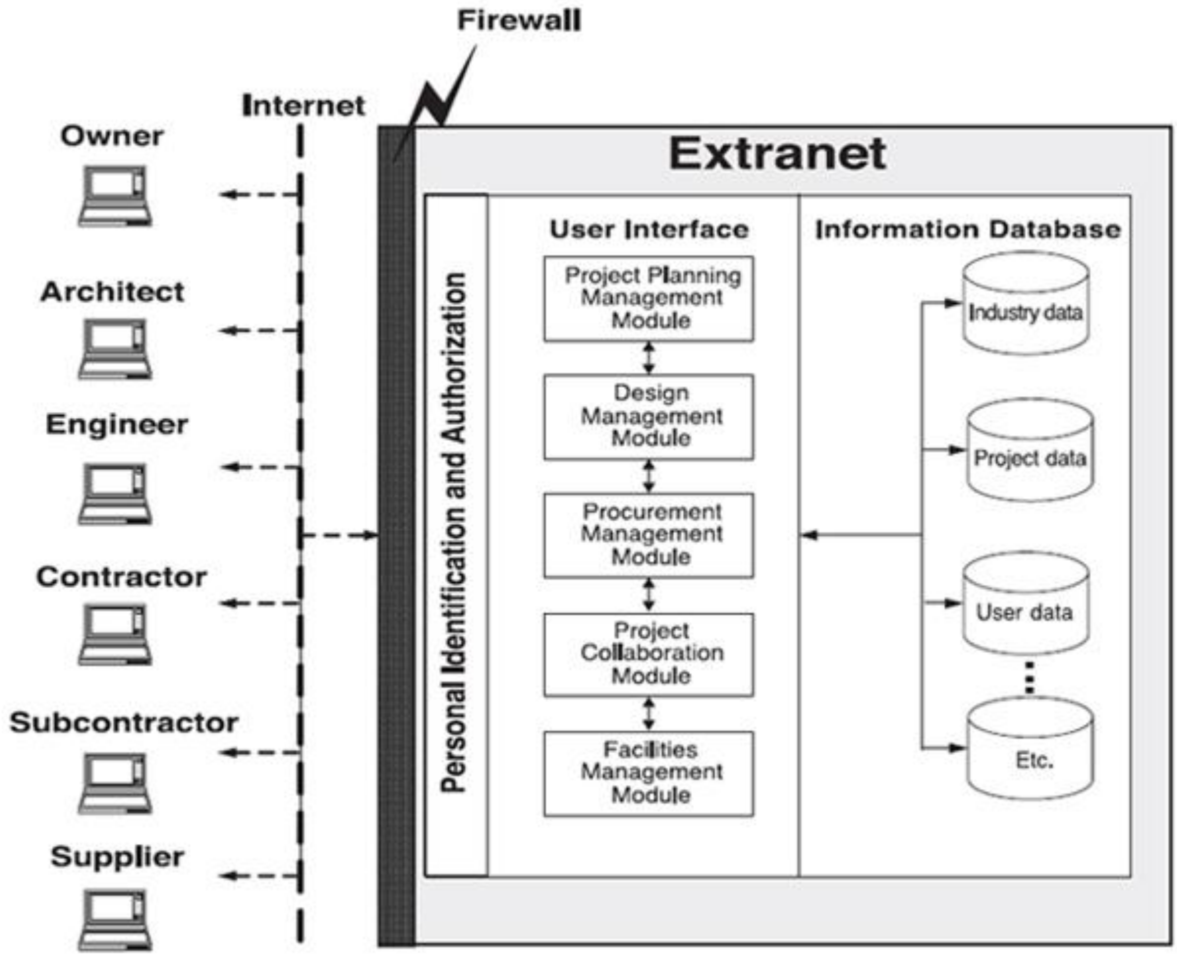


Figure 4.2: Functional scheme of WPMS (Nitithamyong and Skibniewski 2004)

Based on Kamara *et al*.'s (2003) study, Udeaja *et al*.(2008) developed a web-based prototype (CAPRI.NET) for live capture and reuse of construction project knowledge. It allows project participants to document their learning during the course of a project in a project knowledge file (PKF). In this study the knowledge is not related to a particular party (e.g. Architect), instead it integrates knowledge collectively owned by all participating firms, who will have access to the CAPRI.NET through the internet. Figure 4.3 depicts the user navigational process within the CAPRI.NET. The CAPRI.NET is composed of three logical layers: 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 middle layer (tier two), which in turn is connected to the data server (tier three), with access to and control over all types of knowledge and information within the MySQL database. In the future, this data server will contain all the databases and links to other data servers. Project knowledge in this study is the reusable knowledge; however, there are no indications about the type of project knowledge and how it is classified.

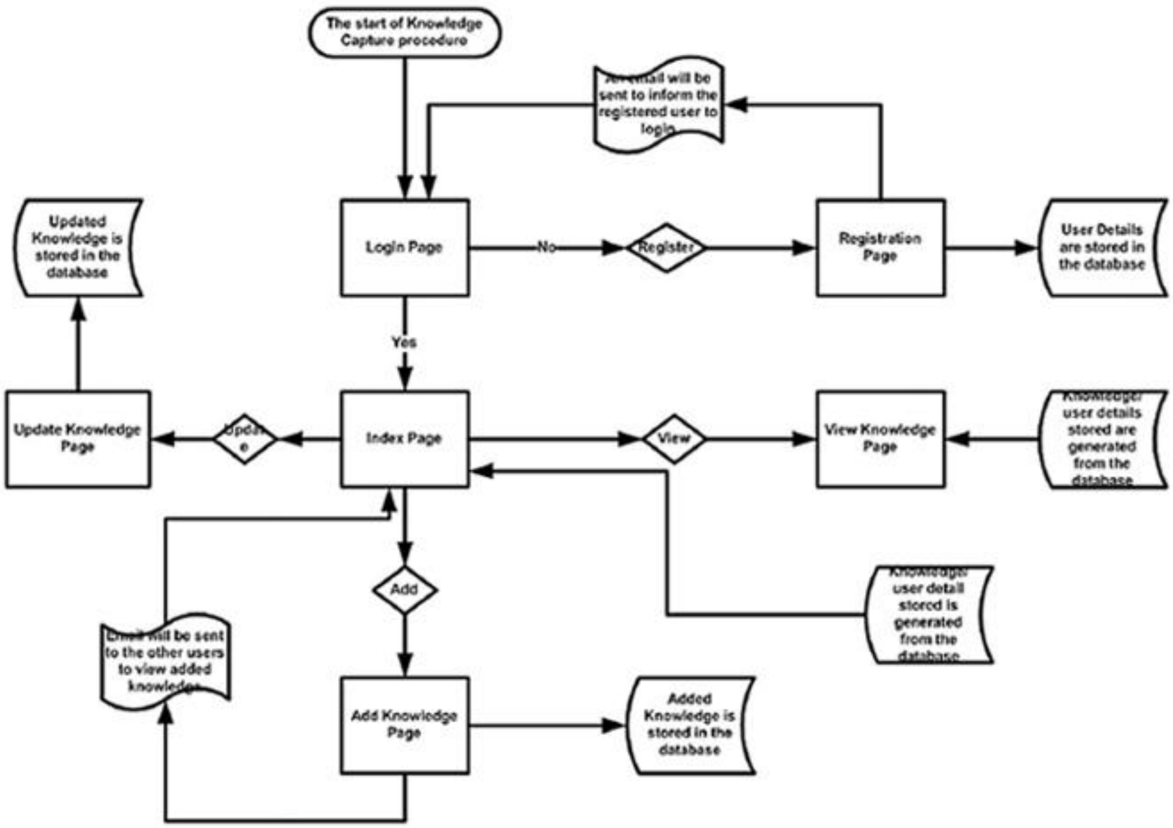


Figure 4.3: Flow chart view of CAPRI.NET approach to knowledge capture and reuse (Udeaja et al. 2008)

Relating more to the research subject, Tserng and Lin (2004) developed a KM concept for general contractors in construction projects (Figure 4.4). This system is based on the activities of project planning and control from the perspective of contractors. Information knowledge gained from a project is categorised and stored as activity units. A knowledge asset contains knowledge of each project saved separately. Therefore, the available knowledge from previous projects can be retrieved by navigating the previous projects knowledge. In this approach, tacit knowledge and some explicit knowledge are considered activities, but some of the information (i.e. project based information) is saved as a non-activity category for the project; therefore, knowledge categorised as activities can be reused in future projects.

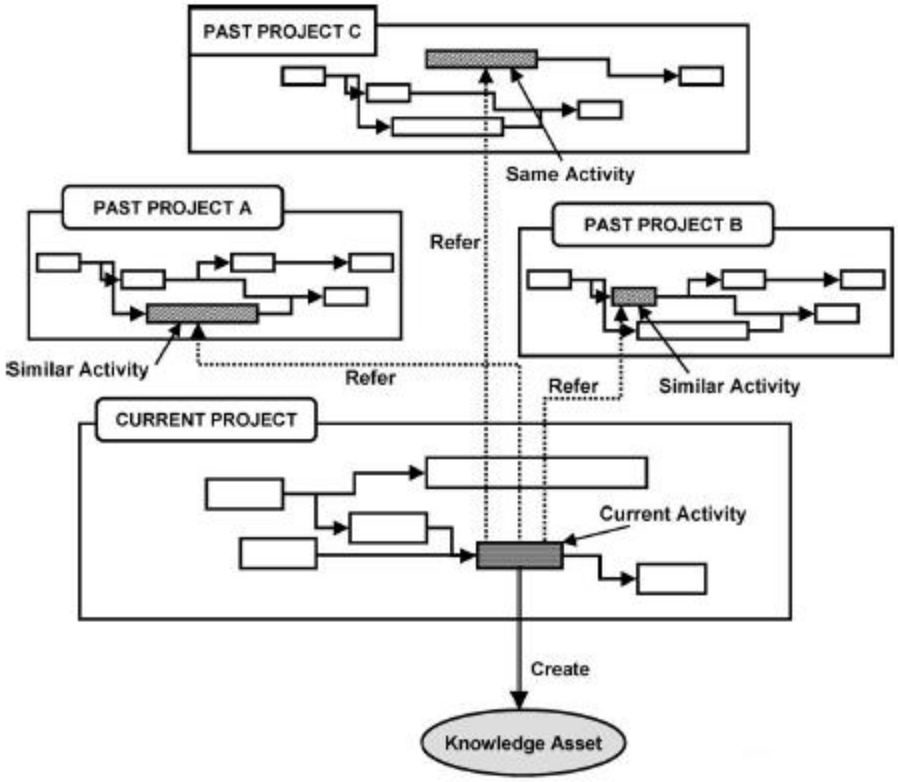
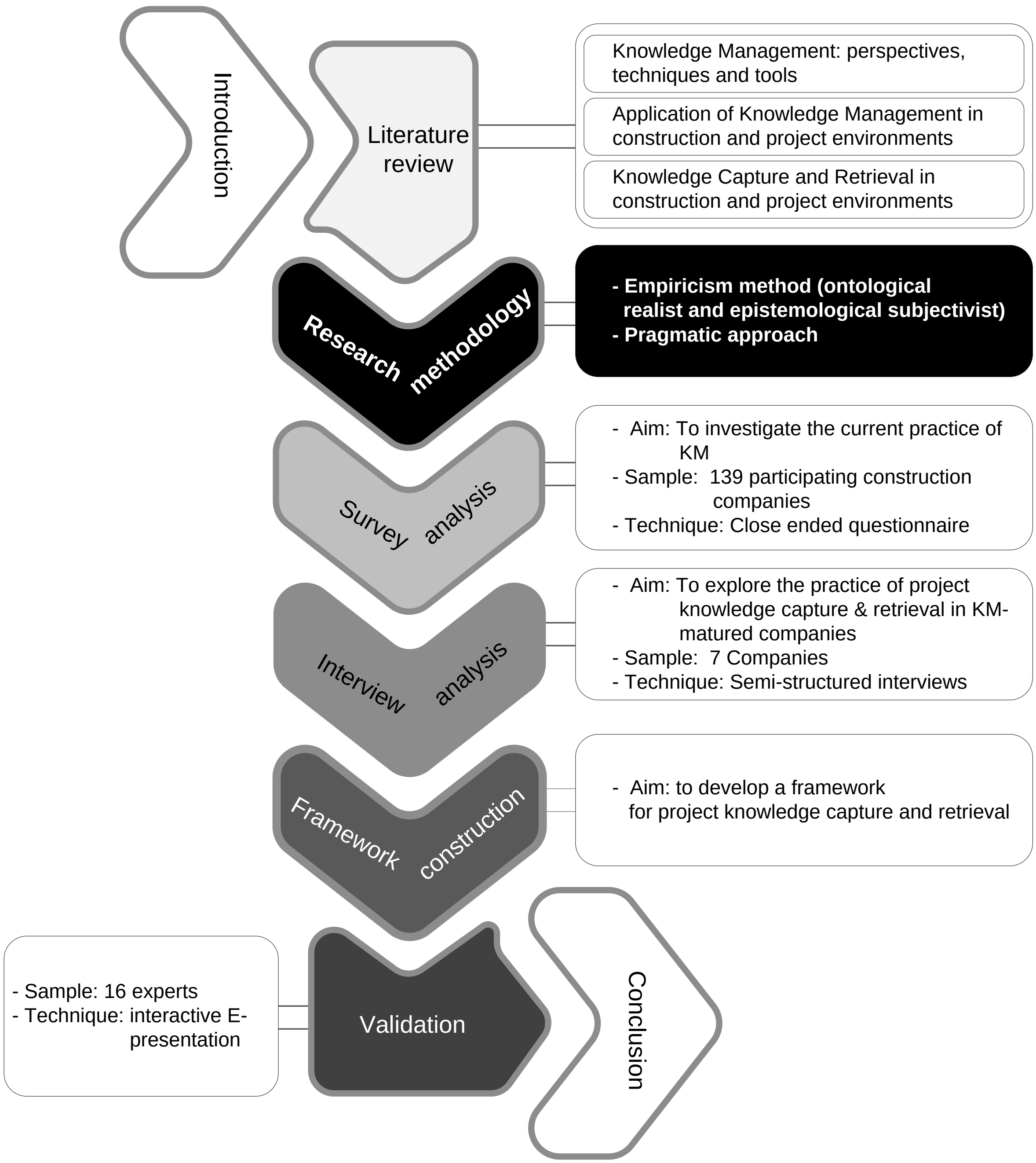


Figure 4.4: The concept of knowledge management for construction projects (Tserng and Lin 2004)

4.13. **Conclusion**

KM consists of four major processes: knowledge creation, capture, sharing, and retrieval & application. The present chapter was designed to present and discuss the literature related to knowledge capture and retrieval in a construction project. During the course of construction projects new knowledge is created. Unless captured this knowledge is often lost. Not all tacit knowledge can be captured, and some tacit knowledge loses its context when codified. There is no agreement on the processes of knowledge capture; however, knowledge capture requires the use of some techniques and tools. In theory, the project review is claimed to be an appropriate and the most popular method for knowledge capture. In addition, the way project knowledge is classified, and how the knowledge base is built, are considered determinants of knowledge capture. The importance of knowledge capture may lead to overload of information. Therefore, capturing knowledge is not enough; distinction should be made between what is important and what is not. Knowledge has to be refined, and appropriate methods and tools should be available to enable project members to retrieve what they want, at the right time, and in a quick and simple way. Search engines and browsing are the major methods for retrieving knowledge. However, browsing is mainly dependant on the knowledge structure and classification. Successful practice of knowledge capture should take into consideration both the hard and soft edges, networks and networking, the management of project knowledge and the management of project teams who possess knowledge.

CHAPTER FIVE: RESEARCH METHODOLOGY



5.1. **Introduction**

Literature shows a lack of consensus regarding the appropriate methodology for use in construction management research (see Betts and Lansley 1993; Runeson 1997; Seymour *et al.* 1997; Seymour *et al.* 1998; and Wing *et al.* 1998). Authors in the construction management field focus on methods and techniques in general, but there is little emphasis given to the related ontological and epistemological perspectives. Many authors limit the combinations between techniques, methods and ontological and epistemological assumptions to two or three. In one respect this is a limited view and has led to less flexible approaches. The next sub-section intends to discuss these points, starting with the research philosophy moving through the research methods, techniques and type. The chapter will then present a summary of the research stages: literature review, survey (current practice), interviews (best practice), framework building, and framework validation.

5.2. **Philosophy: Epistemology and Ontology**

Understanding the philosophy that underlines the ontological and epistemological positions of a research study is necessary as it forms the base for understanding the research methodology. Recognising the different views of ontological and epistemological philosophy can help to get the research work into perspective and ensure that it avoids making unsuitable claims for its results, overestimating what research can achieve by way of truth, certainty, and universality (Thomas 2004).

5.2.1. ***Overview***

To clarify the difference between ontology and epistemology, it should be considered that ontology is "the theory of what there is" (Trigg 2001): it deals with the nature of the phenomenon, what exists, reality and the nature of the world (Flew 1984). On the other hand, epistemology seeks to answer questions about; "how we may come to know, what constitutes knowledge, what relationships exist between the knower and the knowable, and how reality maybe known" (Tuffin 2005). Burrell and Morgan’s (1979) well respected text focusing on sociological paradigms, identified two ontological assumptions; namely realism and nominalism, and two epistemological assumptions; positivism and anti-positivism (subjectivism). Their assumptions reveal that in realism, ontological reality exists independently of human consciousness and cognition, whereas in nominalism reality is simply a product of our minds, a projection of our consciousness and cognition, with no independent status. The epistemology view of positivism (objectivism) suggests that it is possible to observe the empirical world in a natural manner through the accumulation of objective sense data, while in anti-positivism (subjectivism) epistemology there is no natural foundation for knowledge, since all observation is value and theory laden. Ontological and epistemological assumptions are interrelated and it is difficult to think of them separately, because considerations about the state of being usually leads to thoughts about the process by which we are aware of them. When integrating the ontological and epistemological assumptions the base of different research methodologies can be obtained.

5.2.2. *Philosophy of Research in Construction Management*

Any research should be carried out to contribute to the existing knowledge that is related to the discipline, otherwise it is useless. Three methodological paradigms were identified in the construction management research to produce such research; namely, positivist, interpretivist, and combined or pragmatic approach. The positivist paradigm is based on realist ontology and objectivist epistemology, and usually takes the form of deductive research and makes use of quantitative techniques. On the other hand, the interpretivist method is based on nominalist ontology and subjectivist epistemology, and typically takes the form of inductive research and makes use of qualitative techniques. The combined or pragmatic research methodology means both the positivist and interpretivist paradigms are applied in one piece of research.

Betts and Lansley (1993) investigated studies that were published in the Journal of Construction Management and Economics during its first ten years. It was found that discipline was lacking in its guidance from and contribution to theory. It was suggested that such a result may be partly influenced by the determination of an inappropriate research methodology. The question arises here; is there an appropriate methodology that could generate the best results for construction management research? This has been a point of debate in the construction management research, as well as in social science in general. While some argue that only quantitative approaches should be applied to the study of social sciences, others have insisted that only qualitative approaches were appropriate (Punch 2005). Construction management research commonly uses different techniques. Some of the functions are based on, or can be explained by various scientific theories, some of the techniques have a theoretical background (Runeson 1997). Seymour *et al.* (1997) believed that the researchers should pay attention to the interpretivist approach, as it was clearly stated: "Our suggested alternative is to concentrate upon the interpretative methods that researchers and managers use to make sense of the world. It is our belief that such an account better reflects the realities of construction management as a practice" (Seymour *et al.* 1997). This means that if any research related to construction management was conducted using interpretive methods, then it would generate more valuable results. Seymour *et al.* may have built this principle because of the assumption that in our discipline the 'objects of study' are people, whereas in many significant studies in construction management the object is data, as was clearly explained by Wing *et al*. (1998).

In contrast, Runeson (1997) argued that positivism provides the best insurance against bad research in construction management studies. Runeson asserted that positivist methods of theory building have been sufficiently modified to deal with the special demands of management research. However, adopting Runeson's approach would lead to the loss of important knowledge. There are certain categories of problems that cannot be solved by applying positivist methods alone. For example, if a researcher is seeking to know the processes of knowledge capture that were used in an organisation, these processes could not be identified without observing them or without an explanation of the people involved, and it would not be possible to know what parts of the process are not working perfectly without the views of the experts concerned. The positivist approach may play an important role in reporting how regularly the processes are carried out and who the people involved are, but such an approach can never reflect the process to the extent that the interpretivist approach would. Of course, knowing the process of knowledge capture may lead to the building of theory (body of knowledge).

It is not common in construction management research to mention the ontology and epistemology of the research; most researchers are content to simply indicate whether it is a positivist or interpretivist approach. The research studies that have emphasised this theme were limited to two choices: either ontological realist with an epistemological objectivist approach (positivist paradigm); or ontological nominalist with epistemological subjectivist (interpretivist paradigm). That is perhaps because most authors believe that ontological realist research cannot be epistemological subjectivist at the same time. This belief could be caused by the restrictive definitions of the ontological and epistemological assumptions that were identified by Burrell and Morgan (1979). However, the limitations presented in the previous research do not match the research methodology in practice.

Table 5.1: Research philosophy paradigms Johnson et al. (1984)

Paradigm	Ontology	Epistemology
Substantialism	Realist	Objectivist
Subjectivism (idealism)	Nominalist	Subjectivist
Empiricism	Realist	Subjectivist
Rationalism	Nominalist	Objectivist

There are many research studies that have been conducted by integrating ontological realist and epistemological subjectivist positions. Johnson *et al.* (1984) identified all the possible ways of integrating ontology and epistemology assumptions. For instance it was affirmed that when objectivism and subjectivism are combined with the two major alternative ontological positions, realism and nominalism, a four-way classification scheme is generated. Substantialism combines a realist ontology with objectivist epistemology, subjectivism (idealism) combines a nominalist ontology with a subjectivist epistemology, Empiricism combines a realist ontology with a subjectivist epistemology, and rationalism combines nominalist ontology with an objectivist epistemology (Table 5.1). Therefore it can be seen that Johnson's classification is more detailed and accurate in presenting possible ontological and epistemological combinations. However, when looking at the research in our field it would be found that lots of researchers used empiricism, substantialism, and idealism as the basis of their research methodology. There may be no obstacle to applying the appropriate methodology, but there is a problem with researchers presenting that methodology in their research. That is very obvious when researchers see respondents as the best instrument for knowing the facts. For example, if a researcher seeks to discover the tools and strategies of KM in a company, then the researcher would request a person in authority to complete a questionnaire: in this case the research regards the knowledge that is given by the respondent as reality. That is because the respondent is not giving his opinion; instead, the respondent is reporting actual practice. Obviously, the respondent in this case is conveying facts. Despite that, the researcher is taking the reality from people; the reality here is not a product of people's minds: this way of dealing with fact combines realism ontology with subjectivism epistemology.

5.2.3. *Research Philosophy*

This research is ontologically realist and epistemologically subjectivist, and this combination forms empiricism research. Empiricism is appropriate since the study is building a theory based on the experience/good practice.

Ontologically the research views that the phenomena (i.e. processes of capturing and retrieving project knowledge) as an existing fact and knowledge comes from experience. In terms of epistemology, and how we obtain the research data , collecting the data of this phenomenon through the people actually involved in the process is considered appropriate (subjective). The data regarding current practice (Stage 2: survey) and good practice (stage 3: interviews) is collected from experts. Collecting the data directly from its sources (documents and observing the processes) may take a very long time, and there is a risk that organisations may not allow access to the data in order for it to be collected. Furthermore, assuming that the research is epistemologically objectivist; does this mean more accurate data would be obtained? Of course not, because collecting data directly from the documents and processes may not generate much knowledge, as it is very difficult to understand the processes directly without hearing from the people experiencing it. Furthermore, the culture, organisational factors and strategic decisions behind the practice could be difficult to identify without having the people involved speak about it.

5.3. **Research Methods and Techniques**

While some researchers have expressed the view that only quantitative approaches should be used to study social sciences, others have been emphatic that only qualitative approaches are appropriate (Punch 2005). It is believed that the researcher should choose the method that suits the nature of the research, and it is not necessary to follow just one research paradigm in a dogmatic fashion. It is considered that the perception of methodological pluralism that was suggested by Wing *et al.* (1998) is the most appropriate of the approaches available. The research method used should be appropriate to the objectives of the research and the needs of the particular stage reached, and hence the type of knowledge to be discovered. Different approaches can serve different functions in the knowledge discovery process (Wing *et al.* 1998).

Here the research technique refers to the method of collecting and analysing the research data; these methods can be quantitative or qualitative methods. The research problem, questions, and hypothesis are the elements that can guide the researcher to the appropriate research technique and methodology. Because of the association between technique and methodology, many researchers stick to either the positivist or interpretivist methodologies and quantitative or qualitative techniques (Bryman 1984). Table 5.2 shows the two extremes of research paradigms. It should be known that it is not necessary for a positivist methodology to use a quantitative technique and, equally, an interpretivist research approach should always use the qualitative technique. There may be some integration between the two extremes: positivists may use qualitative techniques, and interpretist may use quantitative techniques. Qualitative and quantitative research should never be thought of as opposites but rather as the right tools for performing two different kinds of job (Grainger 1999).

Table 5.2: The characteristics of the two research paradigms

Variable	Extreme [1] Systematic Scientific	Extreme [2] Ethnographic
Ontology	Realist	Nominalist
Epistemology	Objectivist	Subjectivist
Methodology	Positivist	Interpretivist
Technique	Quantitative	Qualitative

The situation with research techniques today is less ‘quantitative versus qualitative’ (Table 5.3), and more focused on how research practices lies somewhere on a continuum between the two (Creswell 2003). A research project may utilise both techniques, and what is appropriate at one stage of the research maybe not appropriate at another. Both quantitative and qualitative techniques can also be combined in one stage as "many studies mix and match statistical sampling techniques, qualitative data collection, and statistical analysis from the qualitative and quantitative traditions" (Bamberger 2000). Qualitative techniques of data collection may be very helpful at the earlier stage of most research as it widens the knowledge of the researcher, while quantitative technique maybe more appropriate during the later stage of some research as the researcher is more confident with the area that has been investigated, so for any work it would be necessary to design an accurate format of the all the aspects required.

Table 5.3 Features of qualitative and quantitative research techniques - Adapted from Park and Mauch (2003)

Qualitative	Quantitative
Aims to provide full and accurate descriptions of phenomena in all their complexity	Aims to reveal or establish cause-and-effect relationships in or among experiences or occurrences
Offers particular value in the process of generating new concepts or theories	Focuses more on the testing of existing theories or generalisations
Relies on deduction	Relies on induction
Attempts to discover and show the assumptions that underlie events or actions	Focuses more on testing the operation of assumptions
Deals mainly with statements and questions couched in words and with details of settings and events	Deals chiefly with amounts and numbers as primary data
Tends to deal with small samples and uniqueness	Encourages studying large samples and prizes representativeness
Depends on thoroughness and depth of reporting to demonstrate significance	Utilizes statistical analysis, particularly employing probabilities, to demonstrate significance

The study will use both quantitative and qualitative techniques, but in the main the research will take the form of qualitative research. At the beginning of this research the qualitative technique was used in the analysis of literature review and took the form of inductive method. In the second stage (Survey), and fifth stage (framework validation) the quantitative technique was used to collect and analyse data. In the stage of exploring the processes of capturing and retrieving knowledge in a small number of case studies (stage 4), the data will be collected by interviewing the people participating in these processes (qualitative technique). This will then be followed by qualitative analysis and by use of the inductive method. The inductive-qualitative method was already used when the researcher was looking for an area of interest (stage 1), but after identifying that area, the research switched to deductive-qualitative method (stage 3 & 5) in order to establish the case.

5.4. **Research type**

Exploratory, testing-out and problem solving are the types of research identified in the literature (Phillips and Pugh 2000; and Walliman 2005). Testing-out is a basic form of research and aims to evaluate the validity of a previous generalisation. Exploratory research is conducted to tackle a new and not previously identified problem, issue or topic, while, in contrast problem solving research tackles an already identified problem and seeks to find a solution for it. Walliman (2005) affirmed that exploratory and problem solving research hold the greater risks, as they require more expertise and experiences on the part of the researcher and demand the enthusiastic support of the supervisor. Nevertheless, PhD students may start without experiences in the processes of the research methods, although it is not difficult to gain that experience during the course of the study, and that is a major role of the PhD study. Kumar (1996) identified another way of classifying the research: he did so from the perspective of the separating it into two broad categories; pure research and applied research. Pure research is conducted without a practical end, while applied research involves a practical investigation.

This research is exploratory; it has been involved in the processes of identifying a real problem. The aim of the research is to explore new concepts instead of testing existing theory. The final product of the research (the framework) cannot be tested in practice in the short term, as the tangible results require the application of the framework at least on several projects, and that could take tens of months. However, the framework is assessed by a number of experts, and this could be considered practical research.

5.5. **Research design**

The research was designed to address the problem identified in 1.4 and achieve the objectives mentioned in 1.6. It was considered essential to obtain a complete understanding of the study by setting out the various elements in a logical sequence, so as to avoid misunderstanding about any point in the research. The problem, aims, objectives and questions of the research were therefore stated at the outset. In order to achieve the aim of the research, it was decided to conduct five stages of study. The first was a comprehensive review of the relevant literature, starting with an overview of KM, then shedding light on theories of KM in general and knowledge capture and retrieval in construction and project-based environments. The second stage was to conduct a survey of current practice, to test the problem and identify the techniques and tools available within the industry. The third stage was to explore the best practice of knowledge capture and retrieval by interviewing experts from carefully selected companies. The fourth stage was to build a reliable framework based on the results obtained from the second and third stages. The last stage was to ensure the validity of the purposed framework.

Figure 5.1: Stages of the research

5.5.1. ***Literature review***

After the problem has been identified, the basic concern throughout the review stage was to understand the concept of knowledge capture and retrieval, and to explore the available approaches, therefore identifying the broader parameters that are likely to feed and affect the primary data collection in stages two and three. The literature divided into three sub-stages: studying the literature on KM in general management, KM in construction and project based environments, and knowledge capture and retrieval in construction and project environments. The literature set out to address the following points:

- Identify and describe the major approaches of KM and knowledge capture and retrieval.
- Provide a summary of techniques and tools of knowledge capture and retrieval
- Present and discuss the most relevant studies.
- Demonstrate the functionality of construction projects and conceptualising the effect of construction project uniqueness on the application of knowledge capture and retrieval.

5.5.2. ***Pilot Study***

It was necessary to ensure that the questionnaire for the main survey (Stage 2) was reliable. For this reason, a quality control process was undertaken, starting by ensuring that each objective and hypothesis of this stage had questions corresponding to it, passing through in-depth review by the author to examine the level of clarity. Subsequently, a pilot study was carried out to test whether the questionnaire was intelligible, easy to answer, unambiguous etc., and by obtaining feedback from respondents, there was an opportunity for improving the questionnaire, filling in gaps and determining the time required for, and ease of, completing the exercise (Fellows and Liu 1997).

A provisional version of the questionnaire was then developed to cover all aspects needed to accomplish the purpose of the survey. The pilot study had two objectives: (1) examining the questionnaire design (to make it reliable before launching the main (large-scale) survey), and (2) gaining an initial impression of the KM practices of industry.

A pilot study provides a trial run for the questionnaire (Naoum 1998). All questionnaires should initially be completed by a small sample of respondents, referred to as piloting, for the reasons given above. Bell (1996) defined a pilot study as for the purpose of "getting the bugs out of the instrument". These bugs may not be apparent to the person conducting the survey; therefore the questionnaire should be tested, i.e. completed and commented on by a number of the survey respondents. Apart from the feedback on the questionnaire design by respondents, the responses may also give an indication of how effective the questionnaire is. Khan and Cannell (1957) note five primary reasons for inadequate response:

- Partial responses
- Non-responses
- Irrelevant responses
- Inaccurate responses
- Verbalised response problem, where the respondent gives a reason for not answering.

In addition, the discussion of the questionnaire with a supervisor and other researchers is a useful supplement to the piloting, as it provides a research-oriented view of the questions, the components and assembly of the questionnaire and probable approaches to the analysis of responses (Fellows and Liu 1997). However, the feedback that is given by supervisors and researchers is limited to the questionnaire design, whereas the sample of respondents may show initial awareness of the investigated subject.

In order to get optimum use of the pilot study, it was decided to use Bell’s (1996) recommended questions for respondents:

- How long did it take you to complete?
- Were the instructions clear?
- Were any of the questions unclear or ambiguous? If so, will you say which and why?
- Did you object to answering any of the questions?
- In your opinion, has any major topic been omitted?
- Was the layout of the questionnaire clear/attractive?
- Any comments?

The pilot study used a closed-ended postal questionnaire, and was distributed to 40 firms. However, only seven responses were received; thus, it was necessary to find out the reasons behind this low rate of response. Meetings were therefore arranged with two experts to give live feedback, and later meetings were arranged with three research colleagues to assess the questionnaire design. The feedback gained from these five meetings, in addition to the respondents’ answers to the questionnaire, were the basis for improving the questionnaire design. As a result, modifications to the questionnaire took place and an improved version was created for use in the main survey (see the pilot and final version of the questionnaire in appendices 1 and 2). The major affects of the pilot study were:

- Decreasing the number of pages from four to two pages by removing the least important questions.
- Replacing some technical terms with common synonyms
- Changing the classification of business from ‘architect, consultant engineer, contractor, surveyor, and project manager’ to ‘contractors and consultancy’.
- Restructuring some questions to avoid ambiguity.

5.5.3. ***Survey: Current Practice***

Due to of the lack of reliable large scale studies on KM practice, and because more needs to be known about some elements related to KM practice before they can be used reliably in the subsequent tasks, there was a need for this survey to be conducted. The aim of this stage is to report on the current practice of KM and project review in the UK construction industry (the first objective of the research – section 1.6). In addition, this was a good opportunity to identify companies at advanced levels of KM, so they can be contacted to participate in the third stage of the research, which will investigate the best practice of knowledge capture and retrieval.

In order to achieve the objective of this stage, the following questions are addressed:

- What is the level of KM in current practice?
- What are the KM techniques and tools available in the industry?
- How effective are the available KM techniques and tools?
- What is the current practice of project review?

The survey used a close-ended questionnaire, which was sent by post and email to 1200 randomly selected contractors and consultancies. With 277 being returned as wrong addresses, the entire response for both the postal questionnaire and the e-questionnaire was 139, giving a 15% rate of response. However, many studies of KM have obtained low response rates (Table 5.4), and this could be because KM is a new topic. The response rate does not necessarily reflect how accurate and reliable the results of the survey are. Therefore a high response rate does not necessarily:

- compensate for a faulty questionnaire or weak data analysis; (Langer 2003),
- obviate non-response bias; (Barclay *et al.* 2002)
- or guarantee high quality responses (DeLeeuw and Hox 1988)

In addition, a low response rate does not necessarily:

- entail non-response error; (Dillman 1991),
- affect the validity of the data collected (Templeton *et al.* 1997),
- translate into response bias (Loges and Jung 2001),
- mean that there is response bias; (Vitell 2001),
- mean that the results are biased; (Lahaut *et al.* 2003),

- mean results cannot be generalized to the target population (Watts *et al.* 2003).

Table 5.4: Examples of the response rate of published KM related research

Paper Title	Response rate	Reference
Workforce agility: the new employee strategy for the knowledge economy	**3.6%**	(Breu 2002)
Use of e-books in an academic and research environment: a case study from the Indian Institute of Science	**4%**	(Anuradha and Usha 2006)
Knowledge Harvesting from International Joint Ventures	**6.4%**	(Terese *et al.* 2004)
What is the value of intellectual capital?	**6.6 %**	(Coakes and Bradburn 2005)
Managing and leveraging knowledge for organisational advantage	**6.6%**	(Coakes *et al.* 2004)
Local government organisation on its journey to becoming a learning organisation	**10%**	(Sharma 2005)
State-of-Practice of Knowledge Management Systems	**11.9%**	(Maier 2002)
Knowledge connections as a pointer for models in e-business: some evidence from Australia	**12%**	(Martin and Zadeh 2003)
Bridging the implementation gaps in the knowledge management system for enhancing corporate performance	**13.6%**	(Lin and Tseng 2005)
Knowledge management obstacles in Australia	**15.1%**	(Zyngier 2002)
Knowledge management research & practice: visions and directions	**15.8%**	(Edwards *et al.* 2003)
CRM and customer-centric knowledge management	**16.9%**	(Stefanou 2003)
An Integrative Framework for Knowledge Management Effectiveness	**19%**	(Khalifa *et al.* 2001)

- ***The structure of the questionnaire***

The questionnaire asks the respondents to answer the questions based on their organisation's practices. In order to present the questionnaire in a systematic way, it was decided to divide the questions into four sections:

Section One: Concerned with the organisation's experience. It only includes two questions which are about the specialisations and size of the organisation.

Section Two: Deals with KM practice in the organisation, including the level of KM practice, the techniques and IT tools that are available in the organisation.

Section Three: Considers the practice of project review. It includes questions about its characteristics, conducting method and time, the parties involved and its final format.

- ***Considerable points***

With the purpose of increasing the rate of response, several points were considered in the questionnaire design — these are:

- Providing a covering letter (see Appendix 2) to do the following:
    - Identify the type of research, sponsoring organisation and the researcher's name.
    - Explain the purpose and the benefits of the study.
    - Encourage the participants to fill in the questionnaire using tactful language.
    - Inform the participants that their name, department, or company name will not appear in the research.
- Structuring the questionnaire in a smart and attractive design.
- Presenting the questionnaire in a multi-options format with no open questions.
- Keeping the questionnaire as short as possible, but comprehensive enough, so that it could be completed within 7 to 13 minutes.
- Using original terminologies that relate to KM key references to avoid misunderstanding of any part of the questionnaire.
- Use of individual coding to check respondents and non-respondents, and to form the second administration.

Apart from the simple style and structure of the questionnaire, another three points were considered in the piloting to guarantee a fast and high level of response:

- A reply envelope was provided with each letter;
- A stamp was affixed to each reply envelope;
- Academic address labels were used on the envelopes.

In order to explore if there is evidence for the research hypotheses, it was necessary to test the null hypotheses. An accepted null hypothesis means there is no evidence for the research hypothesis, and vice versa.

5.5.4. ***Interviews: Best Practice***

The aim of the interviews is to employ the best practice of knowledge capture and retrieval. Interviews are semi-structured, one-to-one communication, and face to face interaction (sections 7.4 -7.6) and the interview carried out for this study relates to three major themes: knowledge capture, knowledge retrieval, and project review.

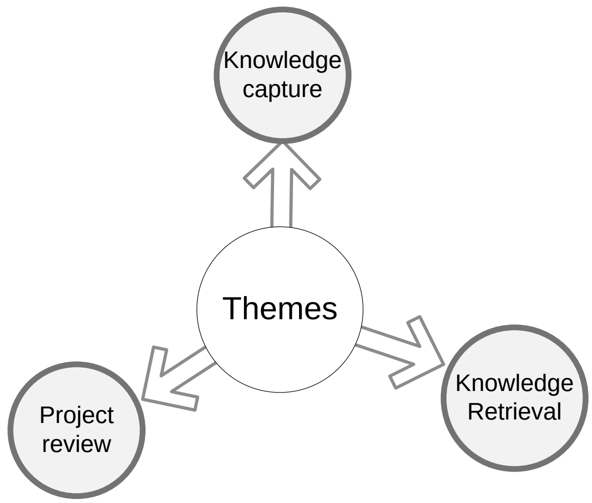


Figure 5.2: Themes of the interviews

To enrich the study and acquire the most effective results possible, it was decided to interview three types of participants: construction companies, a project-based company, and an idealistic view representative organisation (an educational institute). The total number of participants comprised seven organisations; five construction companies, one project-based company, and one KM leading consultant. Strict criteria for selecting the appropriate companies and the right experts in those selected companies were identified. For further details about the reasons behinds selecting the three categories, and about the selection criteria please refer to sections (7.10 - 7.14).

At the analytical stage, the themes were changed to match the logic of the collected data. Four major themes were identified, and the project review became part of the knowledge capture theme.

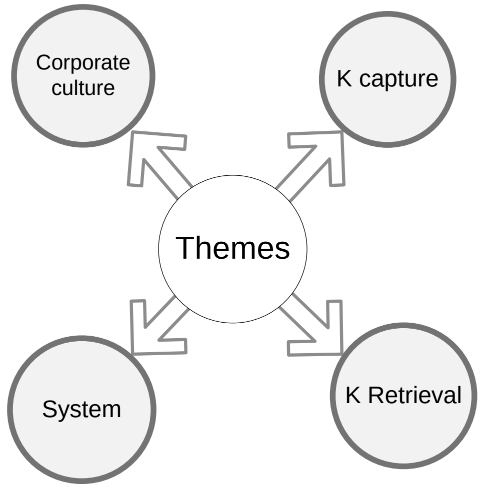


Figure 5.3 Themes of the interview analysis

To avoid bias, detailed criteria were designed for the interview analysis; these were based on a number of previous studies in the field of qualitative analysis and they compromise three major processes, as shown in Figure 5.4. Further details and explanations of each process are available in sections (7.177.19).

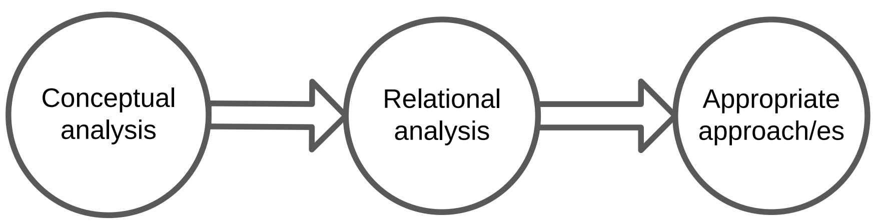


Figure 5.4: Processes of interview analysis

5.5.5. ***Framework Construction***

Building the framework is based on the results obtained from the survey analysis and interview analysis. The building processes commenced with the presentation of the conclusion for each and every theme; this conclusion was then linked with the results obtained from the literature. Then the whole parts were integrated to form the framework. The framework is presented in three levels: strategic, tactical, and operational.

5.5.6. *Validation of the Framework*

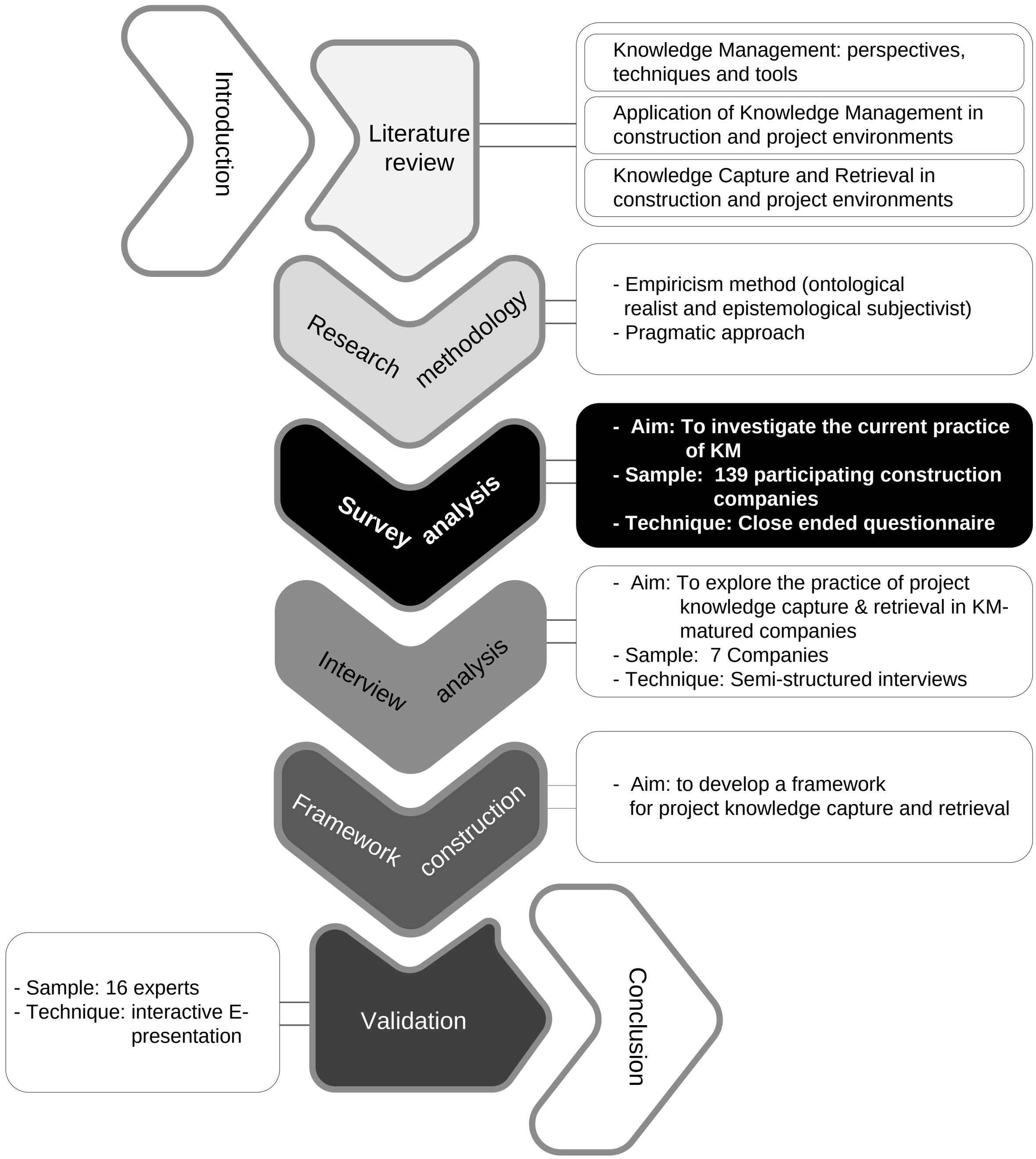
For the purposes of validation, the framework was summarised in three diagrams and supplied with detailed electronic interactive presentation. It was presented on an online page with the validation questionnaire. The questionnaire was designed to determine the applicability and efficiency of knowledge capture, knowledge retrieval, knowledge structure, architecture of knowledge base and the entire framework. It is based on a scale of 1 to 5. Sixteen academics and practitioners participated in the validation stage; the results were quantitatively analysed and the framework validity was then tested.

5.6. **Summary**

This chapter explored the philosophy, methods, techniques, and types of research. It also explained the approaches used in this study. The research uses empiricism philosophy: realist ontology and subjectivist epistemology, pragmatic method; it is mostly qualitative and, in terms of research type, it is considered to be exploratory research.

Five major stages were designed to achieve the aim and objective of the research: literature review, survey (current practice), interviews (best practice), framework building and framework validation.

CHAPTER SIX: SURVEY ANALYSIS: PRACTICE OF KNOWLEDGE MANAGEMENT IN THE UK CONSTRUCTION INDUSTRY



6.1. **Introduction**

A thorough study of related literature was conducted to understand the current practice of Knowledge Management (KM) in the UK construction industry; this found a shortage of available information, or extensive surveys, relating to the industry in question. Thus, it was decided to conduct a survey using the questionnaire method to fill this gap and discover the missing information. The questionnaire aims to achieve the first aim of the research (see 1.6) by providing an answer to the first research question (see 1.7). The main question addressed in this chapter is: what is the current practice of KM in the UK construction industry? Three major areas were investigated to answer this question: 1) the maturity level of KM in the industry; 2) the availability (and popularity), and effectiveness of KM techniques and IT tools; and 3) the practice of project review (PR).

This chapter provides information about the participating companies and then presents an analysis of the collected data. The analysis is divided into two major sections: 1) KM practices; 2) PR practices. Finally the major question is broken down into a number of questions and hypotheses, with the last section of this chapter seeking to provide answers to those questions and hypotheses by either summarising the answers from the analysis or using appropriate statistical tests.

6.2. **Distribution and responses**

The questionnaire was sent by post to 800 construction organisations; 103 responses were received and 94 questionnaires were returned, this gives a response rate of 14.6 %. An electronic questionnaire was then sent to 400 construction organisations by e-mail, aiming to increase the number of respondents; 183 of the addresses were incorrect and 36 responses were received, giving a response rate for the e-survey of 16.6%.

In total, the questionnaire was sent to 1200 construction organisations; of these 277 were returned as wrongly addressed. The entire response rate for both postal questionnaire and e-questionnaire was 139 representing a 15% response rate overall. Table 6.1 shows the distribution of the questionnaire and the response rate.

Table 6.1: Questionnaire distribution and response rate

<table>
<tr><th colspan="2"></th><th colspan="4">Post</th><th colspan="4">E-mail</th></tr>
<tr><td colspan="2"></td><td colspan="2">Top companies</td><td colspan="2">Industry</td><td colspan="2">Top companies</td><td colspan="2">Industry</td></tr>
<tr><td colspan="2"></td><td>Contractors</td><td>Consultants</td><td>Contractors</td><td>Consultants</td><td>Contractors</td><td>Consultants</td><td>Contractors</td><td>Consultants</td></tr>
<tr><td rowspan="3">Sent</td><td></td><td>140</td><td>160</td><td>300</td><td>200</td><td>58</td><td>87</td><td>120</td><td>135</td></tr>
<tr><td rowspan="2">Total</td><td colspan="4">800</td><td colspan="4">400</td></tr>
<tr><td colspan="8">1200</td></tr>
<tr><td rowspan="2">Response</td><td></td><td colspan="4">103</td><td colspan="4">36</td></tr>
<tr><td>Total</td><td colspan="8">139</td></tr>
<tr><td rowspan="2">Return</td><td></td><td colspan="4">94</td><td colspan="4">183</td></tr>
<tr><td>Total</td><td colspan="8">277</td></tr>
<tr><td colspan="2" rowspan="2">Actual response</td><td colspan="4">14.6%</td><td colspan="4">16.6</td></tr>
<tr><td colspan="8">15%</td></tr>
</table>

6.3. **Sampling**

The size of the sample should be large enough to avoid failure to detect significant findings as a result of the sample size being too small. Using Cochran's (1963) formula with a confidence level of 94%, the sample size can be calculated. The total number of UK contractors and consultancies with eight employees and above was reported at 32693 companies in 2006 according to the department of trade and industry (DTI 2006).

$$n = \frac{n_0}{1 + \frac{(n_0 - 1)}{N}}$$

$$n_0 = \frac{Z^2\,pq}{e^2}$$

$$n_0 = \frac{1.88^2 * 0.5 * 0.5}{0.1^2} = 88$$

$$n = \frac{88}{1 + \frac{(88 - 1)}{32693}} = 78\ Companies$$

Where: n: sample size
N: population size
Z: the critical value for the confidence level (1.88 for 94% confidence level)
e: the desired level of precision
p: the proportion of population elements that belong to the defined class
q: equals 1- p.

However, a large sample does not necessarily guarantee easy distinction between statistical significance and commonly determined important findings. Authors generally suggest a minimum of 30 participants per major groups in a sample to measure breadth of opinion and knowledge. With a strong treatment or low within-group variability, groups as small as 10 can be compared (Gliner and Morgan 2000). In this study, each major group consists of more than 60 participants and the majority of the sub-groups include more than 30 participants; those groups with fewer than 30 participants were found to have low variation, and were not included in the research hypothesis and questions.

6.4. **Reliability**

In any study there will be some amount of error, some of which can be classified as either random error or measurement error. Selecting a larger scale can minimise random error as statistics can be used to either reject or accept null hypotheses. Measurement error, in contrast, deals with the accuracy of the instrument's performance (Litwin 1995). This can be tested using two types of reliability scale: test-retest reliability and internal consistency (Pallant 2001). In this study there is no need to test the reliability because there are never two or more questions testing the same hypothesis. However, other factors pertaining to reliability have been considered; i.e. standardisation, to ensure that every participant is asked precisely the same question in same way (Sapsford 1999). In addition the rating scale was reliable in that it gave respondents the option of an average point.

6.5. **Validity**

Validity refers to how well the measuring instrument measures what it sets out to measure (Litwin 1995). However, it is important to consider: "One validates, not a test, but an interpretation of data arising from a specified procedure" (Cronbach 1971: p. 477). A measuring instrument could be valid for one purpose but not for another, therefore validity here should consider any instrument in relation to the purpose of the current phenomena.

Five types of validity for consideration can be identified from existing literature: predictive validity, concurrent validity, face, content validity and construct validity. The first two of which can be considered together as criterion validity (Feigl 1956; Walizer and Wienir 1978). Deploying the right types of validity depends on the measuring instruments the researcher is using. Face validity can be established by having experts examine the questionnaire and check whether the questions assess what they are designed to asses (Light *et al.* 1990). Content validity is when a test (questionnaire) accurately represents the relevant content domain and excludes content outside that domain. This could simply be achieved by judging the questionnaire items as within or outside of the domain (Rudert 1993). Face validity and content validity were implemented in this research prior to and during the pilot study and resulted in changing some terms, and restyling and rewriting some questions in addition to removing a number of questions. Refer to section (5.5.2) for further details.

6.6. **Group Analysis**

The questionnaire was sent to two major groups: (1) top companies and (2) randomly selected companies (referred to in tables and figures as 'Industry' to signify overall representativeness). Four lists of top contractors and top consultants (Building Magazine July 2005; July 2006; October 2005; October 2006) were used to identify and target top companies, whilst other construction companies were randomly selected from the yellow pages. The two major groups include sub-groups of contractors and consultants from small, medium, and large sized organisations. The motive behind the studying of various characteristics of construction organisations was to:

- Discover if there is any variation between the answers from the different groups.
- Investigate if there is a particular group that is performing better than the others; this would then draw more attention at the next stage, which aims to explore best practice in highly mature cases.

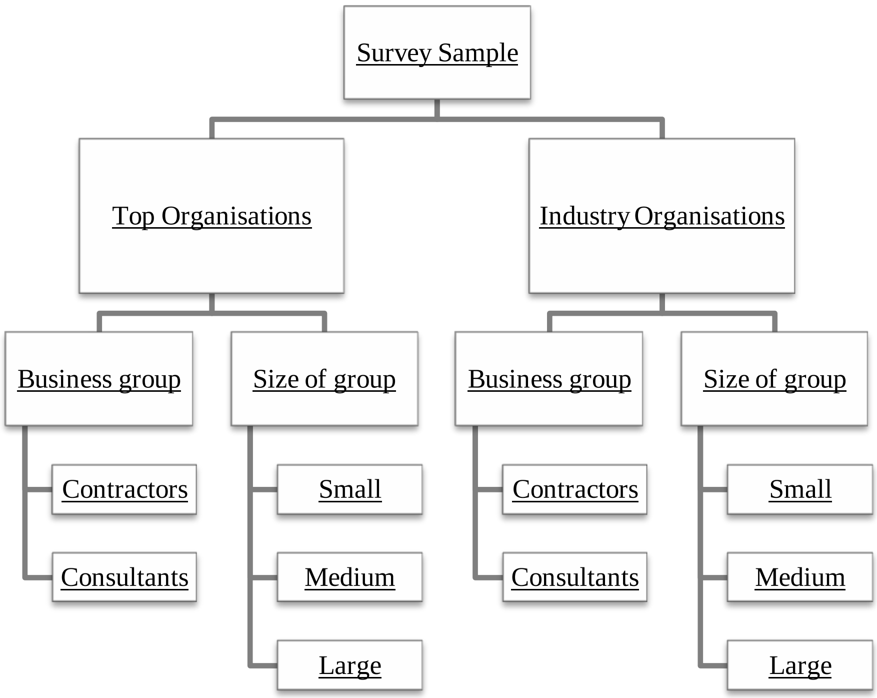


Figure 6.2: Groups participating in the survey

The following sub-sections are intended to explain and analyse the role and participation of each group involved in the survey.

6.6.1. ***Main groups***

Table 6.3 illustrates the participation level from both the industry (randomly selected companies) and the top companies. The total number of respondents participating in this survey was 139. 61 of them are top companies and the remaining 78 participants were randomly selected to represent the industry.

Table 6.3: Participation frequency of the main groups

Valid	139		Frequency	%	Valid %	Cumulative %
Missing	0					
Group		Top Companies	61	43.9	43.9	43.9
		Industry	78	56.1	56.1	100
Total			139	100	100	

As shown in Figure 6.4 the top companies participating are fewer in number than the randomly selected companies. This is because the distribution of the questionnaire to random companies was almost double that to the top companies.

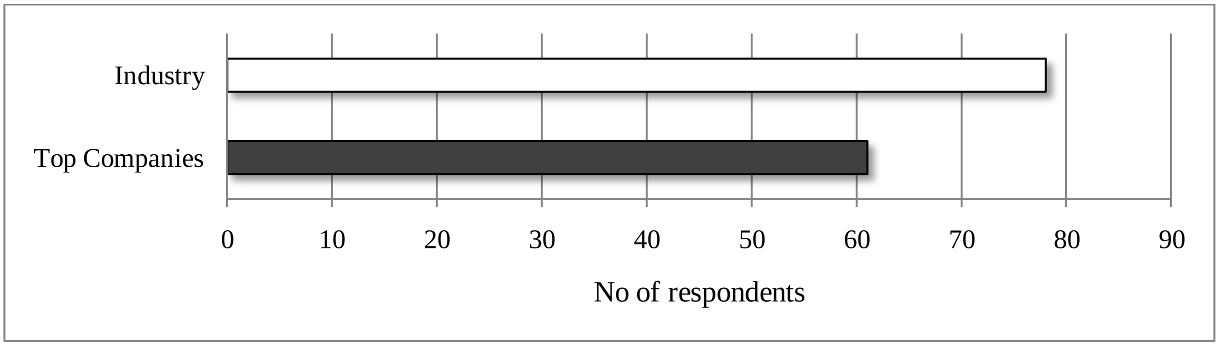


Figure 6.2: Participation frequency of main groups

6.6.2. ***Business-based groups***

Table 6.4 provides the total frequency of participating contractors and consultants. The respondent was asked to select his/her organisation business in the case of construction projects. While the total number of participating contractors was 61, participating consultants were 78.

Table 6.4: Participation frequency of the business groups

Valid	**139**		**Business**	
Missing	0		**Contractors**	**Consultants**
Group		**Top Companies**	25	36
		Industry	36	42
Total			62	78

Figure 6.3 indicates the entire percentage of the contractors and consultants. It can be seen that the difference between participating contractors and consultants is less than an eighth.

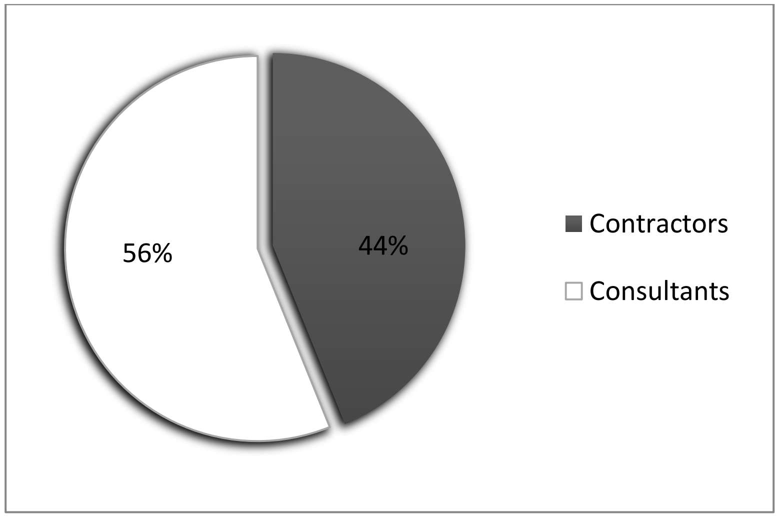


Figure 6.3: Participation percentage of the business groups

The number of participating consultants is higher than the contractors for both top companies and industry. As shown in Figure 6.4, the number of participating consultants from the industry group covers 42 companies, while the number of participating consultants from the top companies was 36. On the other hand, 36 of the participating contractors are from the industry, whereas, the remaining 25 contractors were from top companies.

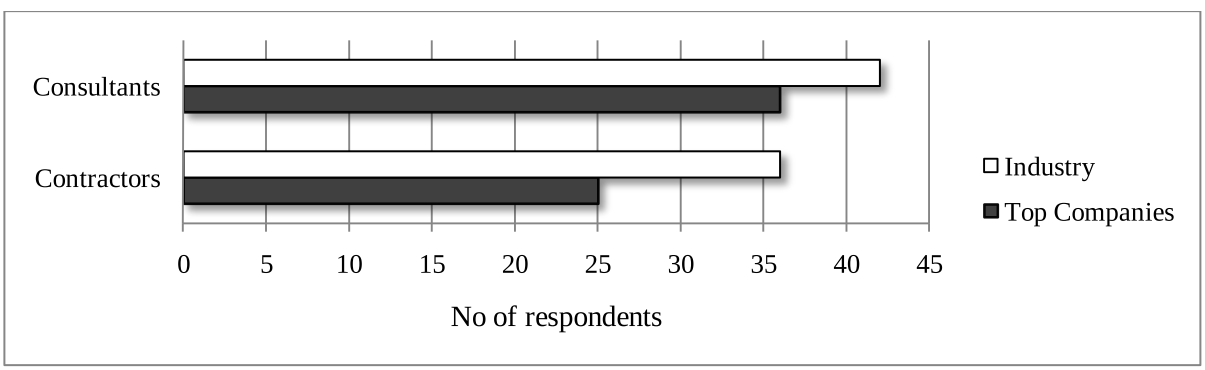


Figure 6.4: Participation frequency of business groups - Industry and top companies

6.6.3. ***Size-based groups***

In this section, respondents were asked to determine the size of their organisations. Table 6. shows that small and large sized organisations participated in equal number, 48 firms for each of them, and the number of medium sized organisations that participated in this survey was 43.

Table 6.5: Participation frequency of the size groups – Industry and top companies

Valid	139		Size of organisation		
Missing	0		**Small**[1]	**Medium**[2]	**Large**[3]
Group		**Top Companies**	2	23	36
		Industry	46	20	12
Total			48	43	48

From the graph below (Figure 6.5) it can be seen that the percentages of participating small, medium, and large sized firms are relatively similar. Small and large sized firms participated with the same percentage; 34.5% for each group. The participation of medium sized organisation forms 31% of the total participation in this survey.

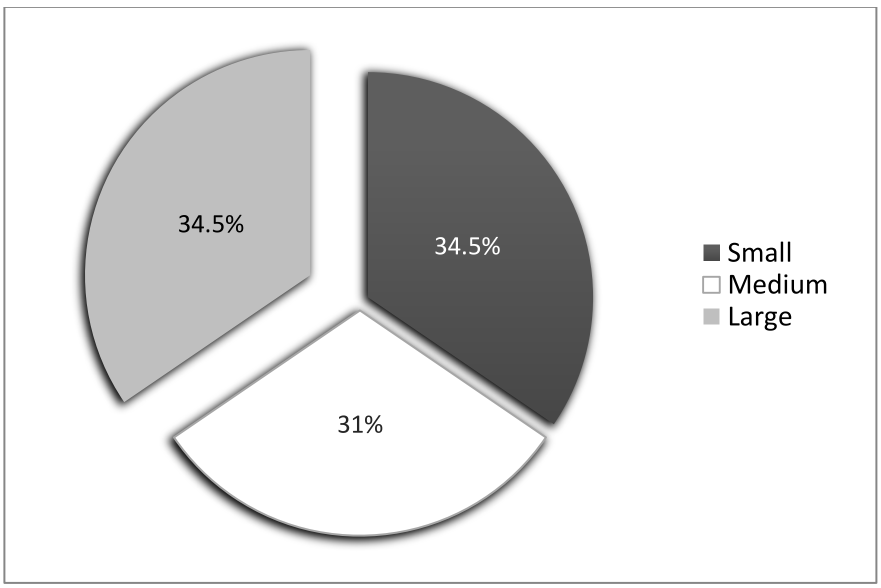


Figure 6.5: Participation percentage of small, medium, and large sized organisations – all companies

It is obvious from Figure 6.6 that there is a clear contrast between the number of participating large and small sized organisation in the top companies and in the industry. While 46 small sized organisations selected from the industry as a whole participated, only two small sized organisations from the top companies were counted in this survey. This is

[1] 8-49 employees

[2] 50-249 employees

[3] > 249 employees

because fewer small organisations are listed as ‘top companies’. In contrast, the number of large sized organisations from amongst the top companies participated in this survey is 36, while, only 12 large sized organisations participated from the industry. However, the number of medium sized organisations from top companies and industry is relatively similar, as 23 organisations participated from top companies and 20 organisations participated from industry.

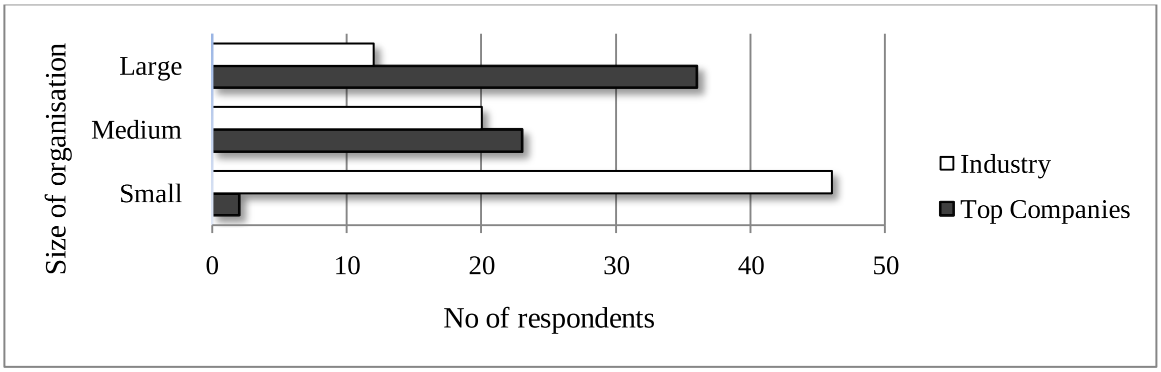


Figure 6.6: Participation frequency of small, medium, and large sized organisations – Industry and top companies

6.7. **Knowledge management (KM) practice**

This section presents the core data analysis relating to the current practice of KM in the UK construction industry. It analyses the KM stage of maturity of the different groups. In addition, it illustrates the frequency of use and the effectiveness of previously identified KM techniques and information technology (IT) tools.

6.7.1. ***Knowledge management stage of maturity***

The aim of this section is to determine the level of maturity in relation to KM amongst the top companies, industry, and size and business based groups. A previously identified organisational maturity matrix (see section 3.4) was given to the respondents to determine the stage that best describes his/her organisation’s practice in relation to KM. The organisational maturity matrix consists of five stages starting with the newest stage; the pre-awareness stage, and ending with most mature stage; sustainability. The respondents were not given the title of the stages; instead they were given a description (see the questionnaire form in appendix 2).

Table 6.6: KM level of Maturity – Industry and top companies

Valid	139	Group			Total	
Missing	0	**Top Companies**	**Industry**		**Frequency**	**%**
Pre-awareness stage		3	23		26	18.7
Start-up stage		20	32		52	37.4
Take-off stage		12	16		28	20.1
Expansion stage		18	2		20	14.4
Sustainability stage		8	5		13	9.4
Total		61	78		139	100.0

Table 6.6 and Figure 6.7 illustrate the frequencies of the KM level maturity for all participating companies. The start-up stage (which indicates that the organisation is aware of the benefits of KM for business performance) was selected most frequently, since 37.4% (52 companies) of the participated organisations are at this stage. The second most frequent stage was the take-off stage, with 20.1% (28 companies) of the organisations at this stage. 26 of the organisations (18.7%) are unaware of the benefits of KM for business performance.

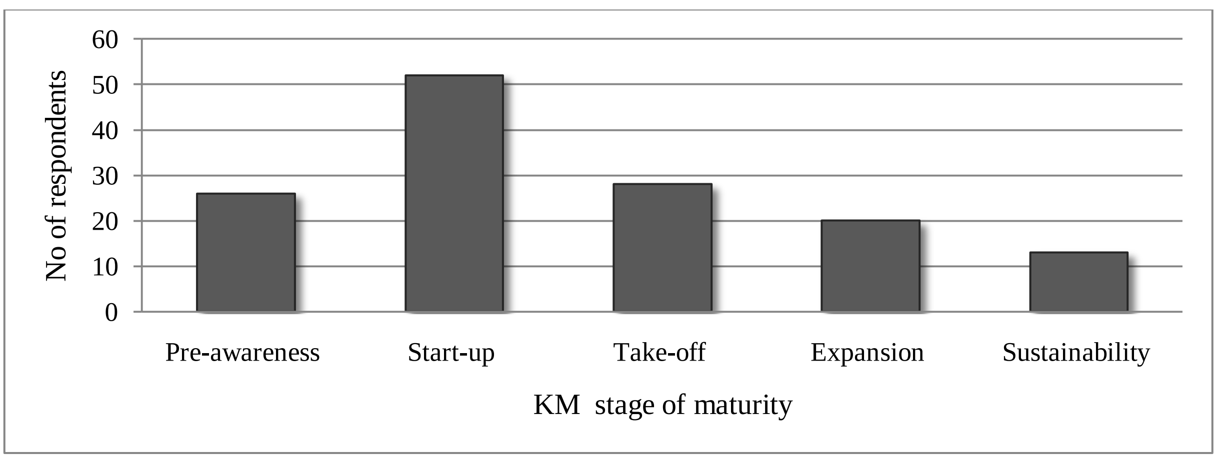


Figure 6.7: KM level of maturity of the entire respondents

The two most advanced stages were chosen less frequently than the other stages. 20 of the participating organisations (14.4%) were at the expansion stage, and only 13 organisations (9.4%) identified themselves as being at the sustainable stage.

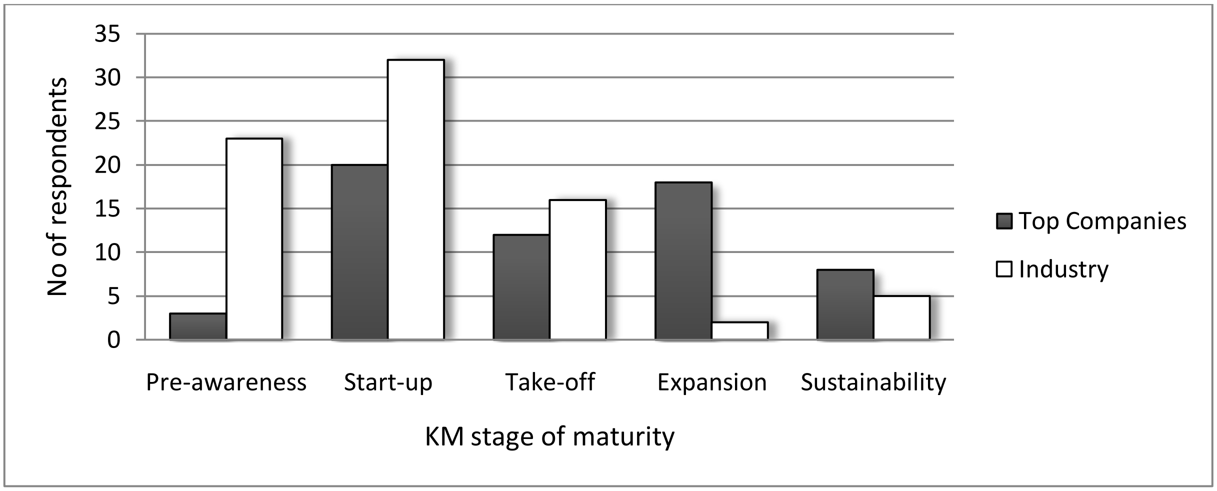


Figure 6.8: KM level of maturity for the industry and top companies

Turning to characterisation of the group of randomly selected companies and top companies; Figure 6.8 and Table 6.6 showed that only three organisations from the top companies are at the lowest stage of maturity; start-up stages and 23 organisations from the industry group are at the same stage. The most frequent KM stage of maturity for both the randomly selected companies and the top companies is the start-up stage, since 20 such organisations come from top companies and 32 organisations from the wider industry at this stage. There is no significant difference between the number of top companies and randomly selected organisations that are at the take-off stage. In contrast, only two organisations from the top companies, as compared to 18 elsewhere in the industry appear to be at this stage of expansion. Finally, 8 of the top companies were found at the most advanced stage; the sustainability stage, whereas 5 of the organisations selected from the industry as a whole were at the same stage.

Table 6.7: Percentage of KM stage of maturity within main groups

Valid	139		**Top Companies**	**Industry**	**Total**
Missing	0				
KM stage of maturity		**Pre-awareness**	4.9%	29.5%	18.7%
		Start-up	32.8%	41.0%	37.4%
		Take-off	19.7%	20.5%	20.1%
		Expansion	29.5%	2.6%	14.4%
		Sustainability	13.1%	6.4%	9.4%
Total			100.0%	100.0%	100.0%

Studying the frequencies to compare top companies and randomly selected organisations may not be appropriate. This is because the number of the participating organisations for each group is either not similar or relatively similar. Therefore it was determined to use the percentage at the KM stage of maturity within the group to compare both groups' answers.

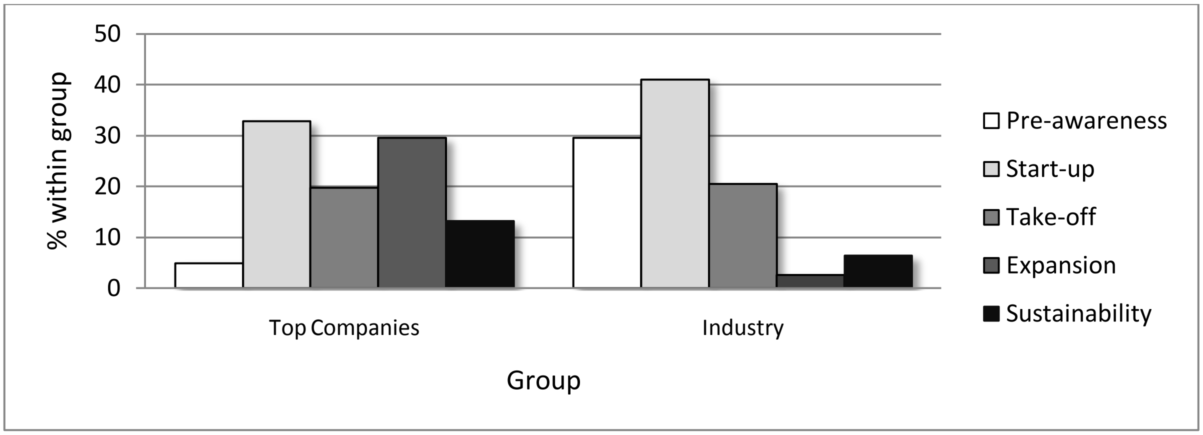


Figure 6.9: Percentage of KM stage of maturity within main groups

As Figure 6.9 indicates, most of the top companies are at the second, third and fourth stages which form 32.8%, 19.7% and 29.5% of the top companies respectively (see Table 6.7). The first stage achieved the lowest percentage as only 4.9% of the top companies were at this stage. The remaining 13.1% of top companies were at the last stage. The majority of the organisations taken from throughout the industry are at the first, second, and third stages, forming 29.5%, 41% and 20.5% of industry organisations respectively. Very few companies in the industry are at the fourth and final stages, these form 2.6% and 6.4% of

Table 6.8: KM stage of maturity of the contractors and consultants

Valid	139		Business	
Missi ng	0		**Contractor**	**Consultant**
KM stage of maturity		**Pre-awareness**	13	13
		Start-up	24	28
		Take-off	11	17
		Expansion	7	13
		Sustainability	6	7
Total			61	78

the randomly selected organisations respectively. To measure the level of KM maturity according to the presentation of contractors and consultants, the respondents' answers were divided based on their business. As Table 6.8 shows, there is a difference between contractors and consultants in relation to the KM level of maturity. In general, consultants report a little more mature than contractors in terms of KM practice.

As Figure 6.10 indicates, the most frequent stage for both contractors and consultants is the start-up stage. However, the second most frequent stage for contractors is the pre-awareness stage, while the take-off stage is the second most frequent stage to consultants. In addition, the third, fourth and fifth frequent stages for contractors are the take-off, expansion and sustainability stages respectively. On the other hand expansion, pre-awareness and sustainability stages are the third, fourth and least frequent stages for consultants.

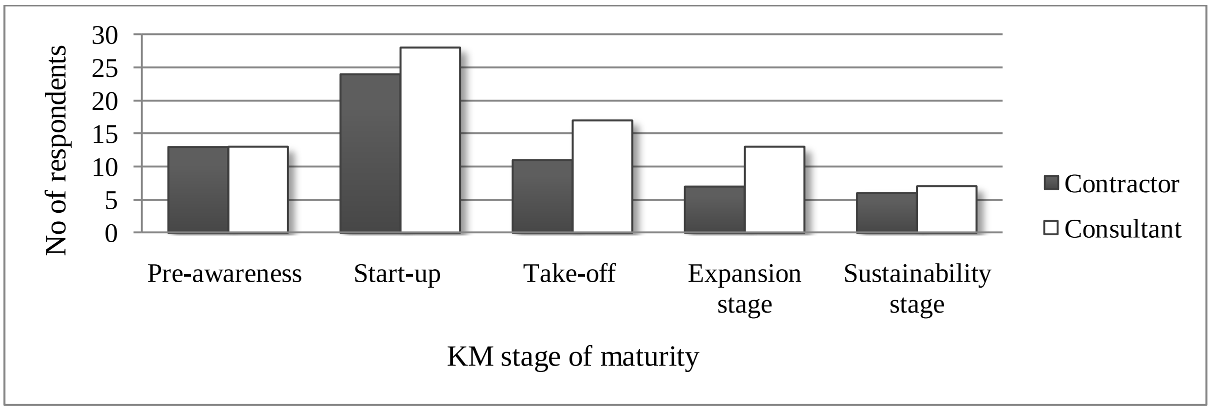


Figure 6.10: KM stage of maturity of the entire contractors and consultants

Table 6.9 compares the KM stage of maturity according to contractors and consultants for both top companies and randomly selected organisations. It might be more appropriate to compare contractors and consultants from both groups based on the percentage at the KM stage of maturity within the businesses included in the study. As Figure 6.12 shows, the greatest numbers of contractors in the industry as a whole are at the pre-awareness (33.3%) and start-up (38.9%) stages. The remaining 27.8% of the industry based contractors are distributed between the take-off (13.9%), expansion (2.8%), and sustainability (11.1%) stages. On the other hand, 40% of the top firms’ contractors are at the start-up stage; 48% of top contractors are distributed equally between the take-off and expansion stages; 8% of the remaining 12% of the top contractors are at the sustainability stage; and 4% are at the pre-awareness stage.

Table 6.9: KM stage of maturity of contractors and consultants for both the top industry and top companies

Valid	139		Top Companies		Industry	
Missing	0		**Contractor**	**Consultant**	**Contractor**	**Consultant**
KM stage of maturity	**Pre-awareness**	Count	1	2	12	11
		% within Business	4.0%	5.6%	33.3%	26.2%
	Start-up	Count	10	10	14	18
		% within Business	40.0%	27.8%	38.9%	42.9%
	Take-off	Count	6	6	5	11
		% within Business	24.0%	16.7%	13.9%	26.2%
	Expansion	Count	6	12	1	1
		% within Business	24.0%	33.3%	2.8%	2.4%
	Sustainability	Count	2	6	4	1
		% within Business	8.0%	16.7%	11.1%	2.4%
Total		Count	25	36	36	42
		% within Business	100.0%	100.0%	100.0%	100.0%

The situations with the consultants appears to be quite different. As illustrated in Figure 6.11, 42.9% of the wider industry consultants are currently at the start-up stage, and 52.4% of those are distributed equally between the pre-awareness and take-off stages. 2.4% of the remaining 4.8% of the industry consultants are at the expansion stage, and the other 2.4% are at the sustainability stage. Conversely, most of the top consultants are concentrated in the take-off (16.7%), expansion (33.3%), and sustainability (16.7%) stages, leaving 5.6% of the top consultants at the pre-awareness stage, and the remaining 27.8% at the start-up stage.

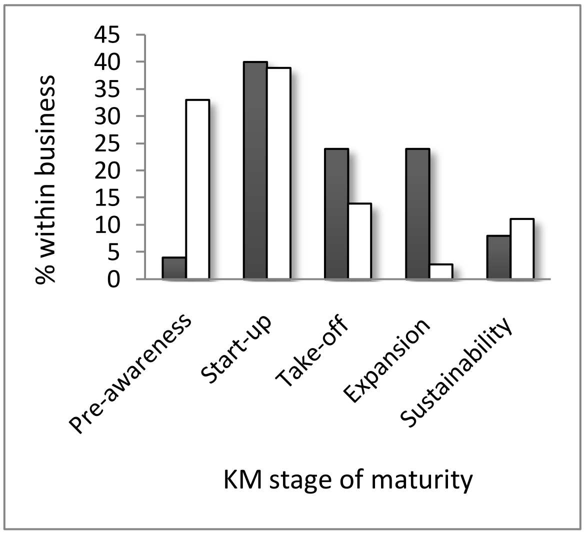


Figure 6.12: KM stage of maturity of industry and top contractors

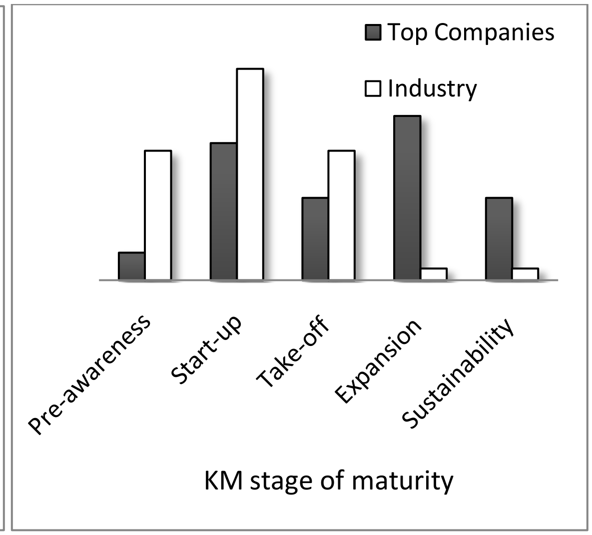


Figure 6.11: KM stage of maturity of industry and top consultants

Figure 6.13 and Figure 6.14 indicate the position of the consultants and contractors in each group. It can be observed from Figure 6.14 that top contractors tend to be more mature in their application of KM than top consultants; as shown by top contractors being concentrated over the last three KM stages of maturity, with top consultants more concentrated in the second, third and fourth stages.

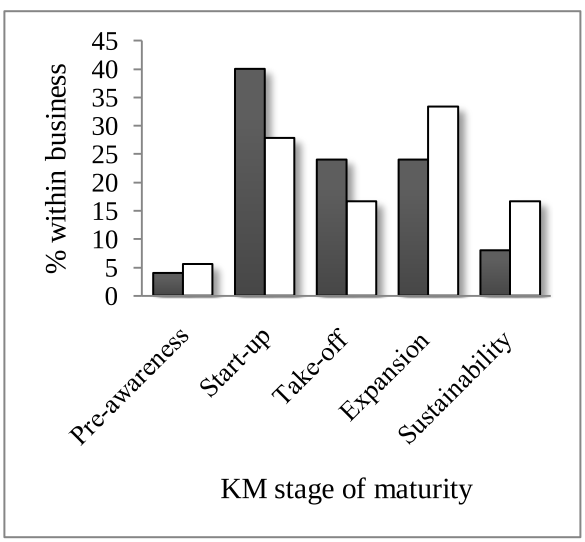


Figure 6.14: KM stage of maturity of the top contractors and consultants

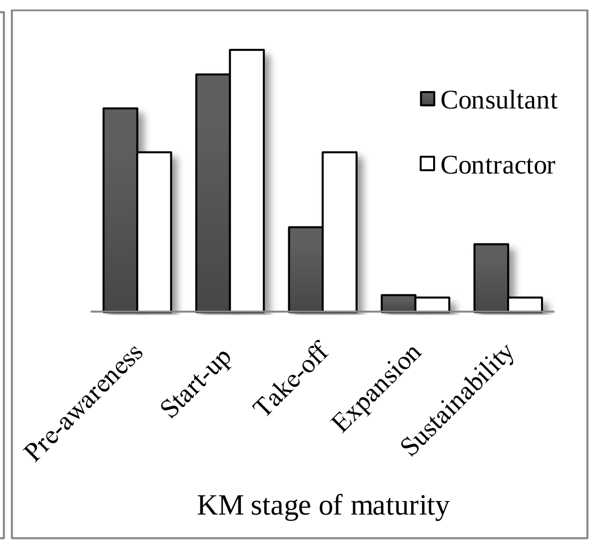


Figure 6.13: KM stage of maturity of the industry contractors & consultants

The situation is different in the case of industry organisations. Despite the fact that the distributions of industry contractors and consultants appears to be dissimilar, their level of

KM maturity is comparable. Both contractors and consultants are concentrated at the first three stages, but in different proportions. This can be observed from Figure 6.13.

Table 6.10: KM stage of maturity of small, medium, and large sized industry and top companies

Valid	139		Top Companies			Industry		
Missing	0		**Small**	**Medium**	**Large**	**Small**	**Medium**	**Large**
KM stage of maturity	**Pre-awareness**	Count	1	2	0	18	3	2
		% within the size of firms	50.0%	8.7%	.0%	39.1%	15.0%	16.7%
	Start-up	Count	1	12	7	19	11	2
		% within the size of firms	50.0%	52.2%	19.4%	41.3%	55.0%	16.7%
	Take-off	Count	0	4	8	9	4	3
		% within the size of firms	.0%	17.4%	22.2%	19.6%	20.0%	25.0%
	Expansion	Count	0	3	15	0	1	1
		% within the size of firms	.0%	13.0%	41.7%	.0%	5.0%	8.3%
	Sustainability	Count	0	2	6	0	1	4
		% within the size of firms	.0%	8.7%	16.7%	.0%	5.0%	33.3%
Total		Count	2	23	36	46	20	12
		% within the size of firms	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 6.10 illustrates the KM stage of maturity at each size for both groups. The percentage of KM stage of maturity within the size of firms will be used in this analysis. Starting with the top companies in Figure 6.16, small sized organisations are equally distributed between the pre-awareness and start-up stages. No small sized top organisation is found to be at any of the other stages. Medium sized organisations are distributed, with different percentages over the five stages. However, over half (52.2%) of those organisations are at the start-up stage; 17.4% are at the take-off stage, 13% at the expansion stage and the remaining 17.4% are distributed equally between the first (pre-awareness) and last (sustainability) stages. Large sized top organisations appear to be more mature than the other two sizes, as none of these large organisations at the pre-awareness stage. In addition, 41.7% of the top large sized organisations are at the expansion stage, and 16.7% are at the most mature stage;

sustainability. The remaining 41.6% of the top large sized organisations are at Start-up and take-off stage with 19.4% and 22.2% respectively.

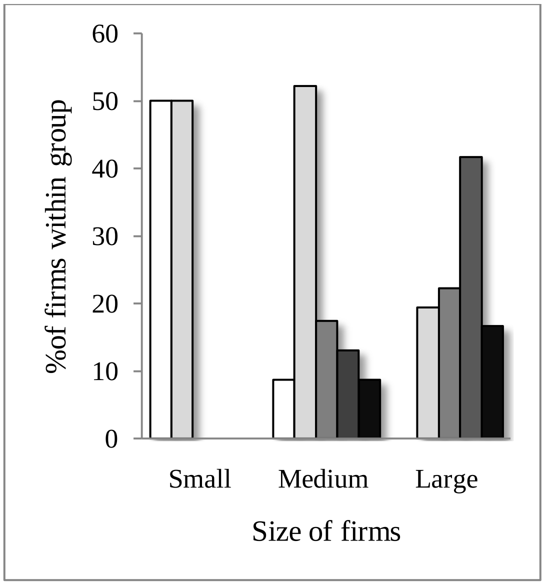


Figure 6.16: KM stage of maturity of the top small, medium and large sized organisations

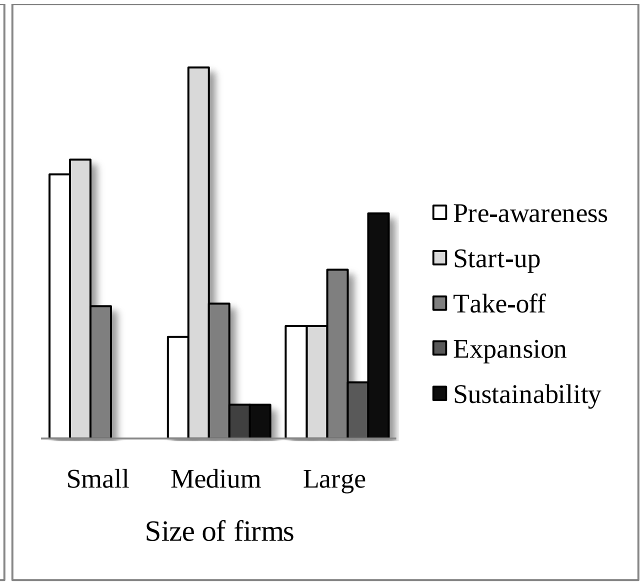


Figure 6.15: KM stage of maturity of the industry small, medium and large sized organisations

With regards to the randomly selected organisations, different results were obtained. As illustrated in Figure 6.15, the small sized organisations were identified at the first three KM stages of maturity with 39.1%, 41.3%, and 19.6% respectively. 55% of the medium of the industry organisations are at the start-up stage. In addition 15% of the same group are at the pre-awareness stage, 20% at the take-off stage, and the remaining 10% are distributed equally between the last two stages. In addition, the highest percentage (33.3%) of the industry's larger organisations are at the sustainability stage. The remaining percentage of the same group are distributed as follows; both the pre-awareness stage and start-up stage show the same percentage, which is 16.7%; 25% are at the take-off stage, and 8.3% are at the expansion stage.

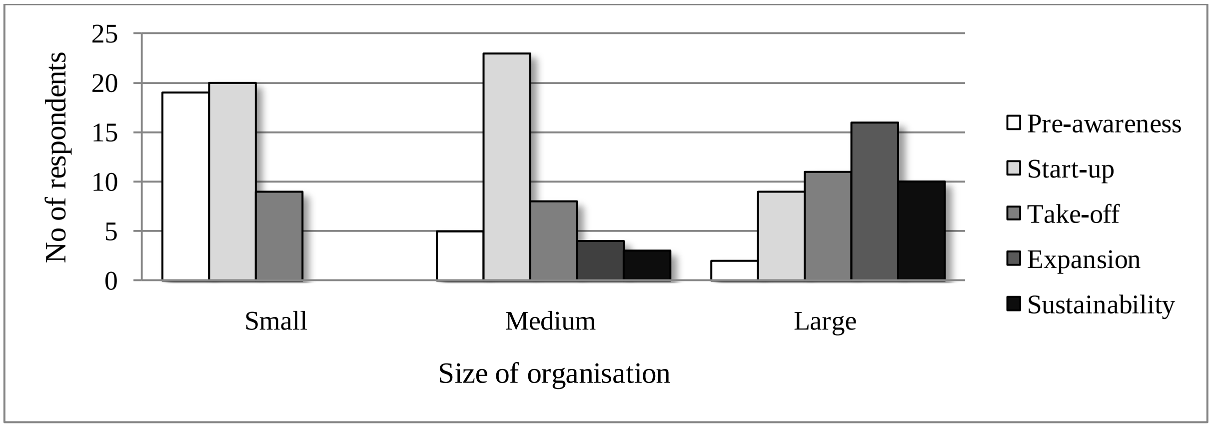


Figure 6.17: KM stage of maturity of the whole participants based on size groups

The complete results obtained from the respondents in relation to the KM stage of maturity and the size of the organisations is shown in Figure 6.17. This shows clearly that the majority of companies are represented by the in-between position, regardless of whether they are top companies or industry organisations.

6.7.2. ***Popularity and effectiveness of KM techniques***

A list of KM techniques was given to the participants. They were asked to determine the KM techniques that are available in their organisations. Also participants were asked to indicate how effective the available KM techniques were. The KM techniques were analysed based on their Average weight of effectiveness (AWE), and popularity. Here are the meanings of the abbreviation that are used in the following sub-sections:

- TW: Total weight of effectiveness
- NR: Number of respondents
- AWE: Average weight of effectiveness [Mean score]
- P-RNK: Popularity ranking
- E- RNK: Effectiveness ranking

- ***Industry and Top companies compression***

Table 6.11 compares popularity and effectiveness of KM techniques between randomly selected construction companies and top companies. It shows that project review, training, and external source of knowledge are the most popular KM techniques in the UK construction industry respectively. This was reported for both; randomly selected organisations (available in 91%, 77%, and 64% of organisations respectively) and top companies (all are available in 92% of top companies). In contrast, knowledge manager (17%) storyboards (14%), and knowledge team (17%) are the least popular KM techniques as reported by the randomly selected companies. The same results were obtained from the top companies but with differences in ranking; the least popular techniques were knowledge manager (32%), knowledge team (42%), and storyboards (43%) respectively.

Table 6.11: Popularity and effectiveness of KM techniques - Industry and top companies

Valid 136 / Missing 3	Industry					Top companies				
	TW	NR	AWE	P-RNK	E-RNK	TW	NR	AWE	P-RNK	E-RNK
1 Knowledge recording	91	44	2.07	4	8	122	54	2.26	4	6
2 External sources of knowledge	83	49	1.69	3	13	99	55	1.80	3	13
3 Training	131	55	2.38	2	3	133	55	2.42	2	2
4 Reassignment of people	32	17	1.88	9	11	67	35	1.91	9	11
5 Research collaboration	26	14	1.86	10	12	76	37	2.05	8	8
6 Preparation of standard details	97	43	2.26	5	6	109	48	2.27	5	4
7 Knowledge team	32	13	2.46	11	2	57	25	2.28	12	3
8 Knowledge manager	26	11	2.36	13	4	40	19	2.11	13	7
9 Mentoring	69	30	2.30	6	5	93	41	2.27	6	5
10 Apprenticeship	37	18	2.06	8	9	57	29	1.97	10	9
11 Discussion groups	56	26	2.15	7	7	74	40	1.85	7	12
12 Storyboards	21	11	1.91	12	10	50	26	1.92	11	10
13 Project review	182	69	2.64	1	1	146	55	2.65	1	1

In contrast to the above, different results were obtained for the effectiveness-based rank of KM techniques. As illustrated in Table 6. and Figure 6.18, the project review was reported as the most effective technique for both groups. While knowledge team and training are the second and third most effective techniques for the industry organisation, they are third and second in top companies.

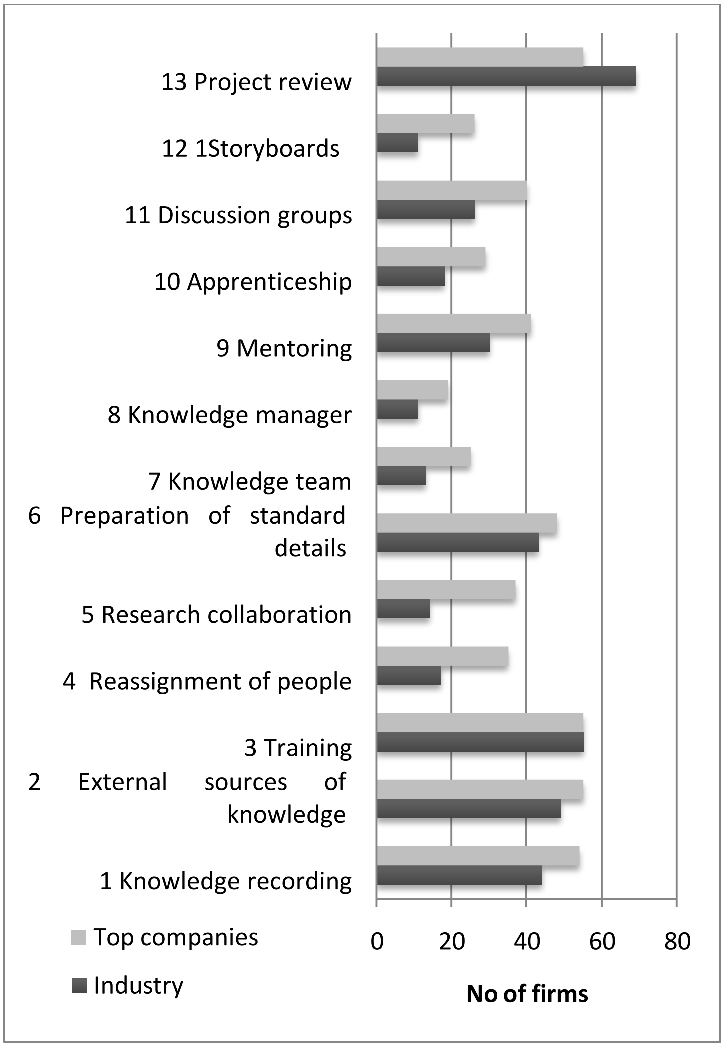


Figure 6.19: Popularity of KM techniques - Industry and top companies

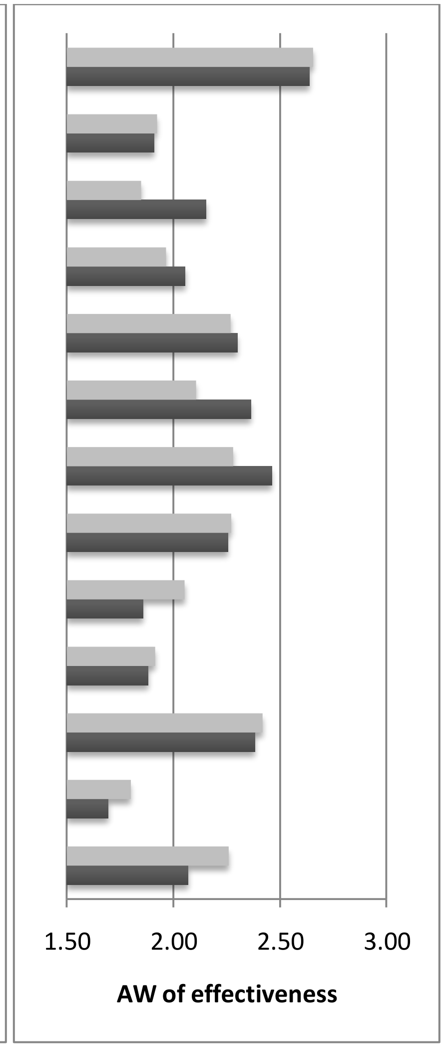


Figure 6.18: Effectiveness of KM techniques - Industry and top companies

Table 6.12 compares popularity and effectiveness of the IT tools between other companies in the construction industry and top companies. Generally, the respondents indicate that IT tools are deployed in top companies more than in other companies. Other companies in the construction industry and top companies share the rank of first, second, and third most popular tools; e-mail (available in 74% of other companies and 97% in top companies), website (50% - 90%), and e-file manger (36% - 60%) respectively. In contrast, groupware (7%), electronic forum (13%) and CMS (13%) are the least deployed tools, with very low percentages of availability. In top companies the least popular tools are available in higher parentages; these are e-messaging system (22%), groupware (32%) and custom designed software (47%).

Table 6.12: Popularity and effectiveness of IT tools - Industry and top companies

Valid: 136	**Industry**					**Top companies**				
Missing: 3	TW	NR	AWE	P-RNK	E-RNK	TW	NR	AWE	P-RNK	E-RNK
14 Portal/Content management system	18	10	1.80	8	10	76	33	2.30	4	4
15 Custom-designed software	32	15	2.13	5	9	60	28	2.14	8	10
16 Expert Directory	47	21	2.24	4	7	73	32	2.28	5	5
17 E-mail	126	56	2.25	1	6	131	58	2.26	1	7
18 Website	82	38	2.16	2	8	118	54	2.19	2	9
19 Electronic File manager	63	27	2.33	3	5	82	36	2.28	3	6
20 Electronic Forum	24	10	2.40	9	4	75	29	2.59	7	1
21 Groupware	14	5	2.80	10	1	42	19	2.21	9	8
22 Electronic Instant messaging system	30	11	2.73	7	2	32	13	2.46	10	2
23 Project Extranet	34	14	2.43	6	3	72	31	2.32	6	3

While the construction companies surveyed consider Groupware to be the most effective tool (scoring 2.8 out of 3, the highest score for both groups), electronic forum is viewed as the most effective IT tool by top companies (2.59). There is an agreement between industry and top companies in ranking e-instant messaging system (scoring 2.73, and 2.46 respectively) the second effective tool and project extranet (2.43 and 2.32) as the third. CMS (scores 1.8 - the least score in both groups), custom-designed software, and websites were ranked the least effective tools by those surveyed. With some similarity, top companies ranked custom-design software (2.14), website (2.19), and groupware (2.21) as the least effective IT tools respectively. It is worth mentioning that only one tool obtained a score of less than 2.0 of effectiveness by other companies in the construction industry, which is CMS. Nevertheless, all the tools scored over 2.0 in terms of effectiveness according to the top companies surveyed.

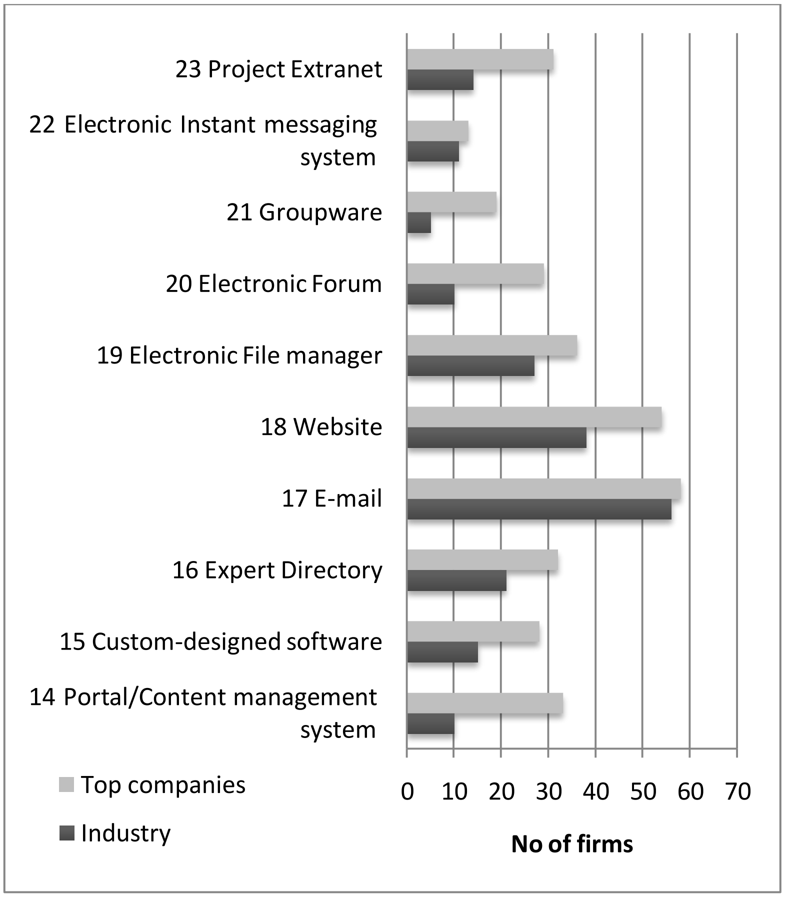


Figure 6.20: Popularity of IT tools in industry and top companies

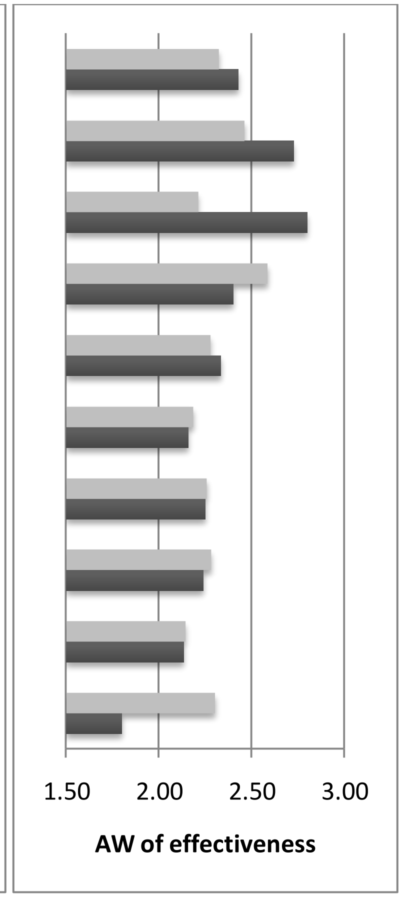


Figure 6.21: Effectiveness of IT tools in industry and top

- ***Industry contractors and consultants comparison***

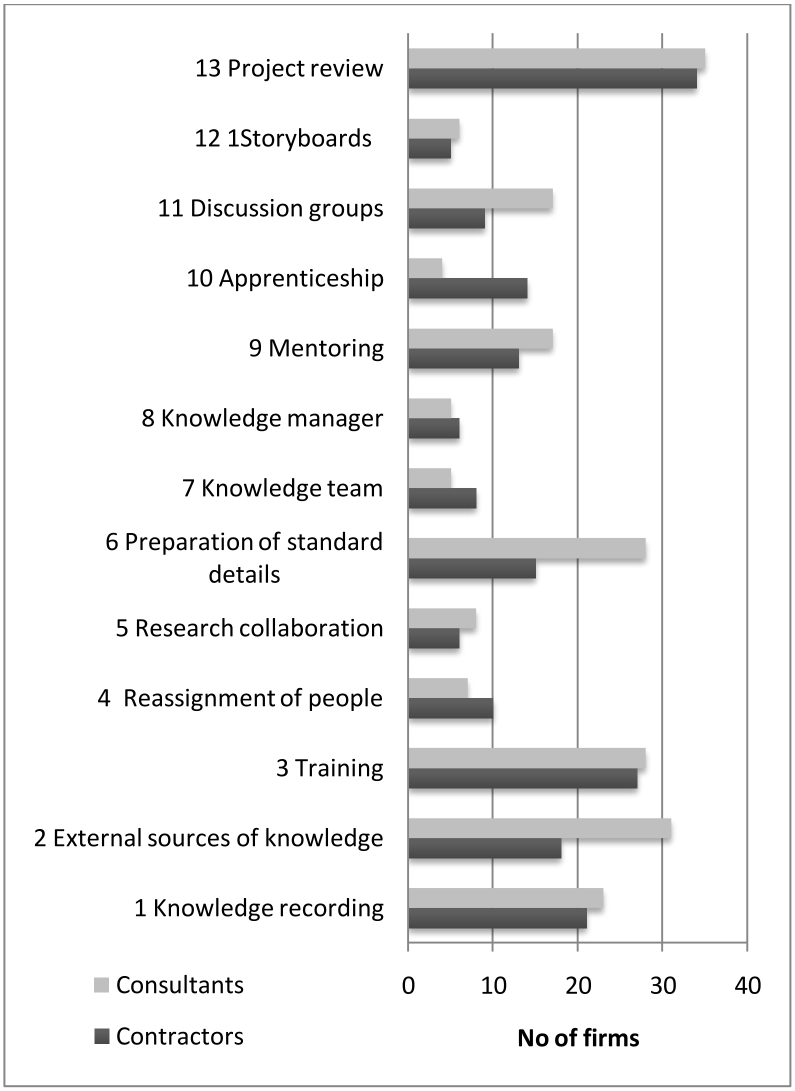
Table 6.13 compares popularity and effectiveness of KM techniques in industry contractors and consultancies. As can be seen from the data, project review is the most popular techniques according to both groups, as it is available in 97% of the industry contractors and 85% in industry consultancies. Training (77%) and knowledge recording (60%) are the second and third most popular KM techniques within the contractors group. On the other hand, the third and second popular KM techniques within consultants group are the use of external source of knowledge (76%) and training (68%).

Table 6.13: Popularity and effectiveness of KM techniques - Industry contractors and consultancies

Valid	76	Contractors					Consultants				
Missing	2	TW	NR	AWE	P-RNK	E-RNK	TW	NR	AWE	P-RNK	E-RNK
1 Knowledge recording		47	21	2.24	3	7	44	23	1.91	5	9
2 External sources of knowledge		31	18	1.72	4	13	52	31	1.68	2	12
3 Training		63	27	2.33	2	5	68	28	2.43	3	3
4 Reassignment of people		19	10	1.90	8	12	13	7	1.86	9	10
5 Research collaboration		12	6	2.00	12	11	14	8	1.75	8	11
6 Preparation of standard details		36	15	2.40	5	2	61	28	2.18	4	6
7 Knowledge team		19	8	2.38	10	3	13	5	2.60	11	1
8 Knowledge manager		14	6	2.33	11	4	12	5	2.40	12	4
9 Mentoring		29	13	2.23	7	8	40	17	2.35	6	5
10 Apprenticeship		29	14	2.07	6	10	8	4	2.00	13	8
11 Discussion groups		21	9	2.33	9	6	35	17	2.06	7	7
12 Storyboards		11	5	2.20	13	9	10	6	1.67	10	13
13 Project review		92	34	2.71	1	1	90	35	2.57	1	2

With regards to the least popular KM techniques, Storyboards (14%), research collaboration (17%) and knowledge manager (17%); these were identified as the least available techniques by the contractors group. However, the situation discovered was quite different within the consultants group, where apprenticeship (10%), knowledge manager (12%), and knowledge team (12%) were identified as the least popular.

Relatively similar results in relation to the extent of effectiveness were obtained from the industry contractors and consultants. For contractors, project review, Preparation of standard details, and knowledge team were considered to be the most effective KM techniques. The rank of the consultancies is somewhat similar to contractors; with knowledge team, project review and training were considered to be the most effective KM techniques.



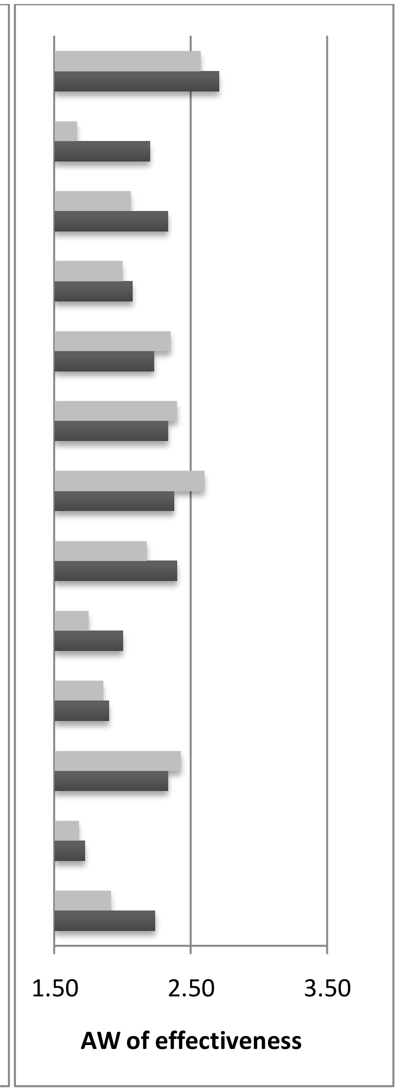


Figure 6.23: Popularity of KM techniques – Industry contractors and consultancies

Figure 6.22: Effectiveness of KM techniques - Industry contractors and consultancies

As Table 6.14 and Figure 6.22 indicate, the least effective KM techniques within contractor organisations relate to the use of external sources of knowledge, reassignment of people and research collaboration respectively. With some differences however, storyboards, external sources of knowledge and research collaboration were considered to be the least effective techniques within the consultancies group.

Table 6.14: Popularity and effectiveness of IT tools - Industry contractors and consultancies

Valid: 76	Contractors					Consultants				
Missing: 2	TW	NR	AWE	P-RNK	E-RNK	TW	NR	AWE	P-RNK	E-RNK
14 Portal/Content management system	5	3	1.67	10	10	13	7	1.86	7	10
15 Custom-designed software	15	7	2.14	7	9	17	8	2.13	5	7
16 Expert Directory	22	9	2.44	4	5	25	12	2.08	4	9
17 E-mail	55	25	2.20	1	8	71	31	2.29	1	4
18 Website	38	17	2.24	2	7	44	21	2.10	2	8
19 Electronic File manager	33	13	2.54	3	4	30	14	2.14	3	6
20 Electronic Forum	14	6	2.33	8	6	10	4	2.50	8	2
21 Groupware	9	3	3.00	9	1	5	2	2.50	10	1
22 Electronic Instant messaging system	23	8	2.88	5	2	7	3	2.33	9	3
23 Project Extranet	18	7	2.57	6	3	16	7	2.29	6	5

In terms of tools popularity within industry contractors and consultants, the results suggested that there is no big difference between the two groups. Table 6.14 and Figure 6.25 show that the first, second, and third popular tools in both groups are e-mail, website, and e-file manager. In addition both groups listed groupware and e-forum amongst the least popular three tools. The contractors found the portal to be the least popular tool and the e-messaging system was placed the second least popular tool by consultants. Again, the effective score for the tools is relatively similar for both groups. Groupware seems to be the most effective tool in both of the groups, scoring 3 and 2.5 with contractors and consultants respectively. The e-messaging system is ranked second by contractors (2.88) and third by consultants (2.33); however, contractors view electronic forums as the second effective tool (2.8) and consultants identified project extranet as the third most effective tool (2.57). It is worth noting that both groups gave a score of 2 or more as the average rate of effectiveness for all tools except one.

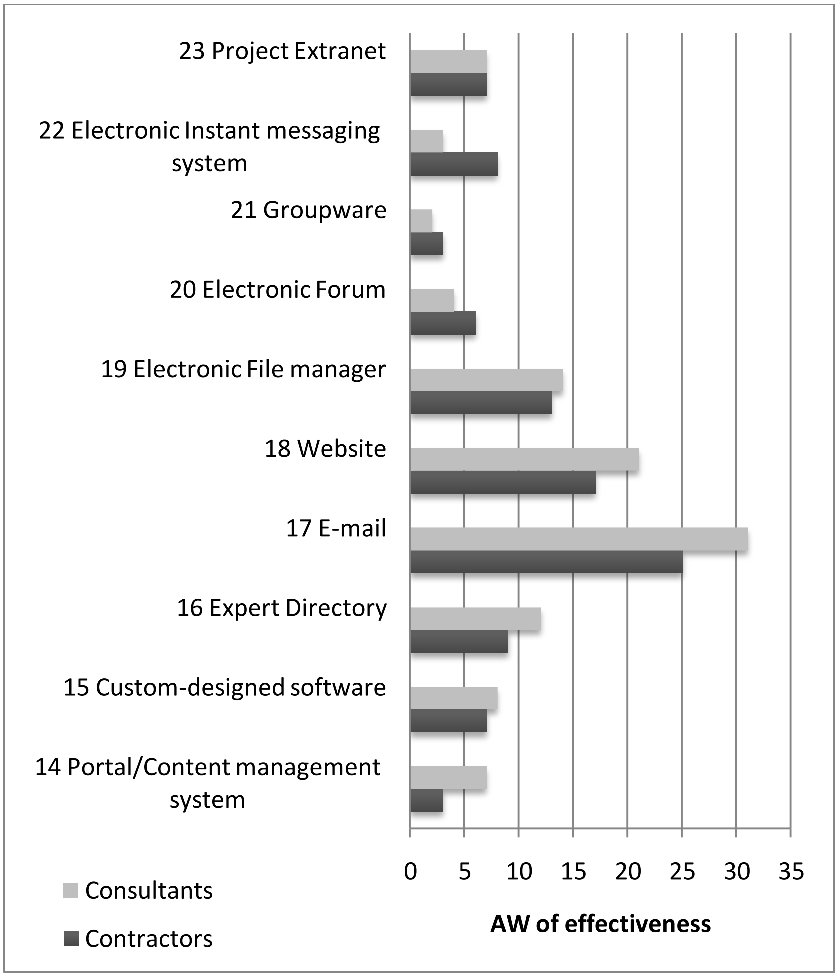


Figure 6.25: Popularity of IT tools – Industry contractors and consultants

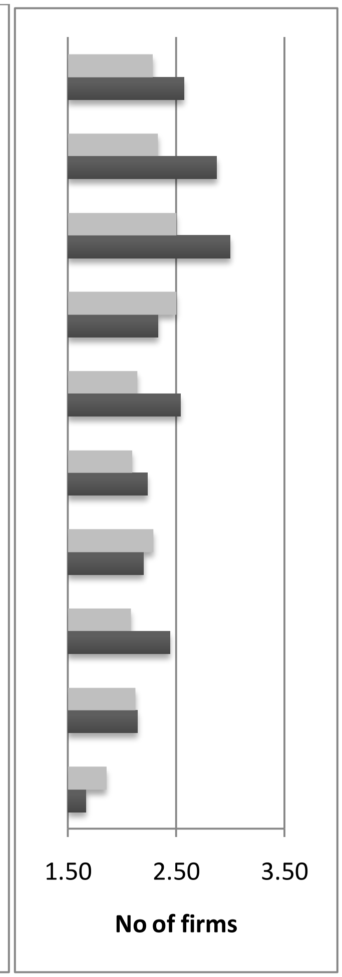


Figure 6.24: Effectiveness of IT tools - Industry contractors and consultants

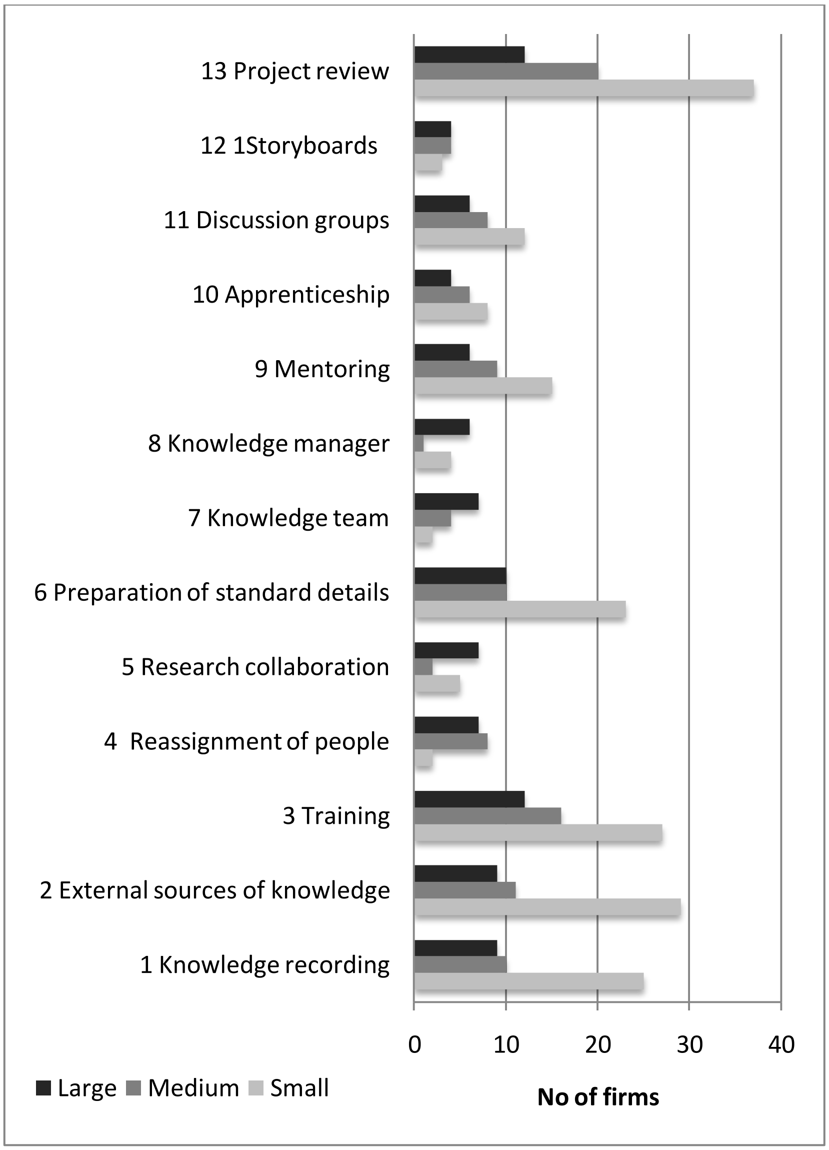
- ***A comparison of small, medium, and large construction industry companies***

Table 6.15 illustrates a comparison of data between small, medium, and large sized organisations. Starting with the popularity of KM techniques, project review was the most popular since it was the most available and useful technique for small (84%), medium (100%) and large (100%) organisations. Training was considered as popular as the project review within large organisations (100%). It was also reported as the second most popular technique within medium organisations (80%), and third within small organisations (61%). External sources of knowledge are ranked the second and third most popular respectively in small (66%) and medium (55%) organisations. Large organisations seem to care more about the preparation of standard details as this was the third most popular technique (83%). Turning to the bottom of the rank, it was found that storyboard is ranked eleventh by small (7 %,) and medium (33%) organisations, and thirteenth in large organisations (63%). Reassignment of people (5%) and knowledge team (5%) are the least and second least popular techniques applied by small size companies. In medium size companies knowledge manager (5%) and research collaboration (10%) are the least and the second least popular techniques. Yet, apprenticeship (33%), and discussion groups (50%) are the second and third least popular techniques in large size organisations.

Table 6.15: Popularity and Effectiveness of KM techniques - Industry small, medium, and large sized companies

Valid	76	Small					Medium					Large				
Missing	2	TW	NR	AWR	P-RNK	E-RNK	TW	NR	AWR	P-RNK	E-RNK	TW	NR	AWR	P-RNK	E-RNK
1 Knowledge recording		53	25	2.12	4	9	20	10	2.00	4	6	18	9	2.00	4	11
2 External sources of knowledge		48	29	1.66	2	11	17	11	1.55	3	10	18	9	2.00	5	12
3 Training		67	27	2.48	3	4	35	16	2.19	2	5	29	12	2.42	2	5
4 Reassignment of people		5	2	2.50	13	3	12	8	1.50	7	11	15	7	2.14	6	10
5 Research collaboration		7	5	1.40	9	12	5	2	2.50	12	3	14	7	2.00	7	13
6 Preparation of standard details		49	23	2.13	5	7	23	10	2.30	5	4	25	10	2.50	3	3
7 Knowledge team		4	2	2.00	12	10	10	4	2.50	10	2	18	7	2.57	8	2
8 Knowledge manager		10	4	2.50	10	2	1	1	1.00	13	13	15	6	2.50	9	4
9 Mentoring		37	15	2.47	6	5	18	9	2.00	6	7	14	6	2.33	10	7
10 Apprenticeship		17	8	2.13	8	8	11	6	1.83	9	9	9	4	2.25	12	9
11 Discussion groups		26	12	2.17	7	6	16	8	2.00	8	8	14	6	2.33	11	8
12 1Storyboards		4	3	1.33	11	13	6	4	1.50	11	12	11	4	2.75	13	1
13 Project review		98	37	2.65	1	1	55	20	2.75	1	1	29	12	2.42	1	6

In relation to the effectiveness of the techniques applied, PR was found to be the most effective KM technique from the perspective of small (scores 2.65 out of 3) and medium (2.7) size companies. Knowledge manager (2.5) and reassignment of people (2.5) were also considered to be the most effective techniques in small size companies. Medium size companies provided different lists regarding the top KM techniques and knowledge team (2.5) and research collaboration (2.5) were deemed the second and third most effective techniques. Despite this, PR is found to be the sixth most effective technique in large size companies, it gained a relatively high average score (2.42). The most effective techniques employed by large size companies are storyboards (2.75), knowledge team (2.57), and preparation of standard details (2.5).



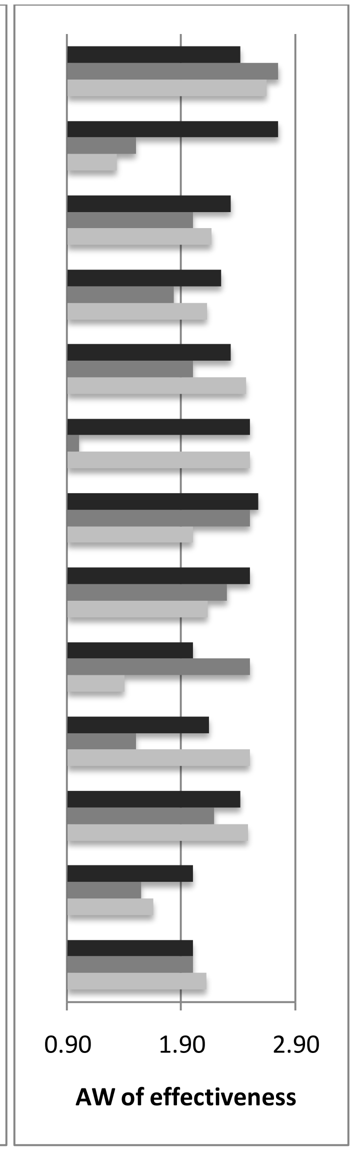


Figure 6.27: Popularity of KM techniques - Industry small, medium, and large companies

Figure 6.26: Effectiveness of Km techniques - Industry small, medium, and large companies

Large size organisations appear to value KM techniques more than the small and medium size organisations. No single technique deserves to score less than 2 (out of 3) in the opinion of large companies. On the other hand, the least effective three techniques scores lower than 2 in the opinion of small organisations (i.e. storyboard (1.33), research collaboration (1.40), and external sources of knowledge (1.66)). Medium size organisation gave five techniques an average score of less than 2. The lowest three are knowledge manager (1.0), storyboards (1.5) and reassignment of people (1.5).

To examine the popularity of IT tools in different sized groups of construction industry companies, Table 6.16 and Figure 6.29 show a consistency between the three groups in terms of the three most popular tools; e-mails, websites, and e-file managers, with some differences in the ranking of each group. Small and medium companies ranked e-forum as the least popular tool (2% and 5% respectively). However e-forum did not appear in the least popular tools according to large size companies; indeed, 67% of the companies use it. The least popular tools include groupware in all three groups (2%, 5%, and 25%), CMS in medium and large companies (10% and 41%), e-messaging system in small companies (4.5%), and expert directory in large size companies (33%).

Table 6.16: Popularity and effectiveness of the IT tools – Small, medium, and large construction companies

	Small					Medium					Large				
Valid: 76 Missing: 2	TW	NR	AWR	P-RNK	E-RNK	TW	NR	AWR	P-RNK	E-RNK	TW	NR	AWR	P-RNK	E-RNK
14 Portal/Content management system	6	3	2.00	7	9	2	2	1.00	8	10	10	5	2.00	8	10
15 Custom-designed software	8	5	1.60	6	10	5	3	1.67	5	8	19	7	2.71	7	3
16 Expert Directory	22	10	2.20	4	5	16	7	2.29	4	5	9	4	2.25	9	9
17 E-mail	67	30	2.23	1	4	29	14	2.07	1	6	30	12	2.50	2	5
18 Websites	38	18	2.11	2	6	16	8	2.00	2	7	28	12	2.33	1	7
19 Electronic File manager	23	10	2.30	3	3	17	7	2.43	3	4	23	10	2.30	3	8
20 Electronic Forum	2	1	2.00	10	8	1	1	1.00	10	9	21	8	2.63	4	4
21 Groupware	2	1	2.00	9	7	3	1	3.00	9	1	9	3	3.00	10	1
22 Electronic Instant messaging system	5	2	2.50	8	1	5	2	2.50	7	3	20	7	2.86	6	2
23 Project Extranet	12	5	2.40	5	2	5	2	2.50	6	2	17	7	2.43	5	6

Regarding the effectiveness of the tools, Groupware was found to be the most effective tool in the case of medium (3), and large (3) companies. The e-messaging system was viewed to be near the top of the list as well, as it is ranked the first by small companies (2.5), second by large companies (2.86), and third by medium companies (2.5). Furthermore, project extranet is ranked the second most effective tool by small (2.4) and medium (2.5) companies. Although custom-designed software is ranked third by large companies, it gained a high average score (2.71).

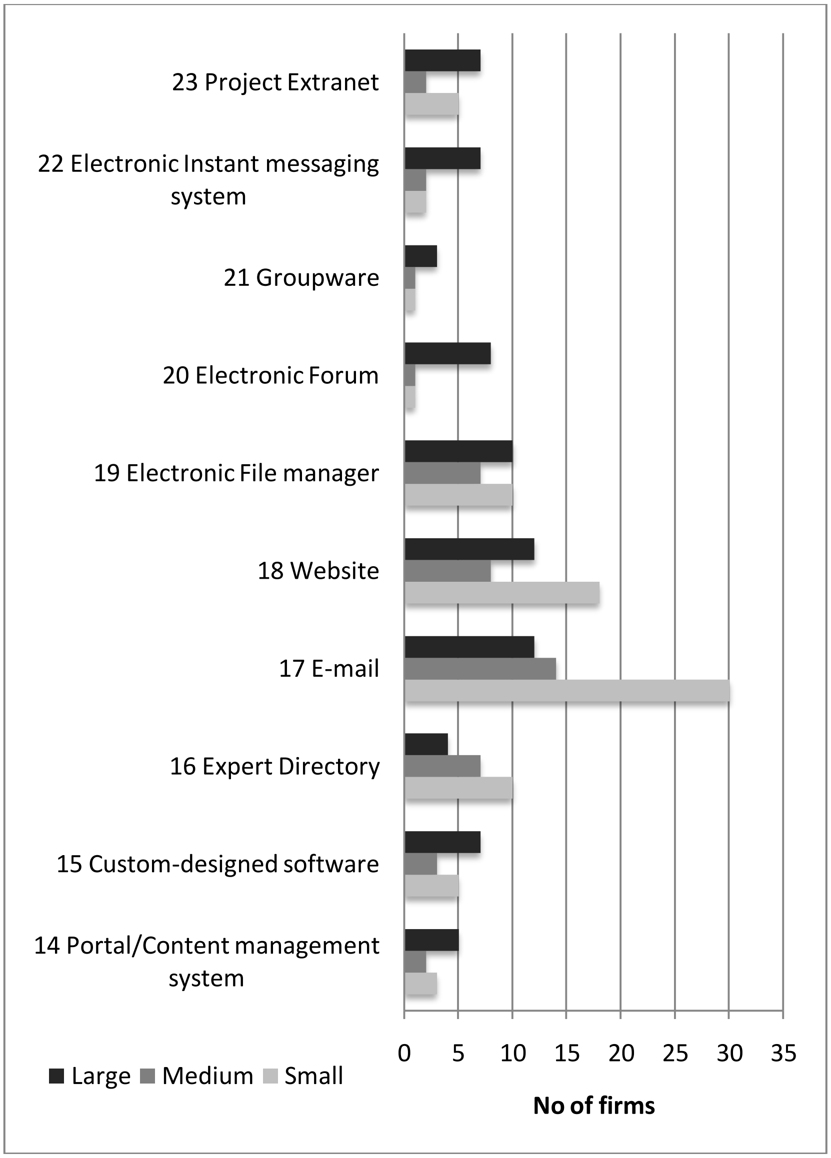


Figure 6.29: Popularity of IT tools - Small, medium, and large construction companies

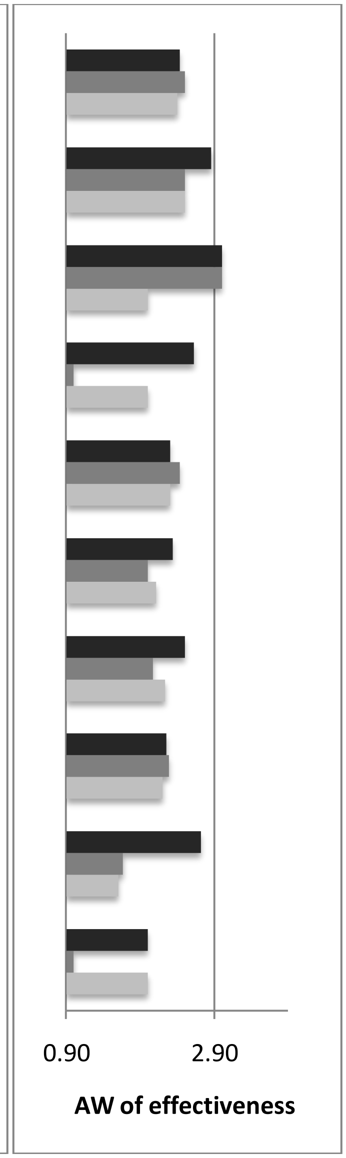


Figure 6.28: Effectiveness of IT tools - Small, medium and large construction companies

Moving to the least effective tools, small and medium companies agreed on identifying the three least effective tools. These include CMS (2, 1 by small and medium companies respectively), custom-designed software (1.6, and 67), and e-forum (2 and 1). The least three effective tools in the opinions of large companies are CMS (2), expert directory (2.25), and e-file manager (2.3).

6.8. **Project Review (PR) Practice**

This section presents and analyses the current practice of PR in the UK construction industry. Its purpose is to determine the aims, time schedules, methods and parties relating to PR.

6.8.1. ***The purpose of conducting project review***

Knowing the purpose behind conducting PR contributes to an understanding of the link between PR and KM in practice. This also can also lead to confirmation or rejection of the claim that PR is a knowledge capture technique, as discussed in section (4.8). The participants were asked about the purpose of project review, and provided with three possible answers: 1) To evaluate the project activities and team performance, 2) To capture the desired knowledge and use it in the future stages/projects, 3) other. It was communicated to the participants that they were free to select more than one answer.

As showed in Table 6.17, 50% of the randomly selected construction companies conduct PR to only evaluate project activities and project performances, 10% solely to capture the desired knowledge, and the remaining 40% of the sample conduct PR for both reasons. This indicates half of the construction companies (10% + 40%) are using the PR as a KM technique to capture requisite knowledge of the project, while the other half are not considering PR as a tool for capturing the desired information as showed in Figure 6.31.

Table 6.17: Purpose of project review according to those surveyed in the construction industry

			Top Companies	Industry	Total
The purpose of conducting project review	To evaluate the project activities and team performance	Count	20	35	55
		% within Group	33.9%	50.0%	42.6%
	To capture the desired knowledge and use it in the future stages/projects	Count	5	7	12
		% within Group	8.5%	10.0%	9.3%
	Both	Count	34	28	62
		% within Group	57.6%	40.0%	48.1%
Total		Count	59	70	129
		% within Group	100.0%	100.0%	100.0%

In the case of the top companies, 33.9% of top companies conduct PR solely to evaluate project activities and team performance, 8.5% to only capture the desired knowledge, and 57.6% conduct PR for the both reasons. With regard to the use of PR as a KM technique it was found that 66% of top companies are conducting PR to capture the desire knowledge, and the remaining 34% are not. This is illustrated in Figure 6.30 below:

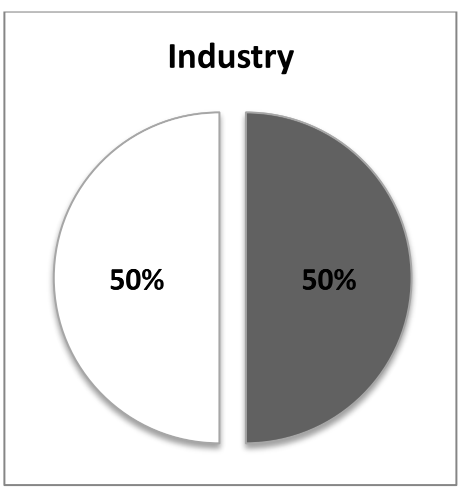


Figure 6.31: Purpose of PR throughout the random industry sample

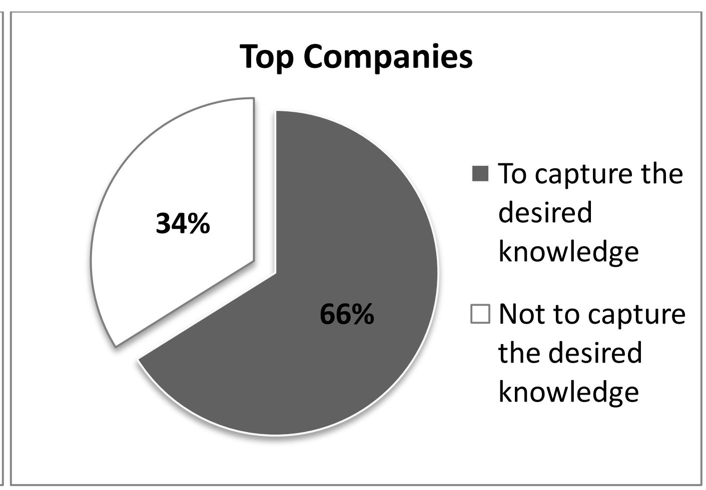


Figure 6.30: Purpose of PR in the top companies

The total response of the entire participants presented in Figure 6.32 indicates that 56% deploy PR to capture the desired knowledge, and the remaining 43% use PR solely to evaluate a project's performance.

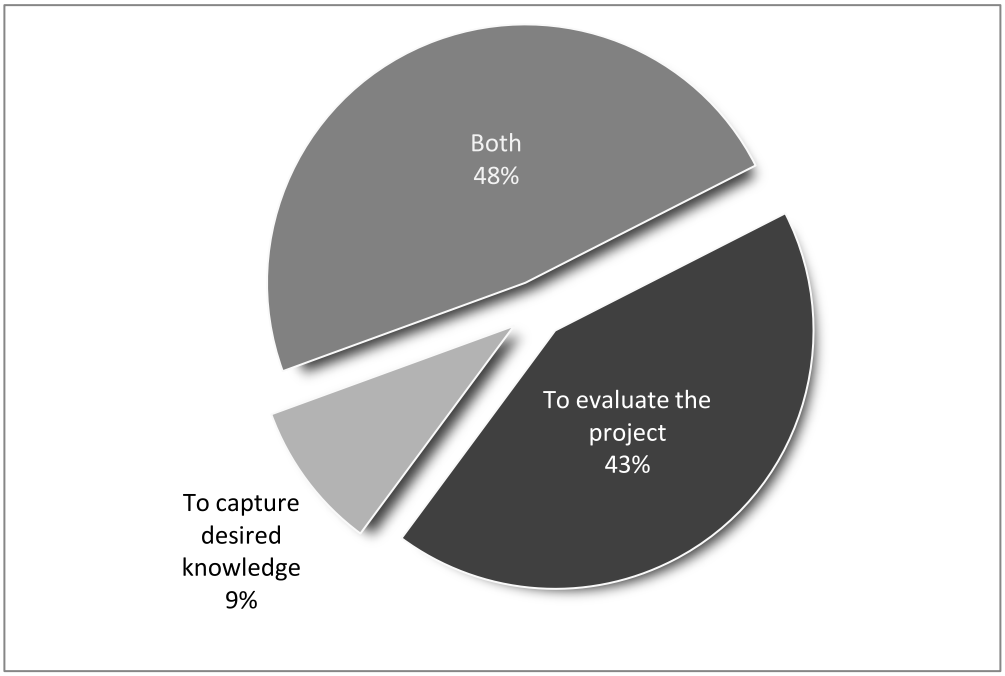


Figure 6.32: Purpose of PR according to all participants – percentage

Additional analysis presented in tables and figures is available in the appendix (4). Briefly, it shows that a higher percentage of consultants consider PR for the purpose of capturing desired knowledge than contractors. It was also found that a percentage of large sized companies consider KM in PR slightly more frequently than the small and medium sized companies. 57% of all participants are using PR to capture the knowledge they desire.

6.8.2. ***Timing for Conducting a Project Review***

The aim of this section is to discover when a project review is typically conducted, based on the stated practices of the majority. The information gained pertaining to PR timings will help in developing the framework at a future stage. Participants were given five choices, four are shown in Table 6.18 and the fifth choice was 'other'. There was a note informing participants that choosing more than one answer was acceptable.

The results revealed that the ranking of approaches to timing are the same for both the top companies and the other companies in the construction industry. As shown in Table 6.18 and Figure 6.33, PR was most commonly carried out 'immediately after project completion'. 56.5% of randomly selected companies and 55.9% of top companies applied this timing. The second most popular timing for PR was 'after the completion of project stages' since 43.5% of randomly selected companies and 54.2% of top companies are using this schedule. The percentage gap between the first and second most popular timing is not large: 13 percent in the randomly selected companies and 1.7 percent in the top companies. The third most frequently occurring timing for conducting a project review is with a time based schedule as it is used by 29.0% of the industry and 37.3% of the top companies. Conducting PR 'one to two years after project completion' was found to be a rare occurrence, with only 5.8% of the randomly selected companies, and none of the top companies applying this timing.

Table 6.18: Timing approaches of PR in the industry and top companies

Valid	128			Group		Total
Missing	11			Top Companies	Industry	
Conduction time of project review	After the completion of project stages		Count	32	30	62
			% within Group	54.2%	43.5%	
	Time based (e.g. weekly, monthly)		Count	22	20	42
			% within Group	37.3%	29.0%	
	Immediately after project completion		Count	33	39	72
			% within Group	55.9%	56.5%	
	1 to 2 years after project completion		Count	0	4	4
			% within Group	.0%	5.8%	
Total			Count	59	69	128

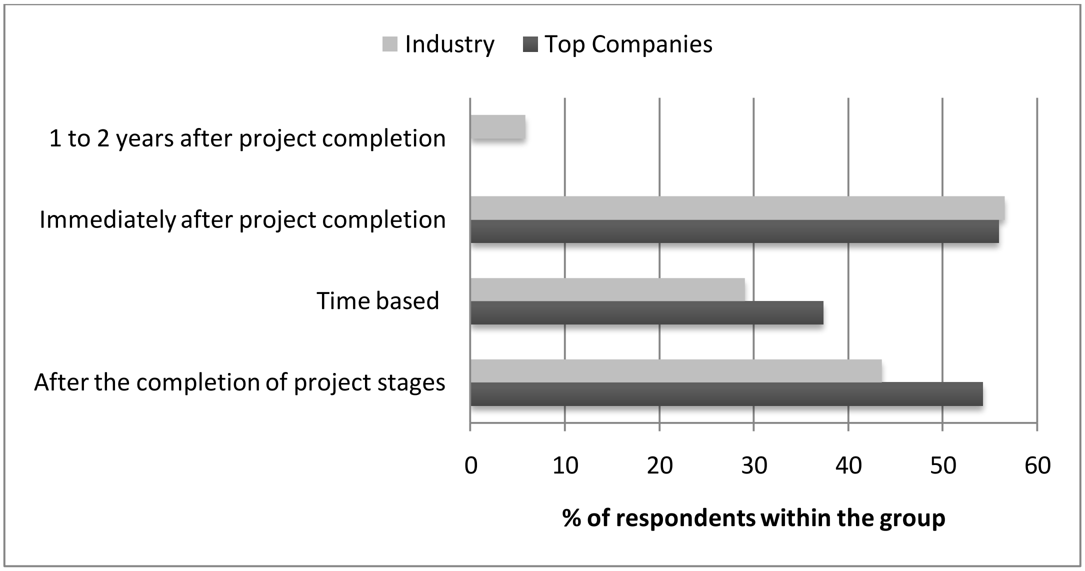


Figure 6.33: Timing approaches of PR in the industry and top companies

The ranking of timing approaches reveals no large gap in selection between 'immediately after project completion' (56%) and 'after the completion of project stages' (48.5%).

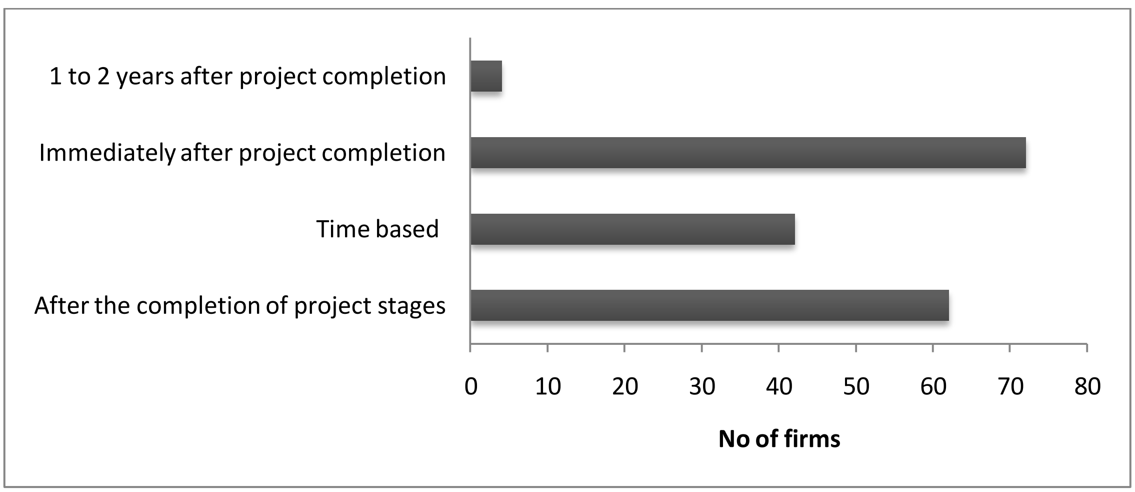


Figure 6.34: Timing approaches of PR in the entire participants

A number of companies were found to be using more than one timing approach towards PR in their projects. As can be seen from Figure 6.35, 83 (65%) of the participants adopted one timing approach; 38 (30%) used two timings; and 7 (5%), make uses of three possible timings.

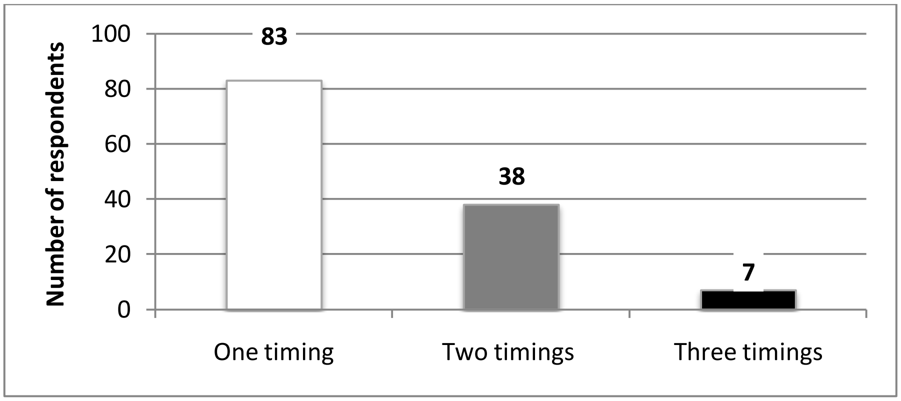


Figure 6.35: Number of timing approaches used in a project: entire participants

Other findings regarding the timing approaches within business groups (contractors and consultants), and organisation sizes groups are available in appendix (4). However those findings were not found to add any extra value to this study.

6.8.3. ***Project Review Method***

This section shows the possible PR methods and their spread and usage across the construction industry. Participants were given five choices (one of which was other) and selection of more than one answer was permitted. As Table 6.19 indicates, there is similarity between the randomly selected companies and the top companies in terms of the popularity of the various techniques. 'Cooperative team meeting' is the most famous

Table 6.19: PR methods in the industry and top companies

Valid	125			**Top Companies**	**Industry**	**Total**
Missing	14					
Project review method	Checklist		Count	32	36	68
			% within Group	57.1%	52.2%	
	Cooperative team meetings		Count	46	49	95
			% within Group	82.1%	71.0%	
	Document analysis		Count	16	14	30
			% within Group	28.6%	20.3%	
	Survey		Count	9	8	17
			% within Group	16.1%	11.6%	
Total			Count	56	69	125

method as 71% of randomly selected companies and 82% of top companies use it; then comes the ‘checklist’ with 52% and 57%; ‘document analysis’ forming 20% and 29%; and finally the survey method with 11.5% and 16% of the randomly selected companies and top companies respectively.

Figure 6.36: PR methods in the industry and top companies

All the participants provided the same order for PR methods; 76% of participants companies deploy cooperative team meetings, 54.5% uses checklists, 24% use documentary analysis, and 13.5% adopt the survey method.

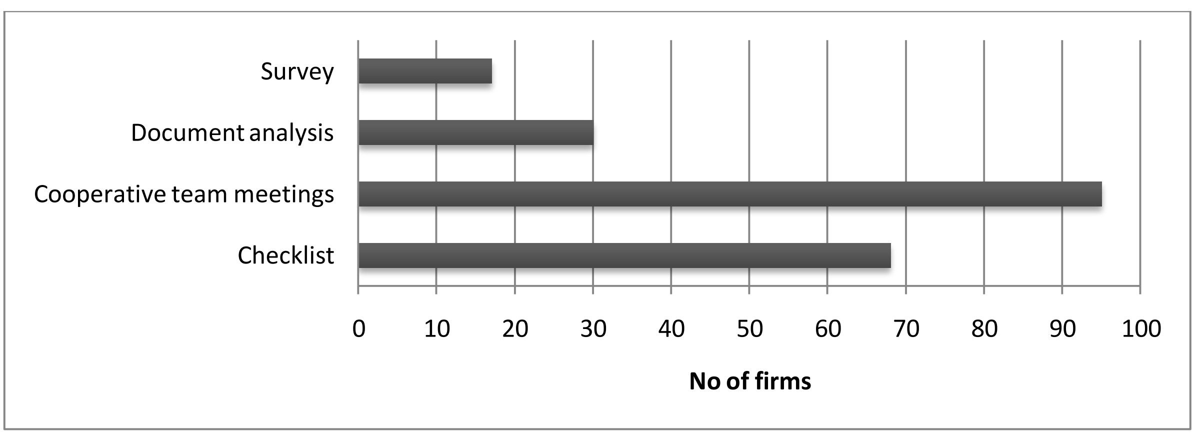


Figure 6.37: PR methods in the entire participants

Additional findings available in appendix (4) indicate that the analysis of business groups and yields relatively similar results across the companies surveyed.

6.8.4. *Coordination with project parties*

This section seeks to detect the status of coordination with the involved parties when conducting PR. The question that was asked is: ‘Does you organisation conduct the project review in coordination with the other parties involved in the project?’ Three answers were provided as shown in Table 6.20.

The results revealed that there is a minor distinction between the practice of randomly selected companies and top companies in this regard. The majority of participant companies coordinated with some of the project parties and this group forms 70% of randomly selected companies and 58.5% of top companies. However, a small percentage of randomly selected companies (18.5%), and slightly more top companies (24%), coordinated with all of the involved parties. This does not necessarily indicate that top companies are considering coordination with project parties more than randomly selected companies, because the percentage of top companies that did not coordinate with project parties at all (17.2%) is slightly higher than that of randomly selected companies (11.4%). Surprisingly the percentage of top companies that coordinate with either some or all of the project parties (82.8%) is slightly less than reported from the randomly selected companies (88.6%).

Table 6.20: PR and coordination with project parties

Valid	128		**Group**		**Total**
Missing	11		**Top Companies**	**Industry**	
Coordination with project parties	Yes, with all parties	Count	14	13	27
		% within Group	24.1%	18.6%	21.1%
	Yes, with some parties	Count	34	49	83
		% within Group	58.6%	70.0%	64.8%
	No	Count	10	8	18
		% within Group	17.2%	11.4%	14.1%
Total		Count	58	70	128
		% within Group	100.0%	100.0%	100.0%

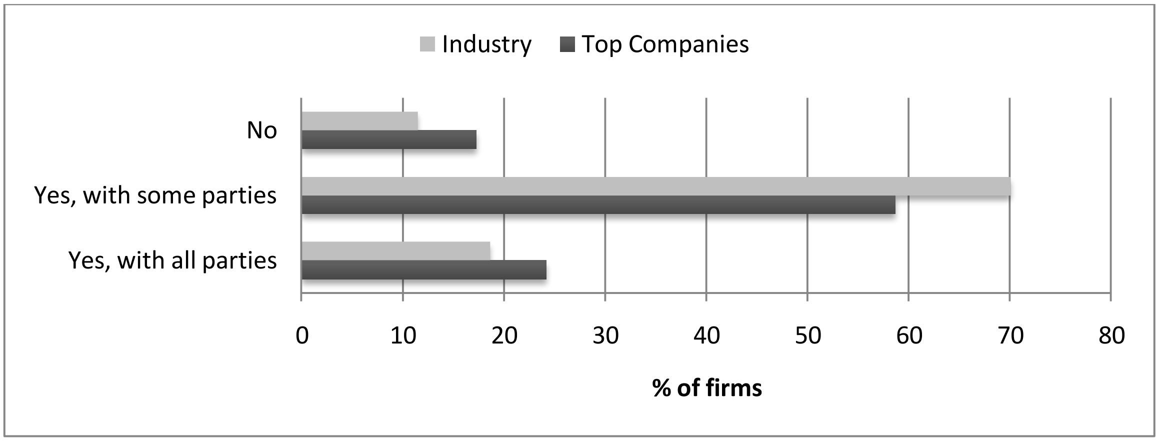


Figure 6.38: PR and coordination with project parties: industry and top companies

The answers given by participants show that 67% of companies coordinate with some project parties when conducting PR, and 22% coordinate with all the project parties. Therefore this means that the vast majority of companies coordinate with either some or all of project parties, i.e. 89% of all participants. Only 11% of companies do not coordinate with project parties when conducting the PR.

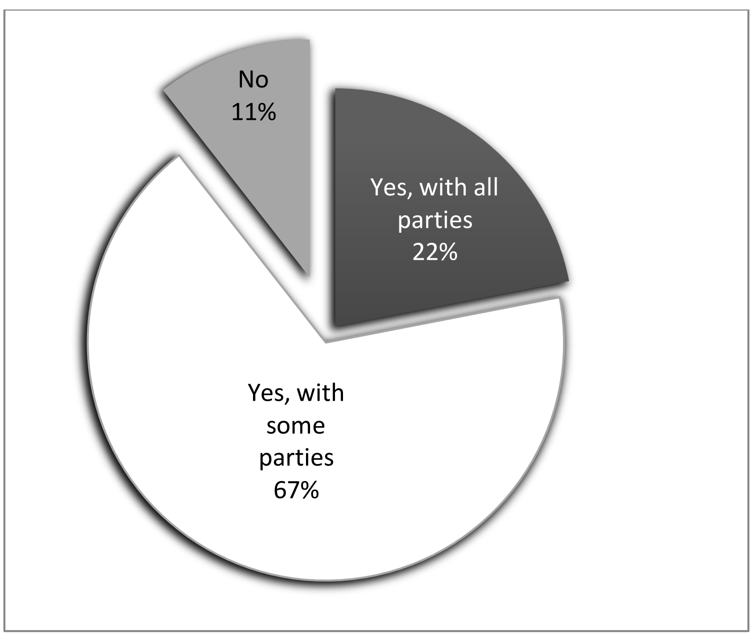


Figure 6.39: PR and coordination with project parties: all companies

No obvious relationship was identified between those parties involved in PR and the business and size of the organisations. However appendix (4) includes tables and figures showing the coordination of PR in relation to type of business and size of companies.

6.9. **Research hypotheses and questions tests**

This section will summarise the answers given to the research questions, and test the null hypothesis:

Research: hypothesis

- Most construction companies have not commenced KM practices.
- Top companies are more mature than the randomly selected companies in relation to KM.
- Large organisations are more mature than small and medium organisations in relation to KM.
- Construction companies conduct project reviews without coordination with the other parties involved in the project.

Research questions:

- What are the most popular and efficient KM techniques and IT tools in the industry?
- Do construction industry companies conduct project reviews to capture the desired knowledge?
- When is a project review usually conducted?
- What are the methods available for conducting project reviews?

6.9.1. ***Hypothesis 1: KM practice vs. pre-practice in the industry.***

The research questionnaire provided an organisational maturity matrix for KM. The maturity matrix was adapted from Robinson *et al.* (2005), and modified to suit the research purposes. The first stage indicates that the organisation is ‘not aware of the benefits of KM’, and that the level of maturity increased gradually until it reached the fifth stage; the most advanced level.

Knowing KM current practice amongst construction industry companies tells us to what extent research for a solution is still required. The research hypothesis would rely on the CIRIA statement: "Most construction companies are still at the stage of building their awareness or understanding of KM" (CIRIA, 2005). However, to cover all the possible outcomes of the test, the research hypothesis (denoted by H_1) and null hypotheses (denoted by H_0) are as follows:

Research hypothesis: Most of the construction companies have not initiated KM.

Null hypothesis: Most of the UK construction companies have already initiated KM

In order to test the null hypotheses it was necessary to divide the five stages of KM into two groups. The first, entitled “pre-practice”, includes organisations that are at the first and second KM stages; the second group, referred to as “practice” includes companies that are currently at stages 3 to 5.

The binomial test will be used to determine if the proportion of people in each of the two categories differs from a specified amount (P). The value of P has been assigned as .51 so as to determine if there is significant majority.

H_1: $P \geq .51$

H_0: $P < .51$

Where P is the proportion of people who selected ‘practice’.

Table 6.21: Binomial test: practice – pre-practice in construction industry companies

		Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (1-tailed)
KM stage of maturity	Group 1	Pre-practice	55	.71	.51	.000(a)
	Group 2	Practice	23	.29		
Total			78	1.00		

Based on Z Approximation.

The results indicate that there is a statistically significant difference (p = .000 < .05);,as a consequence of which, the null hypothesis can be rejected. The observed proportion indicates that the majority group is the ‘pre-practice’ group. Therefore, it could be claimed that at least 51 percent of the UK construction companies have not started the practice of KM.

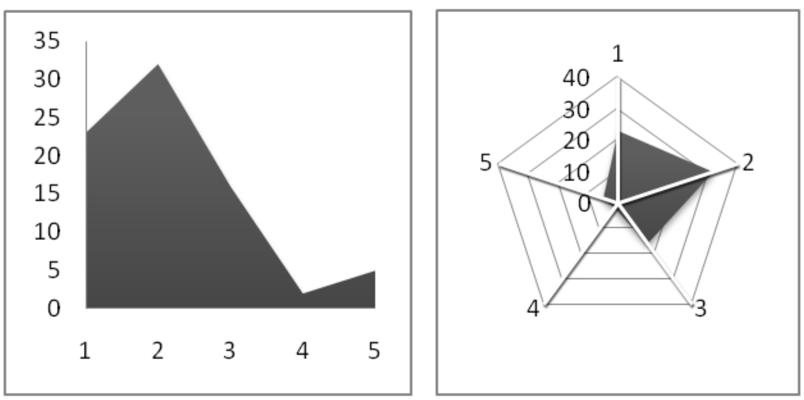
Several attempts were made to identify the maximum significant proportion of organisations that have not practiced KM. It was found that at the 0.05 significance level (p=.036), 60% of the UK construction companies have not started the practice of KM.

Table 6.22: Binomial Test: the maximum significant proportion of pre practice in construction industry companies

		Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (1-tailed)
KM stage of maturity	Group 1	Pre-practice	55	.7	.6	.036(a)
	Group 2	Practice	23	.3		
Total			78	1.0		

Based on Z Approximation.

Histogram and radar charts (Figure 6.40) provide additional indications of how the majority of construction industry companies are spread over the first and second KM level of maturity. In addition, evidence in section 6.7.1 shows that 91% of companies are still at one of the first three stages.



Code	Stage
1	Pre-awareness
2	Start-up
3	Take-off
4	Expansion
5	Sustainability

Figure 6.40: Distribution of the industry companies among the five levels of KM.

6.9.2. ***Hypothesis 2: KM maturity level: Industry vs. Top companies.***

It was hypothesised that top companies practices of KM would be found to be more mature than those of the randomly selected companies. Evaluation of this will enable the researcher to determine if there is a need to focus on top companies' practice in the next stage of the project.

The Research Hypothesis: Top companies are more mature than randomly selected companies in relation to KM

The Null Hypothesis: Top companies are not more mature than randomly selected companies in relation to KM.

H_1: $\mu_{Tc} > \mu_{Ic}$

H_0: $\mu_{Tc} \leq \mu_{Ic}$

In order to test the null hypothesis, the Mann-Whitney test was selected. It is considered to be one of the best non-parametric tests to test significant differences between two independent groups (Top companies and Randomly selected companies) on an ordinal variable (KM stage of maturity).

Table 6.23: Mann-Whitney test: KM maturity in industry and top companies

	Group	N	Mean Rank	Sum of Ranks
KM stage of maturity	Top Companies	61	87.89	5361.50
	Industry	78	56.01	4368.50
Total		139		

	KM stage of maturity
Mann-Whitney U	1287.500
Wilcoxon W	4368.500
Z	-4.806
Asymp. Sig. (2-tailed)	.000

The result indicates that there is a significant difference between the two groups (p = .000). The mean and sum ranks reflect that the average level of KM maturity of top companies is statistically larger than the average level of companies in the industry; therefore, the null hypothesis can be rejected. Figure 6.41 and Figure 6.42 below, show a box plot and histogram charts to illustrate the location and variation changes between top companies and randomly selected companies on the level of KM maturity. Both of the figures indicate that the major distribution of top companies falls within levels two, three and four, and that the median of distribution is level three. Meanwhile, the randomly selected companies are distributed among the first, second and third levels forming medians in the second level.

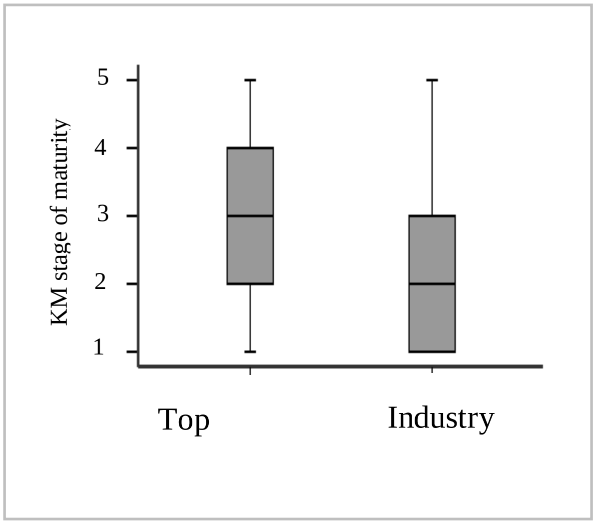


Figure 6.41: Distribution of industry companies and top companies among KM stages of maturity – Box plot

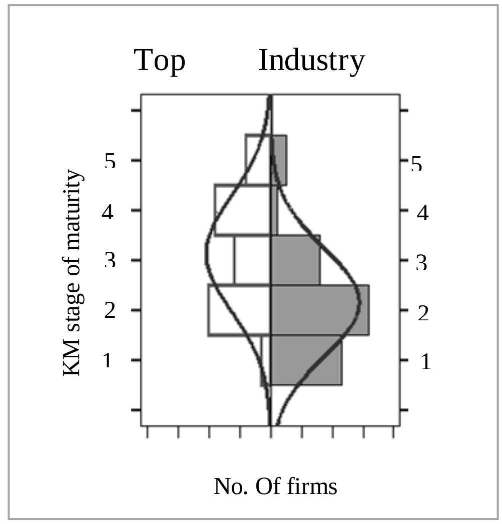


Figure 6.42: Distribution of industry companies and top companies among KM stages of maturity – Histogram

6.9.3. ***Hypothesis 3: The relationship between KM stage of maturity and the number of KM techniques and IT tools***

It is expected that the proposed solution to this research will include a number of KM techniques and IT tools. This leads to several questions regarding the proposed solution: What if the proposed solution includes large number of techniques and tools? And: Does that indicate it is not applicable? To address these potential issues it was decided to determine the relationship between the number of KM techniques and IT tools in use and the maturity stage of KM .

Research hypothesis: The maturity stage of KM is related to the number of KM techniques and IT tools in use

Null hypothesis: The maturity stage of KM is not related to the number of KM techniques and IT tools in use

H_1: r = 0

H_o: r ≠ 0

Where r = the value of the correlation coefficient

Spearman's rank correlation coefficient was found to be an appropriate test since it assesses the relationship between two dependent variables.

Table 6.24: Spearman's rank correlation coefficient: the relationship between KM stage of maturity and the number of KM and IT tools

			KM stage of maturity	No. of tools and techniques
Spearman's rho	KM maturity stage	Correlation Coefficient	1.000	.549(**)
		Sig. (2-tailed)	.	.000
		N	78	77
	Number of tools and technique	Correlation Coefficient	.549(**)	1.000
		Sig. (2-tailed)	.000	.
		N	77	77

** Correlation is significant at the 0.01 level (2-tailed).

The results suggest that the relationship between KM maturity and the number of KM techniques and IT tools (rho = 549, p = 0.000) is statistically significant; therefore, the null hypothesis can be rejected.

The Scatter and box plots in Figure 6.43 and Figure 6.44, show that the number of KM

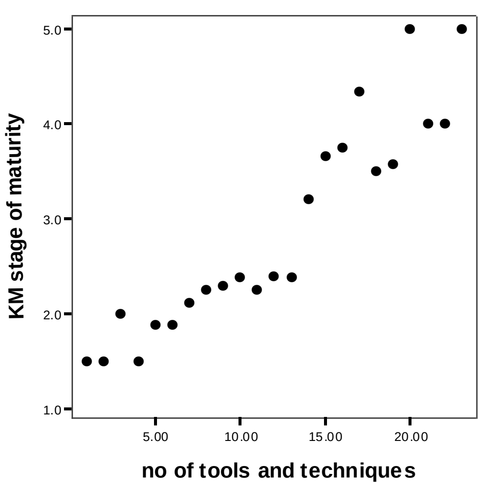


Figure 6.43: The relationship between KM stages of maturity and the number of KM techniques and IT tools – Scatter plot

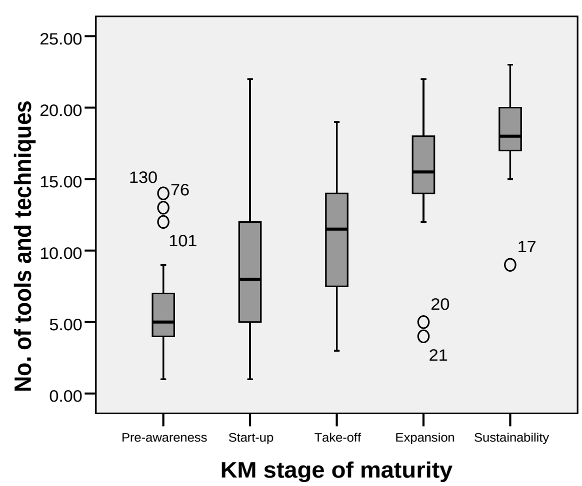


Figure 6.44: The relationship between KM stages of maturity and the number of KM techniques and IT tools – Box plot

techniques and IT tools applied by construction industry companies increases as the maturity of the application of KM increases.

6.9.4. *Hypothesis 4: Conducting a project review in coordination with other parties involved in the project.*

It is imperative to understand how construction companies conduct project reviews in coordination with other parties involved in a project. This information will be significant in designing the proposed approach as it will highlight any necessity regarding consideration of additional situations (i.e. project review within the other project parties) relating to the project review.

Research hypothesis: Construction organisations conduct project reviews in coordination with all or some parties involved in the project.

Null hypothesis: Construction organisations do not conduct project reviews in coordination with all or some of the parties involved in the project.

Chi-square will be used in this test, since it tests whether the observed proportions for a categorical variable differ from hypothesized proportions.

H_0: p = .05

H_1: p $\neq$ .05

Table 6.25: Chi-square test: PR coordination with project parties

	Observed N	Expected N	Residual
Conduct PR with all or some project parties	62	35.0	27.0
Do not conduct project review with the other parties in the project.	8	35.0	-27.0
Total	70		

	Coordination with other parties
Chi-Square(a)	41.657
df	1
Asymp. Sig.	.000

0 cells (.0%) have expected frequencies of less than 5. The minimum expected cell frequency is 35.0.

The results suggest rejection of the null hypothesis, as p = .000 < .05. This indicates that there is statically relevant difference between the two groups. Based on the residual values, it could be claimed that construction companies conduct project reviews in coordination with all or some parties involved in the project. However it should be considered that, this answer does not mean companies do not conduct internal project reviews.

6.10. **Research questions:**

6.10.1. ***Question 1: Most popular and effective KM techniques and IT tools***

- ***What are the most popular and effective KM techniques and IT tools in the industry?***

The availability percentage (or the spread level) of KM techniques and tools in construction companies are shown in Table 6.26. Two key points can be observed here; firstly, KM techniques are deployed more than the IT tools; secondly, IT tools are available in low percentages, with a maximum of 50% (not including ‘e-mail’ which is available in 74% of companies).

KM Techniques	Skewness	Mean	Std.	Avl. %	IT Tools	Skewness	Mean	Std.	Avl. %
Project review	-1.311	2.64	.568	91	E-Groupware	-2.236	2.80	.447	7
Knowledge team	-1.114	2.46	.776	17	E-instant messaging system	-1.189	2.73	.467	14
Training	-.351	2.38	.593	72	Project extranet	-.692	2.43	.646	18
Knowledge manager	-.847	2.36	.809	14	E-forum	-.780	2.40	.699	13
Mentoring	-.499	2.30	.702	39	E-file manager	-.530	2.33	.679	36
Preparation of standard details	-.391	2.26	.693	57	E-mail	-.417	2.25	.720	74
Discussion groups	-.308	2.15	.834	34	Expert Directory	-.368	2.24	.700	28
Knowledge recording	-.106	2.07	.728	58	Website	-.045	2.16	.594	50
Apprenticeship	.073	2.06	.539	24	Custom-designed software	-.227	2.13	.743	20
Storyboards	.190	1.91	.831	14	Portal/CMS	.407	1.80	.789	13
Reassignment of people	.161	1.88	.697	22					
Research collaboration	.151	1.86	.663	18					
External sources of KM	.596	1.69	.769	64					

Std.: Standard deviation
Avl..: Availability in the construction companies

Table 6.26: Effectiveness and availability of KM techniques & IT tools – Construction companies

The mean value shown in Table 6.26 indicates the degree of effectiveness relevant to techniques and tools. However, it does not directly indicate when an item can be considered effective. On the other hand, Skewness measures test the degree of asymmetry of a distribution. Negative value means that the mass of distribution encourages the impression that techniques/tools are effective, and vice versa. The techniques and tools are shown in a descending order according to the mean score, and those considered effective (negative Skewness values) are shaded in grey. The answers provided by top companies can also be beneficial; since it was proved that their practice is more mature than that found in the randomly selected companies. It could be observed from Table 6.27 that the technique, 'knowledge manager', is not considered effective; whilst 'research collaboration', which has smaller mean value, is considered effective. This means that the trend of answers or the mass distribution is not inclined to effectiveness of the 'knowledge manager' despite its mean score being 2.05 out of 3.

Table 6.27: Effectiveness and of KM techniques & IT tools – Top companies

KM Techniques	Skewness	Mean	Std.	IT Tools	Skewness	Mean	Std.
Project review	-1.080	2.65	.517	**E-forum**	-.369	2.59	.501
Training	-.605	2.42	.629	**E-instant messaging system**	-.863	2.46	.660
Knowledge team	-.224	2.28	.614	**Project extranet**	-.243	2.32	.599
Preparation of standard details	-.511	2.27	.765	**Portal/CMS**	-.595	2.30	.770
Mentoring	-.374	2.27	.672	**Expert Directory**	-.301	2.28	.634
Knowledge recording	-.370	2.26	.678	**E-file manager**	-.365	2.28	.659
Knowledge manager	.051	2.11	.567	**E-mail**	-.341	2.26	.664
Research collaboration	-.032	2.05	.621	**E-Groupware**	-.336	2.21	.713
Apprenticeship	.042	1.97	.680	**Website**	-.042	2.19	.585
Storyboards	.099	1.92	.688	**Custom-designed software**	-.273	2.14	.803
Reassignment of people	.120	1.91	.702	Std.: Standard deviation			
Discussion groups	.284	1.85	.802				
External sources of KM	.353	1.80	.755				

6.10.2. ***Question 2: The purpose of conducting project review***

- ***Do construction companies conduct project reviews to capture required knowledge?***

Half (50%) of the companies surveyed conduct a project review to capture desired knowledge; however, 80% of those who use PR to capture knowledge also use PR to evaluate project activities and team performance. This means only 10% of companies are conducting PR solely to capture desired knowledge. For more details, refer to section 6.8.1.

6.10.3. ***Question 3: Timing for conducting a project review***

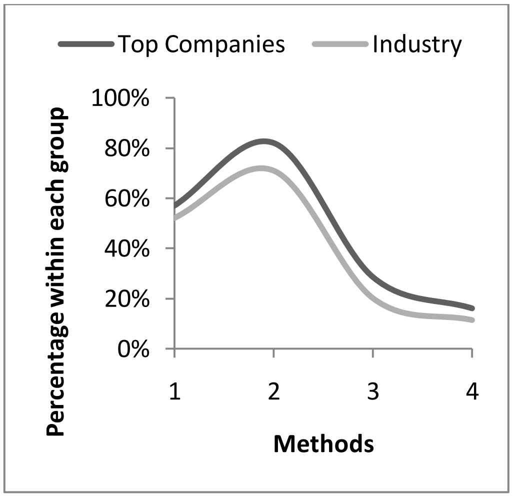
- ***When the project review is usually conducted?***

The vast majority of construction industry companies conduct project reviews immediately after project completion (56.5%), and/or at the end of project stages (43.5%). However, about a third of companies (29%) carry PR on a time based cycle (e.g. monthly). On the other hand, conducting PR one to two years after project completion seems not to be preferable to the vast majority, since only 5.8% deploy this approach to timing. It is worth mentioning that 35% of all surveyed companies deploy more than one timing approach. For more details, refer to section 6.8.2.

6.10.4. ***Question 4: Methods/techniques of conducting project review***

- ***What are the available methods/techniques of conducting project review?***

All four methods/techniques of PR are deployed in the industry and no other method was suggested. Two major elements are considered here: Firstly, that the population distribution of both groups (industry and top companies) on the PR methods is almost the same, as shown in Figure 6.45. Secondly, cooperative team meeting and checklists were found to be popular, while survey and document analysis are deployed by a small percent of the companies. This is illustrated in Figure 6.46. For more details, refer to section 6.8.3.



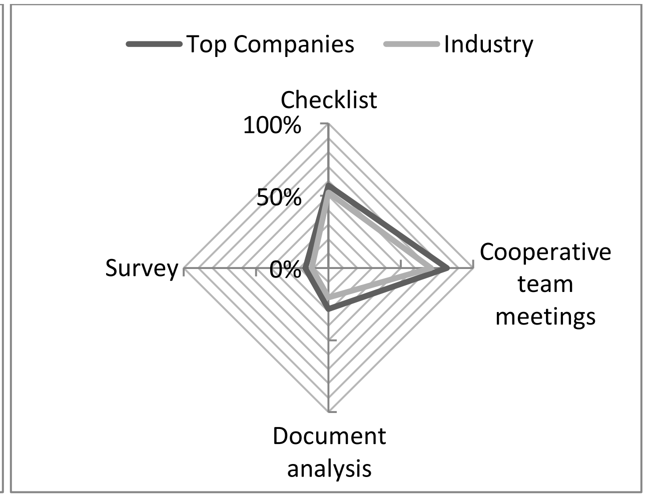


Figure 6.45: Distribution of industry and top companies regarding PR

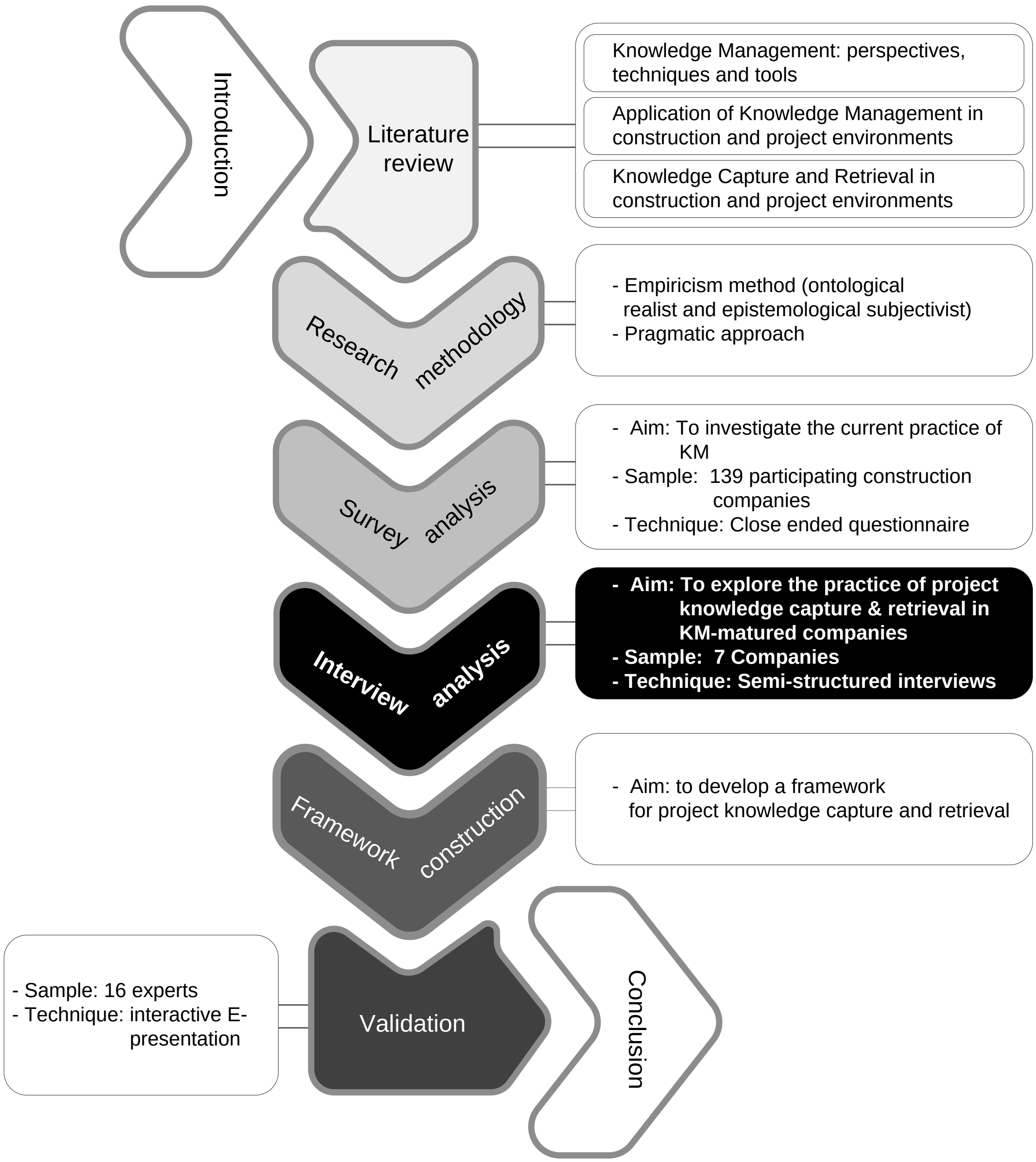
Figure 6.46: Distribution of the popularity of PR methods

6.11. **Summary**

The chapter considered the first question of the research, which relates to understanding the current practice of KM. The answer was provided by the 139 participating companies using a close-ended questionnaire survey. The evidence from this study suggests 91% of the companies are mainly distributed amongst the first three levels in terms of KM maturity (i.e. pre-awareness, start-up and take off stages). Furthermore, at least 60% of UK construction companies have not started the practice of KM, and are still in the first two stages. This provides a solid foundation and a robust motivation for undertaking this study. The second major finding was that top companies are more mature than randomly selected companies in relation to KM. The mean level of KM maturity in a top company is at the third level (take-off stage), while it is at the second (Start-up stage) in randomly selected companies. Therefore, it seems that paying some attention to top companies at the next stage (i.e. exploring the best practice) would be an advantage. It was also shown that as companies' levels of maturity increase the number of KM techniques and IT tools deployed also increases. A number of KM techniques were found to be effective; however, some of the effective techniques and tools are available at low percentages in the randomly selected companies.

One of the most significant findings to emerge from this study is that PR was found to be the most popular, and effective KM technique throughout the industry. This indicates that PR is an appropriate major theme for the next stage of the research. The results of investigating the practice of project review (PR) show that half of companies use PR to capture desired knowledge, which was an unexpected finding. In addition, three PR timing approaches are deployed in the industry, and more than a third of the companies use more than one PR timing approach. Generally, construction companies were found to conduct project reviews in coordination with some or all parties involved in the project. Finally *cooperative team meeting* and *checklist* were found to be popular in the practice of PR.

CHAPTER 7: INTERVIEW ANALYSIS: BEST PRACTICE



7.1. **Introduction**

The first objective of this study was accomplished with the current practice of KM being reported in chapter six. This chapter aims to address the research question: how is project knowledge captured and retrieved effectively in advanced practice? The answering of which will fulfil the second objective of the research. The chapter presents results and analysis based on data collected from carefully selected companies through the means of semi-structured interviews.

This chapter consists of two parts: 1) to detail the participants and identify the criteria that were used in their selection, and, 2) to describe and justify the methodology applied to conduct and analyse the interviews. The second part focuses on the main objectives covered by the interview by reporting results and analysing them. The objectives of the interviews are to investigate the best practice for project knowledge capture and retrieval (PKCR) in a sample of matured construction companies. In addition to explore solutions to PKCR offered outside the industry in a sample including the world leading KM educational institute, and a project-based organisation. The analysis of the interviews should provide information that is sufficient to construct a PKCR framework as the next stage.

7.2. **Research approach**

To choose the most appropriate approach, we must first determine: what knowledge we wish to acquire; what data needs to be collected; why we want the data; and the sources available and applicable for collecting the desired data. In the early stages of the research process, in order to fulfil the criteria determined upon, the qualitative method of research is appropriate.

Qualitative research is concerned with processes, rather than outcomes or products. It focuses on meaning instead of drawing statistical inferences. In addition qualitative data is exploratory focusing on how people make sense of their lives, experiences, and the structure of their world (Merriam 1988; Creswell 1994). This stage involves collecting qualitative data, as the data targeted refers to the processes and techniques of knowledge capture and retrieval.

Qualitative research is not designed to test a hypotheses as is quantitative research; instead its aim is to build theory, this theory would be then tested or validated (Dooley 1984; Glesne and Peshkin 1992).

7.3. **Research technique**

The available and applicable data sources are the experts in the area under investigation. Thus, data acquisition is achieved by conducting interviews with a number of experts from carefully selected companies. In qualitative research reality is socially constructed, and so data is delivered through people (Glesne and Peshkin 1992). In this instance interviews were the only appropriate method for collecting data. The other qualitative methods of data collection are either unsuitable for this study or appropriate (e.g. case studies) or not available to the researcher, due to issues of accessibility.

Furthermore, this stage was designed to explore mature KM practices. One characteristic of qualitative interviews is that the researcher may have no complete picture about the area being investigated (Glaser and Strauss 1965; Calder 1977; Glaser and Strauss 1977; Jick 1979). This explains why qualitative research is most often recognised as exploratory research.

7.4. **Interviews approach**

Interviews are one of the most widely used techniques for gathering qualitative data. Literature is rich in definitions of interview techniques. Many of those definitions are similar in meaning to Kvale's: "An interview is literally an *inter view*, an inter change of views between two persons conversing about a theme of mutual interest" (1996).

Various methods have been developed and introduced to conduct interviews. These methods have been presented with different meanings and names. So as to avoid confusion the following sub-sections present different classifications of interview types, determining the method used for this research and highlighting the reasons why those methods have been chosen.

7.5. **Interview Structure**

The Society for Applied Anthropology (1954) classified interviews in terms of structure into three main types; structured, semi-structured, and unstructured interviews. The structured interview (also called the standardised interview) has a predetermined set of questions. Questions in structured methods are asked exactly as prepared with the same wording and in the same order (Kumar 2005). It is also likely that questions in structured interviews will have a pre-defined limited set of answers; this makes structured interviews particularly useful for testing hypotheses or making generalisations.

On the contrary, the unstructured and semi-structured interview both deploy open ended questions. They aim to elicit genuine responses and to identify people's views, opinions, attitude and experiences. The phenomena being studied are often complex and multidimensional; they are not easily captured through other methods like the survey questionnaire or structured interviews (Becker and Bryman 2004). In semi-structured (or in-depth) interviews, the researcher has a fixed set of themes or topics to discuss (Fitzpatrick and Boulton 1994), which do not have to follow a specific predetermined order (Grix 2001). On the other hand, in unstructured interviews, the researcher has no structure as the name suggests, but may have some idea about the general phenomena being explored. Unstructured interviews might be difficult to guide and require highly skilled interviewers.

The semi-structured interview is used in this research. The structured method is not appropriate for exploratory research and for building concepts. Although, unstructured interviews are more suitable for investigating a general area (Saunders *et al.* 2009) they can be very time consuming, and due to the lack of structure, more than one interview with every participant may be needed.

The semi-structured interview is flexible in that, questions can be changed or added according to the evolving interview situation. At the same time it is controllable, not difficult to manage, and suitable for obtaining the necessary data from interviewees in a sensible timeframe, targeted on expertise.

7.6. **The number of people present**

The number of interviewees being interviewed simultaneously is also important for categorising the unstructured interview. One-to-one and one-to-many are the alternative methods of communication (Powney and Watts 1987). These should consider that this method of categorisation is not applicable to structured interviews (Saunders *et al.* 2009). To achieve confidentiality, the one-to-one approach has been employed in this study. One-to-one interviews are “easier to manage; issues can be kept relatively confidential, analysis is more straight forward in that only one person's set of responses are gathered at any one time” (Powney and Watts 1987).

7.7. **Method of Interaction**

Semi-structured and unstructured interviews can be conventionally categorised according to the method by which the interviewee and interviewer interact. There are several types of interaction that are applicable to interviews. However, face to face, by phone, and internet mediated are the most popular methods (Gubrium and Holstein 2002). Without doubt, face to face interview is the most efficient and thorough method (Sarstedt and Mooi 2011), because face-to-face is a direct method of interaction, while the other two methods are mediated methods. Non-direct methods of interaction would typically be considered where face to face methods are not possible, or difficult to deploy. Face to face is the method applied in this research, and was selected simply because the opportunity was available so there was no need to use secondary methods. The interviewer considered interviewing by telephone in one instance, but circumstances changed and a face to face interview was arranged. While the face to face method is the most efficient in terms of the interview quality and control, the other two methods described can be used to save time and money.

7.8. **Methodology: Perspective**

Fitting all the elements of the interview methods together, and linking them with an original research method, can give us a current and up to date strategic view of the whole situation under investigation. As Figure 7.1 shows, this stage is rooted in the philosophy of empiricism, which is the solid grounding on which the research stands. From this foundation, the research process can be finalised, the data collection techniques confirmed and the purpose of the research achieved.

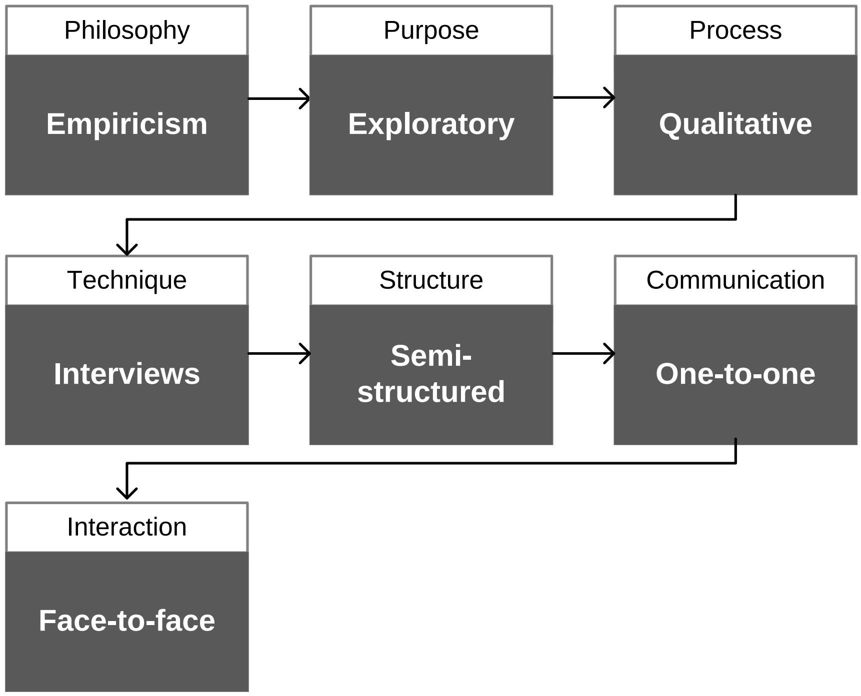


Figure 7.1: Perception of the research approach from the interviewer's perspective

7.9. **Setting the themes**

Qualitative researchers increasingly use theoretical lenses or perspectives to guide their study (Creswell 1994). What to ask in the interviews may the biggest concern and is crucial to determine at the preparation stage. However in the semi-structured interviews, it is important to establish the context of the interview; by identifying interview themes. There are several methods of setting up the context of the research, one method maybe appropriate for one particular piece of research but it may not be the right method for another. Anderson (2004) highlighted that clarification of what research objectives or questions the interview data will contribute towards answering, will assist in identifying the key themes that need to be explored with interviewees. Themes can also be driven from theories discussed in the literature (Rugg and Petre 2007), the researcher's experience of a particular topic, common sense, discussions with co-workers, fellow students, tutors and research participants, or a combination of these (Saunders *et al.* 2009). In this research, the themes of the interviews where identified mainly based on the research questions. However more precise areas were created under each theme, and were driven by theory (or literature).

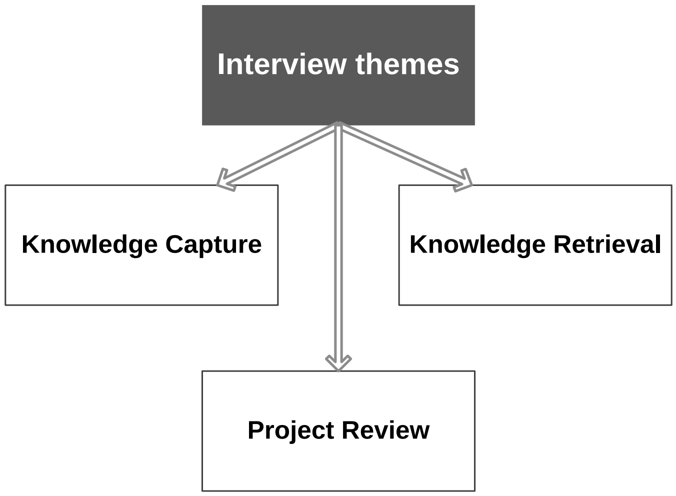


Figure 7.2: Major themes of the interviews

Three major themes were identified for the research interviews, and these themes will be explored in depth. To keep away from questions that may lead the interviewee to a particular answer, and to avoid presenting the interviewer's understanding of the investigated areas, it was decided to begin by asking one open question for every theme; this is the "how" question (e.g. could you explain, how you capture knowledge from your projects?). This will help in attaining a clearer picture of the practice than by asking particular questions. Nevertheless, to achieve the objectives of the study, it is necessary to have some control over the interview. There is a need to ensure the discussion is on the right trail, and that previously identified key points are covered. Open questions do not mean it is possible to have control over the interview. Prompting and probing are techniques that can be used to help achieve the objectives from the interview (Gillham 2000). The scenario of the interview will depend on the answers given. It was expected that some of the interviewees would go through those key points with no need prompt them. However in case an interviewee does not cover any of these points the interviewee will be prompted; (e.g. what about the technology you use to capture knowledge?) In addition, probing questions will be used to acquire more information from the subject (e.g. could you explain more about the way you conduct a project review?).

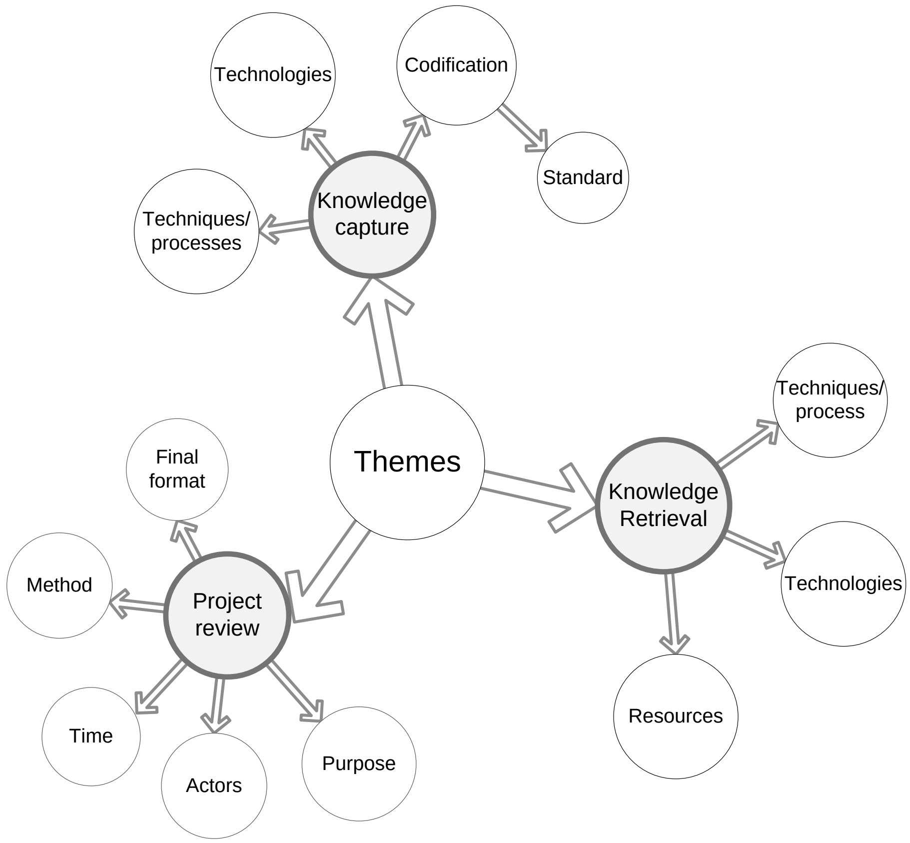


Figure 7.3: Themes and topics of the interviews

7.10. **Philosophy of the sample**

To enrich the study and prompt the most effective results possible, it was decided to involve three types of participants. Construction companies, a project-based company, and an idealistic representative organisation (an educational institute). Seven organisations yielded the total number of participants; five construction companies, one project-based company, and one leading KM consultant. The rationale for those three categories, and more details about the participants, are discussed in the next sub-sections.

<table>
<tr><th colspan="2"></th><th>Efficacy and effectiveness</th><th>Applicability to construction</th><th>Applicability to project environment</th><th>Applicability to knowledge of project processes</th><th>Idea from outside the box</th><th>Applicability to SMEs</th></tr>
<tr><td rowspan="2">Construction companies</td><td>Large</td><td rowspan="2">●</td><td rowspan="2">●</td><td rowspan="2">●</td><td rowspan="2">●</td><td rowspan="2"></td><td></td></tr>
<tr><td>SMEs</td><td>●</td></tr>
<tr><td colspan="2">KM leading educational institute</td><td>●</td><td></td><td></td><td>●</td><td>●</td><td>●</td></tr>
<tr><td colspan="2">Project-based company</td><td>●</td><td></td><td>●</td><td></td><td>●</td><td></td></tr>
</table>

Figure 7.4: Expectation criteria of the participants' groups

7.11. **Construction companies**

Since the final product of this study is largely targeted at the small and medium construction companies (because they form the vast majority of the industry), it was necessary to have participants from the construction industry and to have SMEs participants. The outputs are affected by inputs; therefore, three of the construction companies that participated are SMEs. Those SMEs selected will most likely have the KM components that are applicable to other companies of the same size. The participated SMEs are selected based on criteria that guarantee that they are among those having the best practice of KM, although it was expected that some of the larger companies will have more advanced KM practices. This expectation was built upon the results of the survey in chapter six, which showed that, large companies are currently more mature in terms of KM than the SMEs in the UK construction industry (see section 6.7.1). This in turn led to having a sample of large companies in addition to SMEs. Despite the fact that large construction companies will certainly have many characteristics in common with SMEs; it was considered that, not every practice in large construction companies is essentially applicable to SMEs.

Table 7.1: Profiles of construction companies

Company	**C1**
Industry	Construction
Business	**C**onsultancy **-** Consulting engineers, designers, planners and project managers
Size	International – 10000 employees
About	the Best Innovation in Knowledge Management (International Information Industry Awards) One of the top 25 project managers – Building magazine 2008 One of the top 10 consultancies – Building magazine 2009 One of the Top 43 project managers' websites - Building magazine 2008 One of the top 100 fastest growing companies in the UK - Building magazine 2009
Position of interviewee	Director – level of Europe
Company	**C2**
Industry	Construction
Business	**Consultancy -** project management, quantity survey, management consultancy, SHE consultancy, building survey, facility management, and building service engineering
Size	Large – 1600 employees (UK)
About	One of the top 5 project managers - Building magazine 2008 One of the Top 43 project managers' websites) - Building magazine 2008 One of the top 100 fastest growing companies in the UK - Building magazine 2009
Position of interviewee	Partner
Company	**C3**
Industry	Construction
Business	**Consultancy -** Architecture, environmental space planning, interior design, and the refurbishment and restoration of historically listed buildings
Size	SME – 55 employees
About	Grade 5 in the KM maturity matrices (in the survey) One of the top 200 Consultants - Building Magazine 2008
Position of interviewee	Knowledge Manager
Company	**C4**
Industry	Construction
Business	**Consultancy -** Architecture
Size	SME – 40 employees
About	Has been participating in many events presenting various research and case studies about knowledge management.
Position of interviewee	Practice manager and architect – in charge of managing knowledge in the company

Company	C5
Industry	Construction
Business	**Contractor -** Design and build, and project management
Size	SME – 110 employees
About	Grade 5 in the KM maturity matrices (in the survey) One of the top 10 contractors and house builders by turnover (building magazine 2008)
Position of interviewee	Design and Build Manager – at regional level

7.12. KM: leading educational institute

Respected educational and consultancy institutes that produce bodies of knowledge are usually considered as pioneers in the fields in which they specialise. By having an opportunity to develop the practice and recommendations regarding KM, a specialised institute will most likely enrich the study, and may offer more thorough and reliable approaches.

Table 7.2: Profile of the leading KM organisation

Company	K6: the International Knowledge Management Institute
Industry	Consultancies and Training
Business	KM Training and Solutions
Size	N/A
About	The fastest growing Knowledge Management organisation in the world (Wallace 2007)
Position of interviewee	Chairman Douglas Weidner

7.13. Project-based company

Knowing how the others solve problems, may lead to an inventive solution (Merrell 1985), and innovation can be a result of importing ideas from outside (Leonard-Barton and Leonard 1998). It is not a novel suggestion to study a sample from another industry with the expectation that useful and applicable concepts may be found. Based on this logic, the author decided to find an appropriate example from outside the construction industry. However, utilising an idea from outside the industry to suit a construction company may not be easy. Therefore, it was reasonable to identify a common factor between the construction companies and the company we are looking to study. *'Project'* was the common denominator in the company to be studied, this is so because the application of knowledge capture and retrieval within the project context is the focus of this study. There are many common characteristics to all types of projects, as all of them pass through same stages. It is also known that the processes of project management are the same regardless of the type of project (Project Management Institute 2004). This in turn will contribute to finding approaches that are applicable, or can be developed to be applicable, to construction projects.

Table 7.3: Profile of the project-based company

Company	T7: Project-based company
Industry	Tobacco
Business	
Size	23000 employees
About	One of the 5 largest tobacco companies in the world.
Position of interviewee	Collaboration and Document Management Technology lead, Information Technology - Technical Architecture. (Certified knowledge manager)

7.14. **Selection criteria**

The selection of sample involved two processes; finding the right company, and selecting the right person in that company. The criteria of selecting the right company were initially based on the level of organisational KM maturity matrix, which was determined from the survey questionnaire. It was assumed that companies at level five of the KM maturity matrix are likely to have matured KM practices, or at least serve as an example of the best available practice in the construction industry. Thirteen out of the 139 companies that participated were found to be at the fifth level (see section 6.7.1). Invitations were sent to all 13 companies to participate in this study. Three companies agreed to participate in this study and during the arrangements for the interviews; one company postponed the interview and later cancelled it. Therefore only two companies here were selected according to their level of maturity matrix in KM. The other three construction companies were selected based on having at least two elements of the following criteria, with the provision that criteria number 4 is essential:

- The company has achieved a KM-related award from a respectful institute.
- A published study shows advanced practice of KM at the company.
- A member of the company is known to be active in the field of KM.

- The company has a structured strategy for managing project knowledge.

In all three of the cases, the selection processes started with knowledge of a company that meets criteria numbers 1, 2, or 3. It was then necessary to ensure that the company employs a formal strategy for managing project knowledge.

The project-based company was also selected based on the same criteria used to select construction companies. The international Knowledge Management Institute (KM Institute) was selected as representative of the idealistic company view. This is because the KM institute is a widely known organisation in the KM field. In addition the chairman of the KM Institute; Douglas Weidner, who participated in this study, is a leading international figure in KM. This is illustrated by his biography:

"Douglas Weidner is a pioneering KM practitioner. He is a respected consultant, columnist, speaker and KM Instructor. Prior to joining the KM Institute as Chairman (2004), he co-founded KMPro and was Executive Director of its Learning Center (2001-4). He was the Chief Knowledge Engineer and designated Senior Technical Fellow for $30B Northrop Grumman, the largest professional employer in the DC area. He provided Northrop Grumman's KM innovations to clients worldwide, including KM training, assessment/planning, design, and implementation (1995-2001). He's been directly involved in KM since he designed the KBase Tool for DoD, while working at a DoD think tank (1992-5). He has consulted and mentored the World Bank (1996), the UN (2000), NASA (2000-2001) and many other government agencies and commercial firms."

7.15. **Method of Analysis**

One of the methods for analysis is to describe the concepts provided by interviewees and simultaneously analyse them relationally. The other method is to separate the conceptual analysis from the relational analysis. In this research, the first method has been adopted. That is mainly because the reader may need to see the analysis of the available approaches directly upon their introduction. Thus, the reader can with a fresh memory link between the description of the approaches and the analysis: "A major strength of the qualitative approach is the depth to which explorations are conducted and descriptions are written, usually resulting in sufficient details for the reader to grasp the idiosyncrasies of the situation" (Myers 2000). However the analysis of the qualitative research must follow a structured method in order to produce thorough results. A customised method of analysis has been designed for this study. The method is based on previously identified approaches, which have been utilised to suit this study. A detailed description of the method of analysis adopted will be presented in the subsequent sections.

7.16. **The overall design of the interview analysis**

A structured approach to analysis has been designed to use with every theme and the key points to be analysed. This approach consists of three major processes; conceptual analysis, relational analysis, and indicating the appropriate approach/es to be used in the framework. Each process is detailed with the appropriate instructions, as will be shown in the next sections. The approach of analysis is designed to help with analysing the contents of the interviews with as fixed criteria as possible. However, it is worth mentioning that, this method is to facilitate the analysis; so some flexibility may be needed.

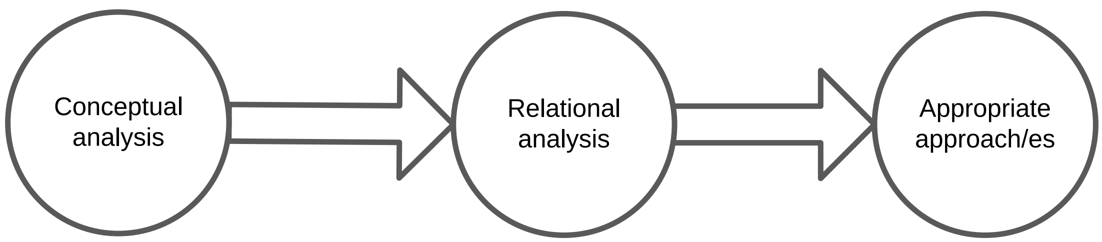


Figure 7.5: The three processes of analysis

7.17. **Conceptual analysis**

This method of analysis is concerned with providing the meaning of the approach, concept, and method presented by interviewees. The aim of the conceptual analysis is "achieved by relating information contained in the text to the reader's prior knowledge. The knowledge stored in the reader's memory is organised in schemata (or related concepts...)" (Lankamp 1988). The primary and the only data used in this stage is the transcription of the interviews. Concepts provided by construction companies will be distinguished from the concepts provided by project based company and the leading KM educational institute. This method includes four sub-processes as follow:

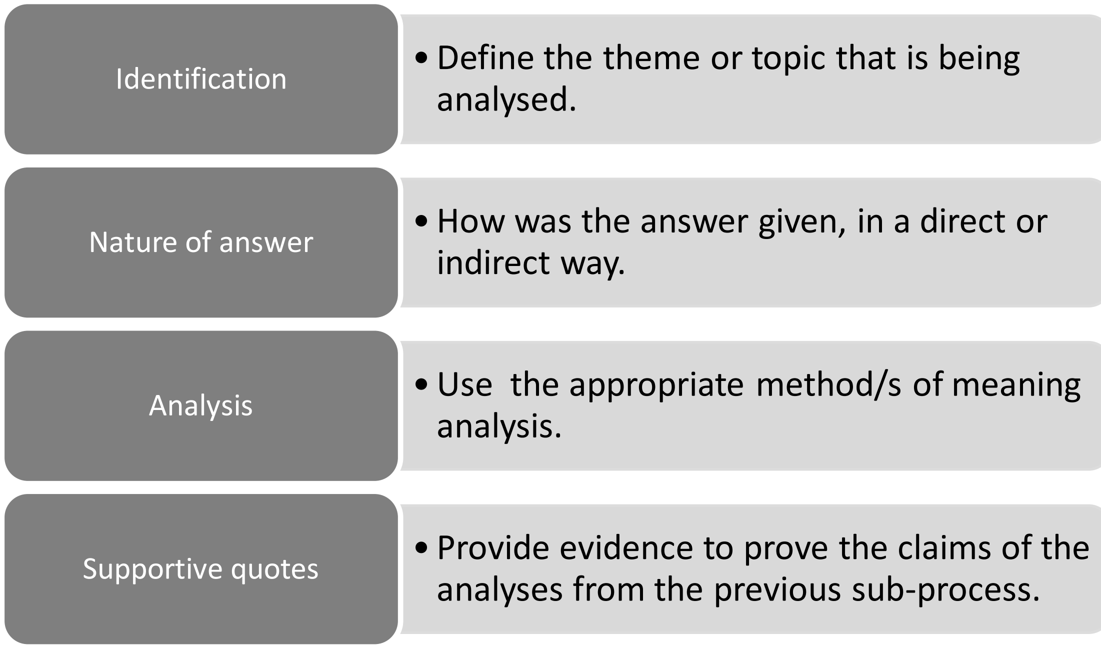


Figure 7.6: Sub-processes of conceptual analysis

Kvale (1996) suggested five methods for meaning analysis which are; meaning condensation, meaning categorisation, narrative structuring, meaning interpretation, and generating meaning through ad hoc methods. The last method is employed in this study. The approach involves choosing what works best from amongst the other four methods. The ad hoc method offers high flexibility for choosing the most appropriate method in every topic, so what works in topic ‘a’ may not work for topic ‘b’. However, this study had nothing to do with narrative structuring method, therefore it was excluded.

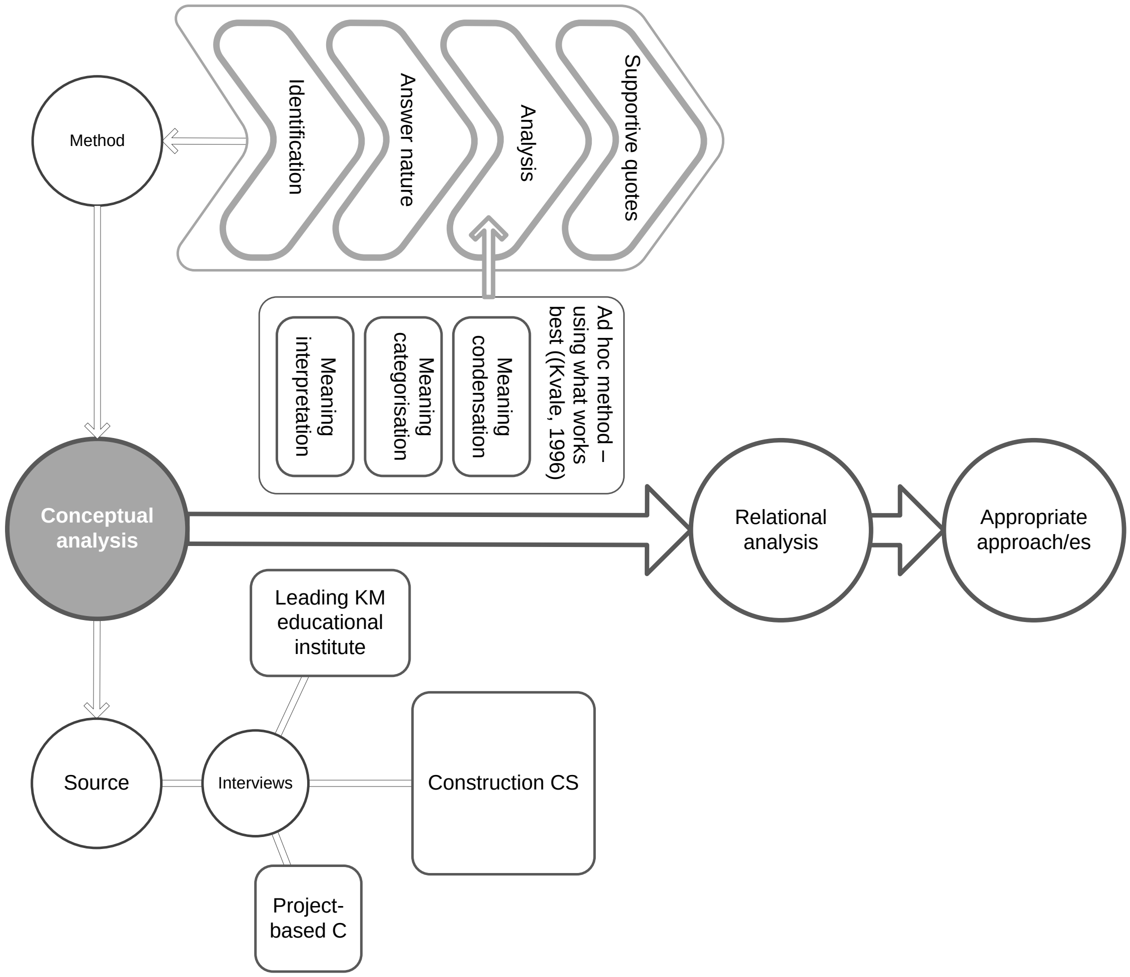


Figure 7.7: Process 1 of interview analysis: Conceptual analysis

7.18. **Relational analysis**

"The meaning sought by relational analysis is established through an exploration of the links and relationships between a text's concepts, words or phrases" (Wilkinson and Birmingham 2003). In this research context, relational analysis aims to discuss the concept, approach and technique provided in relation to one or more of the elements of the critera. For example if an approach is provided by a non construction company, the element of the criteria '*applicability to construction*' could be appropriate for use. A reasoning method has to be used for facilitating the discussion. While an abductive reasoning method is more applicable to content analysis, deductive and inductive inferences are not central to content analysis (Krippendorff 2004). Nevertheless, in some cases there is a need to use a deductive method. The primary data here is taken from interviews; however, survey results and literature review are also used in some cases.

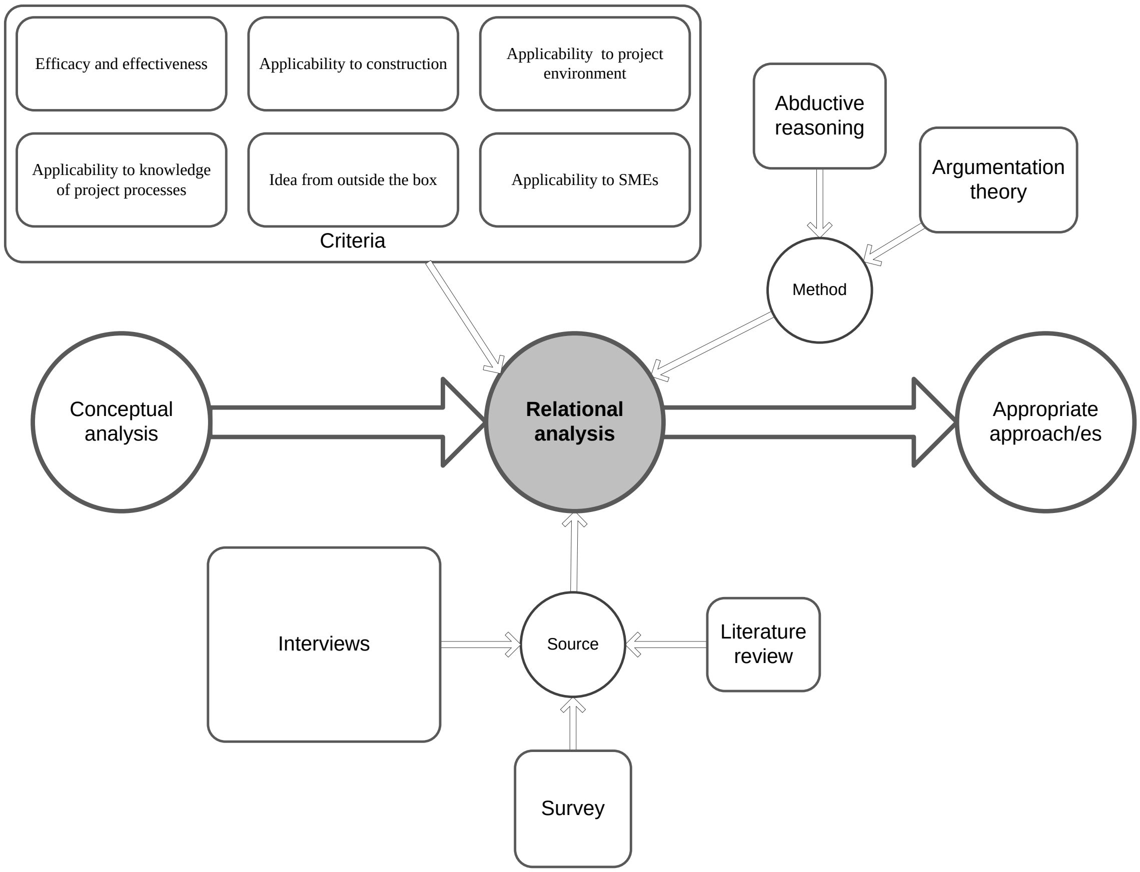


Figure 7.8: Process 2 of interview analysis: Relational analysis

The theory of argumentation offers clear instructions as to how logic can be constructed and this theory could be applied to all the reasoning methods (Krippendorff 2004); this is used in this research when applicable.

7.19. **Appropriate approach/es**

After the relational analysis, the picture becomes clear regarding what the most appropriate approach/es is/are. The appropriate approach depends on the relational analysis.

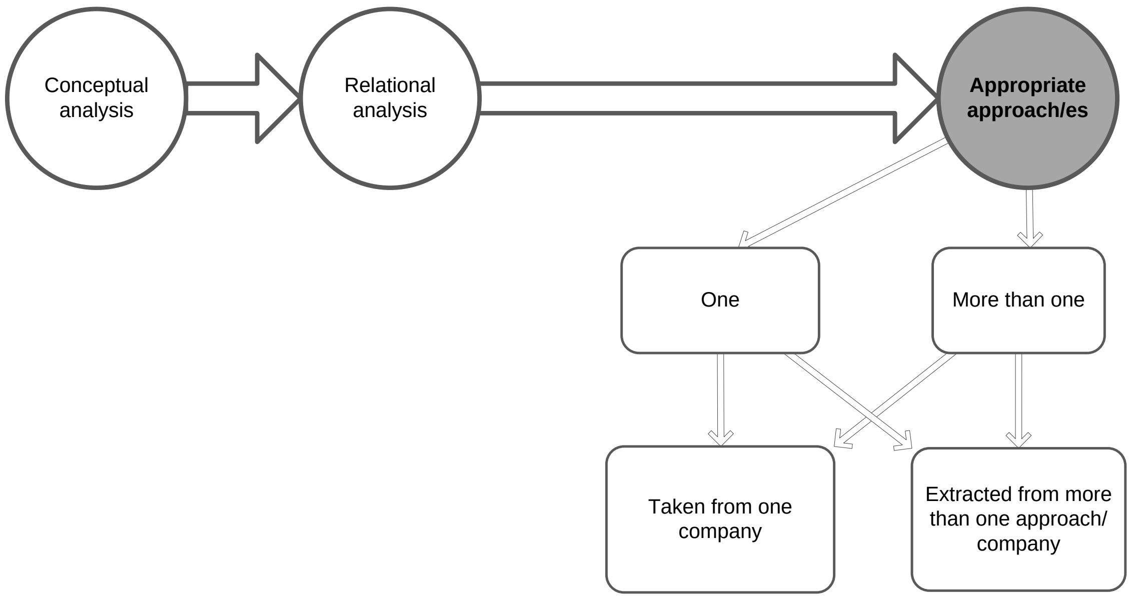


Figure 7.9: Process 3 of interview analysis: Appropriate approach/es

The approach/es 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 approach/es.

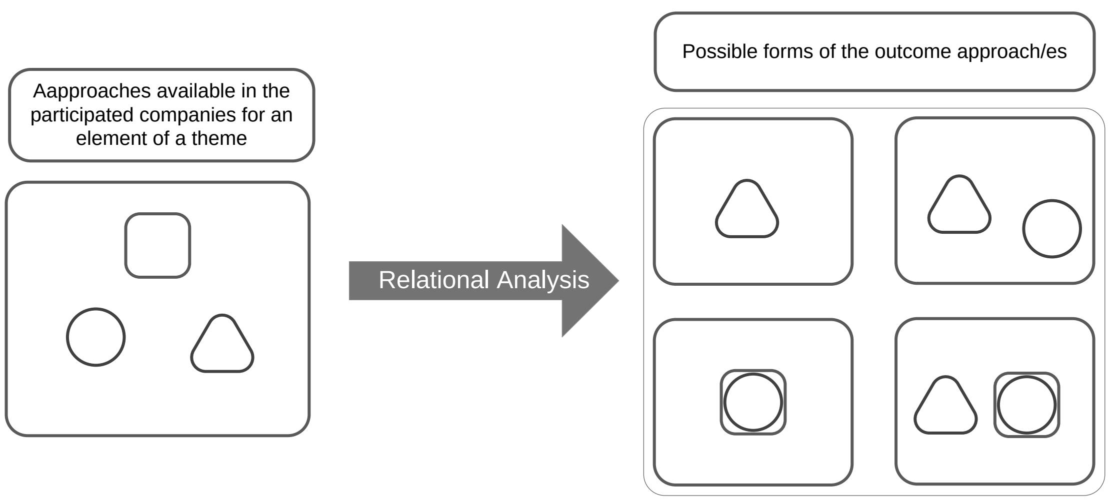


Figure 7.10: Possible forms of the suggested approach/es

Providing that participated organisations from the construction industry are amongst the most mature organisations in the UK in terms of knowledge management, the following cases are considered in the analysis:

- In the instance that all the participated organisations use one method/technique/tool for a particular KM process (e.g. knowledge capture); then the analysis will aim to show this without going further. This is simply because those organisations are mature enough 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 appropriate 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.

- After data collection new themes and topics were created, some of those topics are not approaches, rather they are factors that influence the practice of knowledge capture and retrieval. In this cast the aim of the analysis is to highlight that.

7.20. **Themes of analysis**

After the data had been collected, it was found that the interview themes may not still be valid for analysis. This was due to the fact that, perception of the themes and topics prior to conducting the interviews was not the same as that after data collection. Therefore it was necessarily to revise the previous themes and redevelop them for the purpose of analysis. Themes may have other names in the literature such as coding. "Coding is the process of organising materials into chunks before bringing meaning to those chunks' (Rossman and Rallis 1998). In the next chapter those themes will be interconnected to develop them into a theoretical model (Creswell 1994).

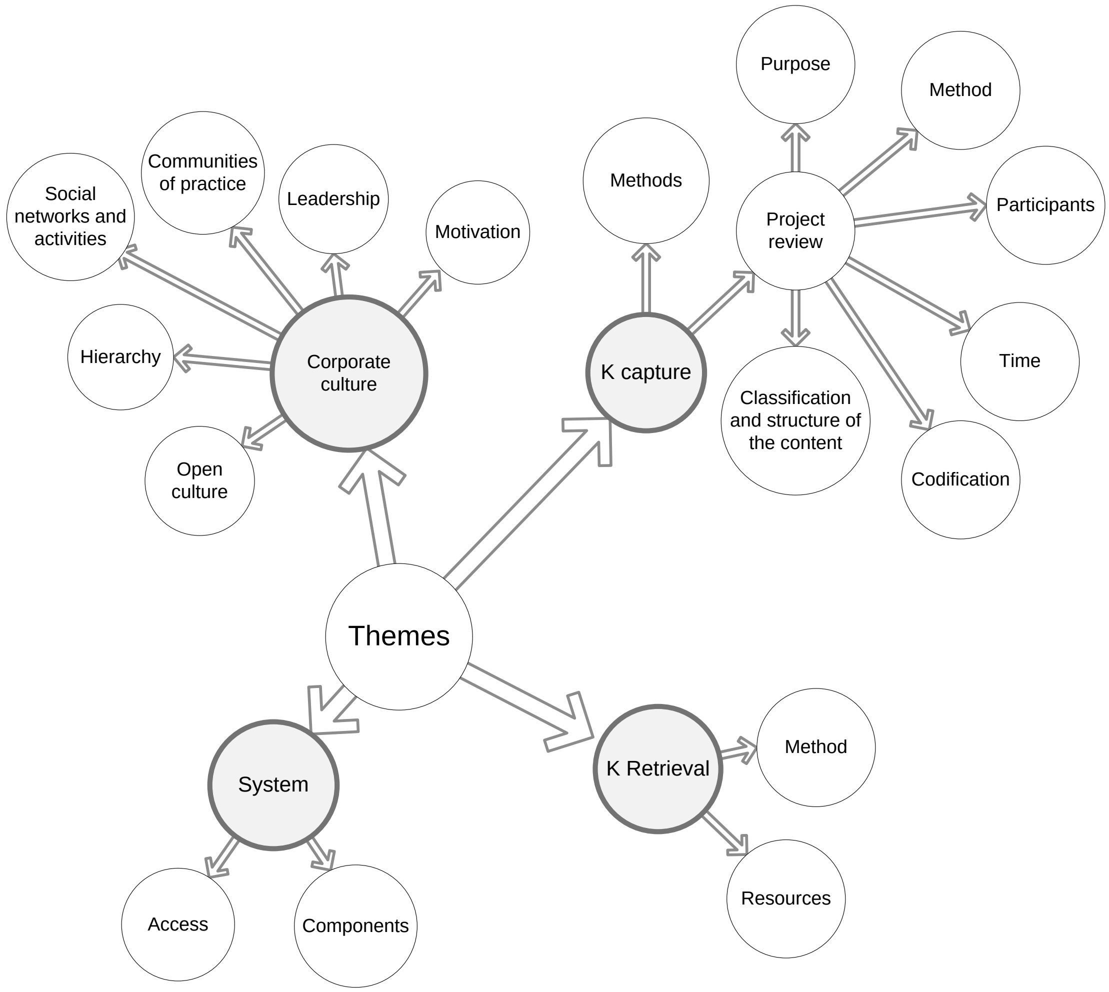


Figure 7.11: Context of the analysis

7.21. **Findings and Discussions**

This section presents and analyses the interviews. The context is presented according to the analysis themes shown in section 7.20.

7.22. **System**

This section deals with knowledge management systems used in the participants' organisations. It aims to identify the systems' functions, which have the right to accesses them, what type of networks they are built on, and finally what the sections or components are in those systems. During interviews, there was no particular theme for gathering information about the system or technology. That is primarily because of the significant interaction between technology and other themes (such as knowledge capture and retrieval).

Therefore it was decided to collect the technology related information while exploring the other themes in order not to split technology from function. However because of this technology related information is now known and designed for the sake of better data presentation; it was decided to present and analyse essential data that is related to systems in a separate category, and then all the answers provided in this section were presented in a direct way.

Technology was identified in the literature review as important enabler for KM application, and system is the major element of technology used to facilitate the management of knowledge (see sections 2.10 and 4.6 for more detail: literature). Therefore it was expected that the system will be an element of KM practice in any matured practice of KM. Unsurprisingly, it was found that all of the participated organisations have KM systems. Some participants began by answering the first question "How do you capture knowledge of your projects" by speaking about the system. This may give an indication of how important the system is to KM; at least in those organisations.

> **C1**: *"We write a lot of reports on our projects and we file them electronically. We have a system called ..."*

> **C3**: *"We developed a system here which is based on intranet ..."*

> ***C5**: "... It all used to be held in paper. It now is usually held electronically"*

Furthermore C4 disposed of the technical library and the practice manager justified this by saying:

> ***C4**: "The idea is, rather than having little scraps of paper, they can put it on to the intranet. It doesn't cost anything. It takes a few minutes to do. It is available for anyone to look at."*

The system can be costly and can be cheap, and a cheap system does not necessarily mean it is not effective. C4 is a small size enterprise which has a system that was developed by an architect working in the same company.

> ***C4**: "We're lucky to have a very good IT person, who quite quickly and efficient kind of does all this software, we have it all, it's all been done in-house."*

Providing that the practice of KM in C4 is at advance level, this may infer that SMEs can have an affordable system that can achieve all the predicted functions effectively. But it should also be considered that SMEs may also use a costly and very advanced system, as in C3.

> ***C3**: "To keep a system like this going, it costs money; it costs a lot of money". This new system that we're buying into, is more sophisticated, and cost a lot of money. I think that's the answer. It works."*

7.22.1. ***Access***

Systems can be built on an intranet, extranet, or internet network. While the internet can be accessed by the public, and the extranet provides access to particular users from inside and outside the organisation, an intranet network restricts access to the system to members of the organisation. The systems of all the participating organisations are based on an intranet network.

> ***C1**: "We have intranet, when you switch on your machine, it opens up for you and that is the gateway to almost everything within our central services."*

Even though the intranet is used as a basis for the system, access to some parts of the system or the whole system can be limited to members of the organisation. Also there are three main levels of access: access to view, access to add content, and access to edit content. All the participated organisations bestow access to view content on everyone in the organisation. That should certainly facilitate the sharing of available information in the system. However, not every part of the system is accessed by everyone in the organisation. This may be due to two factors. The first one is that some information is confidential and revelation of this information may harm the organisation or its clients. The second reason is that providing that information to some members will not lead them to benefit the organisation.

> ***T7:** "Not everyone (has access to the entire data in the system). We have sensitive projects, these ones; no. It's not accessible but for projects like the RP implementation, which is basically across all the organization, yeah, you can have access to these records".*

C5: *"Quite a lot of the information is commercial, it is to a certain extent sensitive, and therefore it tends to be pretty much limited to the project team."*

C1: *"Some clients like you to keep some confidential and then it will be kept confidential."*

When it comes to giving permission to add content to system, three methods were found to be used in the participated construction organisations. The first one is that by giving the responsibility to add information to particular people as in case C4, the practice manager is responsible for adding content to the system. The second way is that by giving everyone the right to add content; any addition must be approved by a particular member. The third way is to give everyone the right to add content.

C2: *"Yes. Everyone can add information to the system.... it's (the added information) got to be approved by the Line Manager before its put live for everyone else to use."*

C1*: "Everybody can add content. There is a limit to what you can, you can edit your own material, and I do not think you can edit other people's material."*

It should be considered that 'the content' here does not refer to the content of the project review. It could be a detail about a member's profile, an external link to an article related to the business, instructional information about how to do a particular task in the project, etc. When the right to add content is restricted to particular member/s in the organisation, this may be because of one or both of two reasons; the first one is that the other members are not trained to add content. This could be overcome by giving everyone in the organisation the proper training. The second reason is that opening the door to everyone in the organisation to add content may result in too much unnecessary information being added to the system. This might be true; however, it could be controlled via the approval process and by giving instructions to members about what to add. Therefore, it is believed that the approach used by C2 is the most appropriate approach.

While in some of the organisations intranet can be accessed only from inside the organisation, some participants pointed out that they could also access the system from elsewhere.

C1: *"I have access to everything on our intranet remotely. So if I'm sharing anything or if anyone is sharing anything, everyone has access to it from anywhere."*

7.22.2. ***Components***

Despite the fact that all participated organisations use a system for facilitating knowledge management application, the components and therefore the functions of the system, differs from one organisation to another. Because this section is related to technical matters, the subjects that are related to the purposes of the components will be left for the next sections. Table 7.4 shows the components used in the organisations' systems.

Table 7.4: System components

Case	Component	Description
C1	People:	Content is generated by individuals and includes their skills, hobbies and industry profile.
	Projects:	Project information, lessons, experiences and outcomes of reviews from project team that can be shared.
	Insight:	Knowledge that has been validated as appropriate best practice and can be used with confidence.
	Networks:	Electronic discussion board (E-forum)
	Essentials:	Agreed policies and procedures.
C2	Contacts	Detail about members of the organisation, and the area they are experienced in.
	Service delivery management system	Online forms (questions are already pre populated with the information we are looking for and you enter the information either freehand or from drop down lists of options).
	S3 (Service Solutions System)	Demonstrating the value of the project.
	Portal	
	Blogs	Specific to certain businesses that the organisation has.
C3	Gate system:	To store projects data, track projects and report status.
	News:	Can involve anything (e.g. details of furniture, building regulations, reviews, what's new, what's latest, events...etc)
	Expert directory:	Detail about members of the organisation and other companies.
	External resources:	E-publications form external sources.
	Archive simulation of the library:	An application that simulates the physical library in 3D. It shows the location of the desired reference as it is in the real library.
C4	Time sheet	Process-based knowledge; information about all the

Case	Component	Description
		existing and past works
	Yellow pages:	List of organisation's members, includes 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.
	Outside room:	HIS (Research station: technical information provider for bodies of knowledge like British standards).
C5	Project reports	Long reports about project details and performance. Short reports considering lessons learned from the project.
	Document management system	File manager.
K6	Knowledge nuggets	Processes-based classification database contains learning from previous projects.
	Expert directory	Detail about members of the organisation.
T7	Project reviews (files)	Reviews stored as e-files.
	Instant messaging system	Text messaging application allows members to get help from each other.
	Code of practices	Guidelines for the work procedure.
	Personal blogs	Out of the profession topics, to make people know each other and strength social network.

Apart from instant messaging systems and e-forums, all the other components can be presented in either live pages or files. Navigating and retrieving information from live pages maybe considered easier and faster than from files. Editing and updating information in live pages can be done online directly, while updating information in a file needs to be done on the desktop first, and then the file has to be uploaded to replace the previous version held on the system. In addition, with live pages you can see the desired information live, while on the file system, the desired file has to be downloaded on to the desktop before it can be opened and read. This explains why all of the participants from the construction industry use live pages, in addition, the system recommended by the leading KM consultant (K6) relies mostly on live pages, as it shows a live pages based system on workshop handouts and presentations as the appropriate solution. It is also worth mentioning that all the organisations use document management systems (such as file manager) as a secondary repository. This means, they rely mainly on live pages as a way of presenting information on the system; however they also use file system especially for storing external resources:

C2: *"Some are PDF so if it's like a booklet that's been published it will come out as a PDF but most of it is like live data... it (the information on the system) is real and live and easily accessible."*

C1: *"...everybody in (the company) has their own personal internal web page..."*

7.23. **Knowledge Capture**

Knowledge capture here means transforming tacit knowledge into explicit knowledge by recording it in text, audio or visual format. The data gathered in this section was given in an indirect way, and in most cases, it was necessary to go through all the interview scripts in order to understand the method/s of project knowledge capture.

Unsurprisingly, the main technique that the participating construction organisations used to capture knowledge of the projects was project review. Other secondary techniques that were reported by some of the participated organisations were short report as in C5, the use of e-discussion board or e-forums as in C1, and recording shared knowledge as in C3.

The short report method used in C5 assists in capturing knowledge new experiences, and presenting this knowledge in a short article, generally making it more usable than long articles.

C5: "We have a huge database of information and all the different companies (in our group) have their own pages within that, and what is being encouraged now is to put items on that such as innovation so that if somebody is doing something new somewhere, or if it is new to them anyway, they will do a small report on it and we will put that on to the web site so that it is accessible to everybody in the business. And that is beginning the process of spreading the knowledge throughout the whole of the organization, not just locally."

However, without linking this new knowledge with the project tasks/activities/processes, it may not guarantee that all the desired knowledge is captured, and too much knowledge may be lost (for further details see section 7.24.6).

A second secondary method of project knowledge capture is the e-forums. This method is popular in the internet world and has been used for a long time as an effective way of attaining the customised knowledge that the user needs. Using e-forums to capture knowledge in a construction company and therefore in construction projects may be considered as a new use of e-forums. This has already been reported in the survey analysis, and it was found that e-forums are more popular and more effective if used in large companies. This was confirmed by the director in C1.

> ***C1:*** *"We run things called skills networks where all the structural engineers who want to talk together, or the site engineers only, or a lot of engineers, you can sign on to these things and then somebody in the San Francisco office will ask a question on the forum and as the sun rises around the world, you can see people wake up, come in to the office, read the question and fire in their answer."*

The question that may arise here is; would the e-forum work for SMEs? The answer can be found in the survey analysis (see section 6.7.2). It reveals that an e-forum is used by a very small number (3%) of SMEs, and its average weight of effectiveness in SMEs is considered to be low (1. 66 out of 3).

E-forum could be effective for an SME in some cases; two factors affect the success of using e-forum in an SME, the number of people and the number of branches of an organisation. There might be no reason to use an e-forum for a small enterprise with few employees working on the same office. On the other hand, an e-forum could be useful for an SME that has tens of employees that are spread throughout more than one office. That is because e-forum is designed to share knowledge between people who are geographically disconnected.

The ability of e-forums to capture project knowledge can be questioned, because they are mainly to 'share' knowledge. Of course the information that is written in the e-forum can be considered as captured knowledge. However, it may not be easy to find unless filtration and reorganisation processes are in place. This means that each item is placed in a context, or categorised in its related section.

It could be said that the e-forum can be an efficient secondary way of capturing project knowledge, for enterprises with tens of people spread over one office. In addition, knowledge in the e-forum becomes easier to retrieve if it is filtered and reorganised.

Another method of knowledge capture is through capturing that knowledge shared through emails and telephone. This method provides people with wider knowledge about details of previous experiences.

> ***C3:*** *"Every e-mail, every written item, that leaves this company, goes through the system, it's captured".... "If we are sharing knowledge through either the written form or e-mail or notes from a telephone conversation that is all captured".*

Despite the danger that such a method may lead to overload of information, it would ideally save lots of effort and time reinventing the wheel. One of the advantages of this method is that telephone notes and e-mails are captured as part of the project information/profile. Therefore the profile of every completed project holds all correspondences that have occurred during the project. In addition, the technology used in C3 auto-captures all the electronic correspondences with no need for human interference, unless there is confidential information that needs to be hidden from some users.

C3: *"...if we were writing a letter or e-mail to ... (person name)..., this will log that into that particular project... So anything that is written is captured on that project... So it is actually put all the project references in. So anything that is written is captured on that project."*

7.24. **Project Review**

In the survey, project review was ranked as the most popular and most effective KM technique in the UK construction industry (see section 6.7.2). Therefore it was not surprising to find that all the organisations participated in the interviews used project review as a key technique for project knowledge capture. This section aims to discuss in detail the practice of the project review in the participated organisations; commencing with the purpose behind conducting the project review, passing through the method, players and the time for conducting project review, and ending with method of codifying the project review.

7.24.1. ***Purpose***

Knowing why a project review is conducted can help in understanding the meaning of the project review processes. The answers from interviewees can be grouped into three categories. The aim of the project review in the first group is to track project performance. Only one organisation is conducting project review for this reason.

> ***C5:*** *"[the project review is] to brief senior staff to know what is going on. It is not that they want the knowledge for the sake of the knowledge, they want the knowledge to know how the business is doing and you do not really want these reports so that they can spread them out across the business so everybody knows more, they want them so we can determine how we are performing".*

Despite the tracking of project performance, this may not be considered as part of knowledge capture process, but in certain respects, the data of costs and time gathered in this processes can be used in future to help in decision making. In other words, the data relating to project tracking is part of the knowledge that needs to be captured. Maybe this data is not enough and that is why the design and build manager of C5 suggested that the project review should be conducted to capture much more knowledge than is currently the case.

> ***C5****: "I think there is probably knowledge of projects that is not being captured through that project review and there is bits of that knowledge that really should be shared across the business... there is no reason why the people should not know about it and it is not easy to see how that knowledge being spread across the business other than by the word of mouth and people talking to each other. I am sure we could do better in that."*

The second group conducts project review to track project performance and to capture project knowledge. The significant point here is that tracking project performance can also be considered as knowledge capture, because an organisation can acquire knowledge from the data related to cost and time in future projects.

> ***C2****: "It is to consistently deliver a good quality service and if there are any concerns about service delivery or perhaps about the project generally ... then we*

can flag that and allow some more senior intervention early rather than problems being developed in to problems which are difficult to resolve later.... there would be information in there about best examples or good ways of delivering your services like say a project execution plan .. So when we come to do a new project rather than starting from a blank sheet of paper ...use the best example being in the system."

C4: *"To make sure that people are working, that they are doing the right things. And that they are doing things right, as well. We do a hindsight review... you could say, "Well, we did it like this but we would have been better if we done that."*

C1: *"To make sure that we do the best possible job really that you bring in people who really know about what it really is. People, much involved in the project and the critique he added, and says, that is the competitive derivative of all, which is very good because it is difficult to miss. It is also an occasion when people can capture some knowledge and feed it back into the systems. We are less good at that, but we are trying to get better at that."*

In addition, the leading KM consultant and the tobacco project based company conducted a project review to track project performance and to capture project knowledge.

K6: *"To find out what went right and what went wrong in that particular project, so that you can learn from that and not repeat that mistake next time. So after action reviews are very powerful technique of knowledge capture."*

T7: *"To check if where we are, is in line with the initial scope; is there any impact in terms of timeline, are we still inline on that area; are there new risks; and basically we capture these in specific documents...We capture, as well, decisions that have been made in the project, and lessons learned."*

The third group conducts project reviews to capture project knowledge. Only one company reported doing so:

C3: *"We learn lessons during the course of our project, positive or negative lessons, if you have learned a lesson the hard way... should anyone else in the company, have to learn that same lesson again the hard way? That's wrong. Knowledge management is failing if you repeat a problem."*

It is clear that project review can be used as an effective method to capture the desired knowledge regarding the project. Evidence has already been shown in the survey results (see section 6.7.2). Again, four out of five of the participated construction organisations are using project review to capture the desired project knowledge. Despite this the fifth organisation (C5) is not doing so, the design and build director of C5 indicated that project review should be used to capture desired knowledge. The practice of the leading KM consultant and the project-based company also support the idea that the project review should be conducted to capture knowledge desired. Furthermore, the tracking of project performance can also be considered as step of the knowledge capture process. That is indicated by the chairman of the leading KM consultancy, as by knowing what went right and what went wrong leading us to find out the lessons we need.

7.24.2. ***Method of project review***

The methods that construction companies at the advanced level of KM practice are using to conduct the project review, can help identify some elements of project review matured practice. The project review is conducted through a meeting; however there were some differences between participated construction companies in terms of how meetings were conducted. Five different approaches were identified. The first approach is by conducting interviews parallel with the meeting. This interview is conducted by the knowledge manager with selected members of the project team. These interviews are used to capture project knowledge but also to get detailed information about the participants.

> ***C3:*** *"Also I do particular interview, with designated people from the project to tell us particular information about all the different participants within the project ..."*

The interviewed member could be from the same company or from an external company participated in the project. It could be said that these interviews are major inputs into the company's expert directory. Therefore, the company use the created profiles of those members in future projects.

As discussed in section 7.22.2, most of the participated companies have an expert directory which may be named differently from one company to another. But building an expert directory through the undertaking of interviews in every project with members may mean that more consideration is given to people. That can be seen in the following statements.

> ***C3:*** *"The essence of the fundamental knowledge of the project is related to those who are working on it. It's the people from here and all the other companies that are involved."*

> ***C3:*** *"There was a huge project directory that was built; from the very start. You obtained the client; all the other disciplines and us; who the individuals actually are; their role; how to reach them; their addresses; their telephone numbers; their low bar numbers; their secretaries so that they are all accessible at any given time."*

Using interviews to obtain more detail about project participants may be considered a good approach for building a comprehensive expert directory. The direct interactions and face-to-face discussion can bring the desired information in a more proficient manner than asking people to fill out forms. The interview process allows the interviewer to react to responses and ask for more details on points of interest.

Conversely, interviews can also be used to capture knowledge, as in C3. However, in this case, the interviews are conducted by the Knowledge Manager who is not involved in the project in any direct way. Therefore the questions raised by the Knowledge Manager could be more general than specific; because in this case they are not really aware of the details associated with the project.

Even if the interviewer is considered to be a main actor in the project, it is not considered an improvement to have discussion by all participants instead of separately interviewing particular people. This is probably the reason why all the companies (including C3) use meetings to conduct the project review. However it may be useful to use interviews with particular participants to gain additional information not previously discussed in the meeting. In addition as survey results show (see sections 6.8.4 and 6.9.4), not all organisations conduct project reviews in coordination with the other parties involved in the project, and therefore interviews can be an appropriate technique to obtain information on projects from the other participated companies.

In the second approach a checklist technique is used in the project review. The checklist is standard and fits all the types of projects carried out. This checklist is sometimes referred to by the interviewee as a questionnaire, because it contains some questions:

> ***C4:*** *"It [the meeting] takes between an hour to two hours. We obtained a questionnaire and then we had to write up notes and have actions as well. We just ask questions and looked quite closely at what is going on"*

As the result of the survey suggests, the checklist is a famous technique used in project review (see sections 6.8.3 and 6.10.4). It is a helpful reminder of the elements required for discussion during the project review; and therefore the meeting covers all the aspects mentioned in the checklist. However, relying on the checklist alone may lead to restricting the captured knowledge to those areas mentioned in the checklist sheet. Therefore, another technique (discussed in the following paragraph) may be used to overcome this problem.

The third approach is to carry out a presentation. This presentation is achieved by some members of the project. After the presentation, discussion starts.

> ***C1:*** *"Some members of the project team present on certain aspects of the work and then the general discussion around it. It is mandated with actions, and has quite a full presence. At the end of the project we have a wrap up review to try and establish what the lessons learned actually were."*

In fact, the presentation can be a good media if the project members are trying to provide a picture relating to the project, in an organised way and in a short period of time, for those who are not participating in the project (e.g. explaining what has happened in the project; and what should have happened). Subsequently, project review members can have a better discussion about the project.

After a small search, it was found that part of the project review participants in C1 were not members of the project (see section 7.24.3). This may have explained why the presentation was used in the project review session. Nonetheless, what if the presentation was used in the project review session with all members in the project. Can the presentation in this case add value to the project review? No definitive answer can be inferred from these interviews. There is no single evidence provided proving that the use of the presentation in the project review can add value.

Whilst the first three approaches are being used in construction organisations, the fourth and fifth approaches were reported from non construction organisations. The fourth approach is to some extent different perhaps because it is from the manufacturing industry and that the involvement of third parties is considered as essential. In this approach meetings take place in a hotel and last for many days. A considerable point in this approach is the use of a structured brainstorming technique.

> ***T7:*** *"We booked a hotel for three days. We got together in a room and we brainstormed, for example, about lessons learned and what could have been done differently. Which is a way, as well, of getting right to the point and moving much quicker."*

The brainstorming technique may be seen as inverse to the checklist technique in terms of the discussed topics. In general, discussion in the brainstorming technique can be open to any points related to the project; whilst in the checklist technique discussion is limited to the points that are written in the checklist sheet. Using the brainstorming technique in a structured way may generate innovative solutions to the problems associated with the project. However, following the exact processes of brainstorming that were developed by the originator Alex Osborn in the 1930s (Osborn 1963) it may need a longer time for both preparation and the actual session.

Brainstorming could also result in too many solutions being given to one problem. Many of the presented solutions are expected to be unpractical. Conversely, if the project review is to be conducted on a regular basis and a repeated manner (maybe once a month); then brainstorming that takes place over 3 days may be considered too heavy to be conducted on a regular basis in a construction project. In addition, the luxury of deep thinking that may be attributed to the 3 day-brainstorming process may be considered appropriate for certain aspects such as setting business strategies and academic research; but not for the proper techniques that can be carried out in continuous manner in a construction project.

It could be said that the construction project could benefit from the idealistic forms of brainstorming during the early stages of the project whereby the strategic decisions will take place. This does not necessarily mean however that brainstorming is not an appropriate technique for the construction project review. Thus, nothing may prevent brainstorming to generate those innovative ideas in the construction project review. However brainstorming that lasts for three days, in a hotel, as in T7, can be too great for the regular construction project. Therefore the use of popular short-time brainstorming, which takes place over a short duration of tens of minutes, would be a good addition to the project review.

Because of the four basic rules of brainstorming whereby - criticism is prohibited; free-wheeling ideas are encouraged, concentration is based on quantity and combination and improvement of ideas are needed - (Osborn 1963), thus such could bring out more innovative ideas and overcome the problem of restricting the discussion to the points that are mentioned in the checklist sheet.

The fifth approach is a straight forward process-based approach. It is suggested by the leading KM consultant.

> ***K6:*** *"It's a pretty specific process you have to follow: what we are hoping to accomplish, what did we actually accomplish; for either the better or worse. There is a gap between those two things. You want to look at that gap, and say, "How do we close the gap," and this pretty much leads you to what you might have learned. To make sure you do it differently next time, make sure you catalogue this learning in order to reuse it. You don't walk out of the meeting and forget what you have just talked about."*

The processes in this approach can be grouped into three main areas. The first one is to determine the gap between the project plan and implementation progress. That could be achieved by answering three questions as shown in Figure 7.12. When the gap is identified, the second process is to find a solution which closes the gap. This process is explained in another place in the interview:

> ***K6:*** *"To find out what went right and wrong in this particular project. So that you can learn from this and not repeat the mistakes the next time."*

Comparing what has been completed with the plan is seen by the Chairman of the KM leading consultancy and training institute as a good way of finding out what went right and/or wrong. That can lead to identifying new knowledge that has been gained. The third process is to codify such new knowledge so it can be used in future projects.

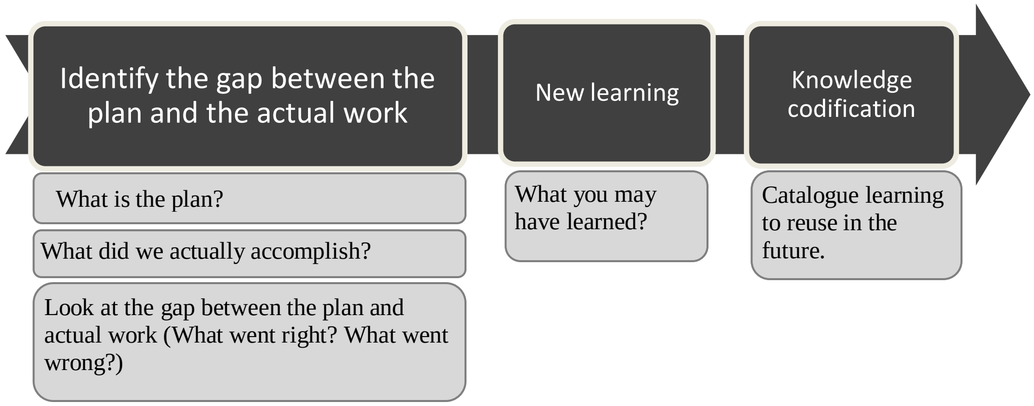


Figure 7.12: Method of project review in K6

Looking more deeply at the approaches being used by the participated companies, it could be found that, those approaches may not be an alternative to each other; but instead are a collection of techniques, each of which does a particular task as shown in the following manner:

Figure 7.13: Techniques implemented by participants to conduct the project review

The good practice of KM in the participated organisations can be considered a credit for the participated experts, because every one of them is firstly responsible for managing knowledge, or at least a key person in the KM board. Provided that people tend to highlight what they consider their strengths (Bonnardel 1949), may suggest that the participated organisation has a tendency to highlight the strong points of their approaches because it is connected with them. This is not necessarily because they want to hide their shortcomings; as some were mentioned without any problem; but possibly because strength points to spontaneity when the questions are asked. This is matched with the results of

Bonnard who found that this happens “consciously or unconsciously” (Bonnardel 1949). Furthermore, participating organisations conduct meetings in order to carry out the interviews; but none of interviewees said this in a direct way. This indicates that they skip directly to the points that they consider to be the most efficient in their practice. This in turn can mean that they provide answers that focus on the positive side of the approach.

Fortunately, interviewees have provided five techniques, each of them covering a side of the project review, and none of them can be considered as an alternative to other techniques.

The first two techniques (interviews and presentations) can be achieved independently. On the contrary, 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 leads to achieving the desired aim of the project review. A point list in the checklist therefore may go through the three process approach. The second process (of the three processes approach) can be achieved by applying the brainstorming technique. Brainstorming in its idealist form takes place when the question: “what have you learned?” has arisen.

7.24.3. ***Participants***

This section aims to determine who is involved and is carrying out the project review. Options that were found can be grouped into two categories. In two of the participated construction organisations it was found that people participating in the work/project are those who were involved in the project review. This approach is also practiced by the project based organisation (T7) and is suggested by the Chairman of K6.

The second approach is used by three construction organisations. It suggests that participants are either known by their positions or selected by a senior member of the project. It is worth mentioning that in the case of C3, the attendance of the project review is open to everyone in the organisation; even those who were not involved in the project.

Table 7.5: Participants in the project review

Case	Participants in the project review	
	People involved in the project/work/activity	**Known or selected people**
C1		The Project Director and the Project Manager hold the review. They choose who to invite and this could be colleagues from within the office or colleagues from other offices and some engineers.
C2		The Service Delivery Manager completes the service delivery review on a monthly basis and this is reviewed by his Team Leader. The Team Leader may manage a team of approximately ten people and then the… what the Team Leaders have reviewed is then reviewed by the Operations Manager.
C3	Basically everybody (who was involved)... there will be a final review at the end of the project for the whole company or those willing to attend it	
C4	It involves a whole team, including the younger participants.	
C5		Generally it is the Senior Managers on the site ...So there is generally about four, five or six people I would say.
K6	The people who were involved in the activity	
T7	Project Manager, Project Leader, and some members of project team.	

The involvement of people participating in the project/work is considered important because they know the most about the project/work. Thus they are expected to know how the project is progressing and what the lessons learned actually are. The involvement of other members will certainly depend on the skills and knowledge of such individuals.

As can be seen Table 7.5, the positions of the non-project members participating in the project review may indicate that they are experts and their presence may generate better outcome. It is also expected that the selected non-project members will either add value to the project review, learn from project review or both.

The chairman of K6 and the practice of the other participating companies suggest that the members of project review are the project participants. But this does not necessarily mean that they refuse the participation of non-project members who can add value to the project review. However it surely points out that the participation of project members is essential.

With regards to the involvement of the parties associated with the other project in the project review, it was found that some of the participated organisations conducted the project review without coordination with the other project parties. Other participated organisations carried out the project review with some participants from other companies who were involved in the project. Finally some other organisations carried out the project review with other parties involved in the project; but only at the end of the project.

> ***C3:*** *"The essence of the fundamental knowledge of the project is those who are working on it. It's the people from here and all the other companies that are involved."*

> ***C1:*** *"Sometimes we invite clients to the review as well. It can be a very useful communications device to have them there and air some of the issues in front of them and some clients."*

> ***C4:*** *"Also done the project review with contractors at the end of a job."*

> ***C5:*** *"The participation of members from other companies is not included in our project reviews. I suppose one reviewing aspect of the project that I haven't covered is the client's project review. Because of course we will just hold what we call progress meetings; which if you like are above our reviews, and in these you may well have people from other companies there. We could have some of our key subcontractors there and we may have some of the designers there as well.*

The project based organisation is also carrying out the project review with the coordination of other parties involved in the project.

> ***T7:*** *"People who participated in the project review are those in addition to members of the external parties involved in the project.*

7.24.4. ***Time:***

The timing of conducting the project review is a critical factor that may affect the value of the final product. Despite this and the fact that time lags may lead to loss of some knowledge; there may be no time for conducting too many reviews during the course of the project. The practices of the participated construction organisations can be grouped into two categories: i) stage-based ii) time-based review.

In the stage-based review, the time between reviews will depend on the length of stages; whereas in the time-based approach the time between reviews is fixed. The monthly and daily reviews are the two methods reported under the time-based review. The Chairman of K6 argues in favour of the daily review and against 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.

> ***K6:*** *"The key variable is how often you have these reviews. 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 actually happened. The second thing is that you won't be able to take advantage of it during the project."*

Some of the participants from the construction industry suggested that it was interesting to see daily-based reviews in construction projects. However whilst they stated that it usually happened in an informal way without capturing knowledge, they also indicated how it might be difficult to implement such in a formal way in a construction project. This is because the project team may not have time to do daily reviews and it may therefore be difficult to organise daily meetings.

> ***C1:*** *"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; but it is very much an informal, almost a social process"*

C4: "That's interesting. If everybody had to fill in their time sheet and write what did about what they had learned today. We could try that."

C3: "It depends on the company, and on the project. There are certainly different elements that come into play. It is very hard to generalise and if it was needed then it should be done. Anything is possible. But what you want to do it is another thing. Because we have to bear in mind how busy these people are."

***C5**: "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, could be half a dozen, 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 provided asserting that the daily-based approach could work in construction projects. Furthermore, 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 indicated that the daily-based review could be difficult to implement in construction. This result does not necessary mean that the daily-based review is not suitable for construction, but it reveals that the collected data did not provide a solid base to support the use of the daily-based review in the construction project.

Table 7.6: Time of conducting Project review

Case	Time of conducting the project review	
	Time-based review.	**Stage/phase based-review**
C1		Stage-based and after project completion.
C2	Monthly.	After project completion.
C3		Stage-based and after project completion.
C4		After each work stage - probably every six months.
C5	Monthly-based and impromptu reviews.	
K6	Daily or at worst once a week.	
T7		At the end of the wave or a phase.

With regards to knowledge capture, the monthly based review can be considered more effective than the stage based review. This is due to the fact that a stage in a construction project can last for months. Therefore the time lag between action and review will always be shorter in the monthly based review. It may seem that in the stage-based review, more of the people who were involved in this stage will have time to participate in the review. However as shown in Table 7.6, C2 and C5 are doing reviews on a monthly basis and no evidence of a problem related to participation was found.

The stage based review is certainly helpful due to the fact that it provides reviewers a wider picture of the stages. Deploying the stage based review alongside the monthly review can provide the benefits of reducing the time lag between action and review and having a broader look at the stages. It would also appear important to have a review after project completion as C1, C2, and C3 suggested. Following on from the project completion a greater strategic oversight can be provided on the project. In addition, survey results (section 6.8.2) have shown that 44% of the industry companies and 54% of top companies use this timing approach.

7.24.5. ***Codification***

The final format of the project review found that the participated organisations are grouped into three types. The first one is the review notes in which you have two columns: tasks/activities in one column; and commentary about those tasks/activities in the other. The comments relating to several participated organisations are short and consist 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.

> C1***:*** *"It is a form with some columns in it and includes someone's commentary. Someone is given the task of responding and dealing with this."*

> ***C4:*** *"We have a system of hindsight reviews. It is all of two columns, observation and commentary".*

> ***C2:*** *"It's like a database, almost similar to an Excel spread-sheet and includes a list of projects and the stages we are at. It will provide a red, amber and green*

colour to determine the position it is in. It is usually all green in colour. It will probably only have comments which are relevant to review if it is amber or red.

C3: *"It is more like notes, because if you want storytelling you can put those within the actual file records, which will then be brought up if you need further data."*

The second approach is the producing of a report. This report will usually include the progress and lessons learned.

C5: *"we do monthly reports on every project and that captures all the information."*

The project based organisation also produces a report at the end of the project; and is continuously updated during the course of the project. Therefore lessons learned are added to the report at different times associated with the project.

T7: *"There is a report on the progress, performance and commercial performance and there are all sorts of different subsections to describe how the project is doing; as well as capturing the lessons learned. But the lessons learned can be updated along with the project life cycle. You don't need to wait until the end to do it."*

The chairman of the K6 criticises the second approach "lessons learned report", and suggests another approach (the third) which is practiced by the KM institute. The approach is to write short reviews or "knowledge nuggets".

K6: *"Most people come out with a lessons learned report. The trouble with this approach is, any one report may contain a lot of things in it, and make it buried in a repository. I prefer much shorter after action reviews, where it may only contain a nugget or two that may come out of what has happened today."*

The problem associated with an overload of information indicated by the Chairman of K6 is a familiar problem in KM practice (see sections 4.7 and 4.10). Knowledge nuggets are a solution used in K6. A further explanation about knowledge nuggets show that it could be instructions, a checklist or names of members in the organisation which can offer help in this area.

K6: *"The knowledge nugget could be a checklist, a paragraph, that says you ought to do this, and we sometimes call this a key to success. It could be a list of two or three people who you should go talk to, if the knowledge base doesn't have an answer."*

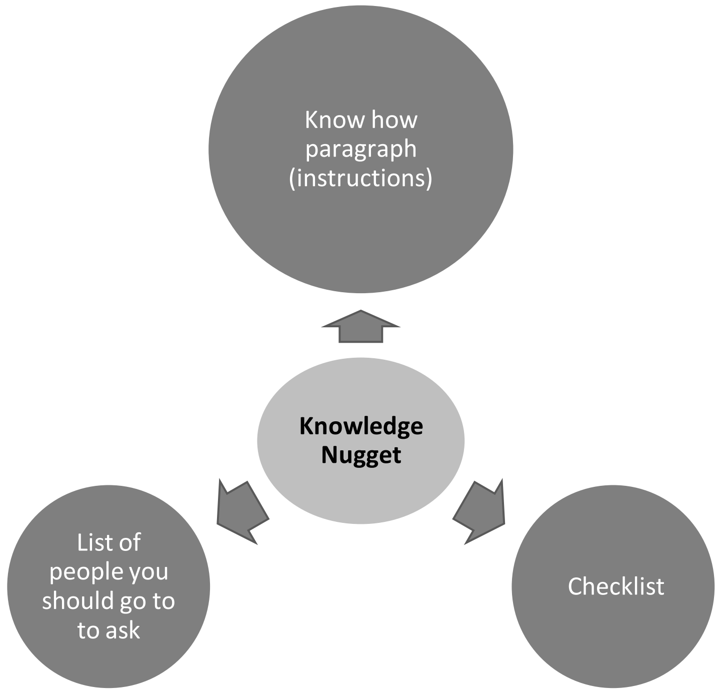


Figure 7.14: Possible forms of the knowledge nugget in K6

The size of reviews can differ amongst projects. The size of PR depends on the size of project as stated by a number of interviews. However rough estimations provided revealed that the project review produced by participated organisations ranged between a paragraph and 100 pages.

C5: *"It may be a dozen pages long relating to reports on progress and reports on performance and commercial performance and there are all sorts of different subsections to describe how the project is doing."*

C5 produces two reports; the first one for measuring project performance; and the second is knowledge focused. The later one is only one page long; whilst C1 produces an average of a five page report for a typical project.

> ***C5:*** *"Maybe a one page reports on 'what we did on this job; 'how it saved money'; or how it was quicker or safer or actually that it didn't really work as well as we would have liked"*.

> ***C1:*** *".a typical one may be for a number of middle sized projects and consist of 5 pages."*

The practice of the project based organisation is similar to the construction organisations as they produce an average of 12 paged reports.

> ***T7:*** *"This depends on the size of the project, but I'll say it is twelve pages on average."*

The case in K6 may be distinguished from the construction companies and T7. This is because K7 is using it after the action review.

> ***K6:*** *"Not a 50-page document, but it could be a page, page and a half, or it could even be a paragraph."*

It should be considered that the chairman of K6 is speaking about the size of one review, and they carry out reviews on a daily basis "or at worst once a week" (K6); whilst the other organisations are speaking about the size of the final report of the project review. This may indicate that the size of the reviews in one project in K6 can be close to the size of the reviews in the participated construction organisations.

It is a difficult task to find out which method may work best for the construction companies: the review notes, lessons learned and progress report; or the knowledge nuggets approach. 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.

It is generally accepted that overload of information is a problem that can block access to desired information. The Chairman of K6 linked this problem with the lessons learned approach. However, such an approach produces a report consisting on average of twelve pages in T7. Therefore the lessons learned approach is not necessary linked with length.

A notable advantage of the review notes approach is that it usually results in a shorter number of pages; because the comments are usually short. For instance, the Director of C1 (who uses review notes) estimated that the outcome of their reviews to be about 5 pages on average. In addition, four out of five participated KM matured construction organisations are using review notes. Accordingly, this may illustrate that review notes works for construction projects and for all sizes of companies.

The knowledge nuggets approach suggested and practiced by the KM institute can be considered as similar to review notes in terms of the size of the final product. The knowledge nuggets approach produces a very short to the point review.

> **K6:** *"Knowledge nuggets which are very compressed, just a nugget of knowledge that's necessary to get something done."*

The reported average number of pages of PR ranges between five to twelve pages as quoted above. However, C5 has a one page report that focuses on the gained knowledge and may seem exceptional. It cannot be claimed that one page is incapable of giving sufficient information; but it can be said that one page could be the minimum but not the average, and it may be insufficient in many cases.

With regards to the form of the content knowledge nuggets approach an extra advantage is featured. Three forms of the desired knowledge are identified in this approach " 1) instructions, 2) checklist or 3) names of members in the organisation who can offer help in that area" (K6). Whereas no clear forms of the captured knowledge has been demonstrated or found in the other two approaches. The identification of the required forms of knowledge seems to provide more potency to the approach because it gives more clarity to the reviewers about what the captured knowledge or information should look like. The three identified forms of knowledge can be regarded as an important element to the review. Whilst the first (instructions) and second (checklist) forms are likely to be used by all the participated organisations, (although none of them has clearly stated this), the third form (listing names of people can offer help in this area) is thought to be needed in some cases. However it could be better to have those details in the expert directory, as discussed in greater detail in 7.25.

Review notes provide short to the point comments on activities/tasks of the project that can be reused in future projects. The knowledge nuggets approach achieves the same principle as it produces information that facilitates the job to completion, and provides a variety of knowledge forms in a methodological way. Where it seems applicable to a construction project, no barrier can be seen to prevent the use of the knowledge nuggets approach in construction projects. That is due to two factor: i) none of the recourses of the knowledge nuggets approach are new to construction projects or unobtainable for SMEs and ii) the approach does not have any features that make it merely applicable to a particular size and type of project. This approach is fixable as in most of the other KM approaches and can be used in a variety of environments.

7.24.6. *Classification and structure of project knowledge*

The way knowledge is classified and organised will impact on the extent to which this knowledge can be easily retrieved.

- ***Representation form***

It was found that the participated organisations are accommodating those review notes, reports, or knowledge nuggets in the KM system (7.22) as either files or live pages. Whilst files need to be downloaded to the desktop-environment-before they can be opened and read; live pages can be accessed and read directly from the KM system. In addition, files cannot be edited from the system; whereas live pages could be edited/updated directly from the system. It was found that four out of five construction organisations are storing the project review in live pages; whilst only one organisation (C5) is relying on files, with the consideration that C4 uses files in addition to live pages.

Table 7.7: Format of the stored knowledge

Case	**The format of stored knowledge**	
	Live pages	**Files**
C1	●	
C2	●	
C3	●	
C4	●	●
C5		●
K6	●	
T7		●

It is not difficult to understand that presenting project reviews in live pages is considered more efficient than storing them in files. The interviewee in C5 (which is the only participated construction organisation that uses files to store the project review) indicated that the use of a file or what he calls “a paper format” is not the most appropriate way of storing project knowledge.

> ***C5:*** *“Now it is nearly always done electronically. It has not been made smart yet. It is very much a word document that somebody sits and types out and fills in. We have not yet graduated to any sort of smart document reporting.”*

In addition the way that a participated company identifies the live pages provides a positive impression about it effectiveness.

> ***C2:*** *“It’s real and live and easily accessible.”*

- ***Classification of the captured project knowledge***

Three major methods of project knowledge classification were found: 1) by project 2) by business/discipline and 3) by process.

Table 7.8: Classification of the captured project knowledge

Case	Classification of the captured knowledge			
	Project		Business/ discipline	Process
	Stage/phase	Process	Project→ Process	
C1		●	●	
C2		●		
C3	●			
C4		●		
C5	●			
K6				●
T7		●	●	

The first method, classifying the project captured knowledge by project, is used by all the construction organisations; in addition to the project-based organisation (T7). This method of classification is to store the data of every project together so the whole picture of the project can be seen. However, this major method can be subdivided into two structures;

subdividing the project knowledge i) by project phase/stage (found in C3 and C5) and ii) by project process (found in C1, C2, and C4, in addition to the project based organisation (T7).

> ***T7:*** *"You will find the initiating process, analysis process, and the controlling and monitoring of the implementation, etc."*

The second major method of project knowledge classification is to classify the project knowledge based on the business or discipline, project and processes. For example, an organisation in charge of doing architectural, structural engineering and project management works in one project, would classify the captured data into these three disciplines (architecture, structural engineering and project management). The content of each discipline will be located separately and the content of the projects in every discipline will be classified by processes. This method can only be used in multidisciplinary organisations, and explains why this method is used in C1 and T7. Both of these are international multidisciplinary organisations.

> ***C1:*** *"The information is usually captured by the discipline or by the project team and then stored. So I suppose by a project team you could say process because you could have a structural engineering process or electrical engineering project management in an architectural process."*

> ***T7:*** *"By business you need this by a project. Whenever we have a project we create a project referential in the portal that allows us to capture all the documentation and knowledge related to the project."*

The third major method of project knowledge classification is to store project captured data by processes alone with no link to project. This method is suggested and practiced by the KM institute (K6). One of the main sections in the K6's knowledge base (the system) is the knowledge nuggets section. This section comprises a list of processes, and inside each process there are activities. The classification of the processes and activities content is based on the work breakdown structure (WBS). Knowledge nuggets from projects are saved in the activity that the knowledge nugget comes from. In other words knowledge nuggets form the elements of activities; and the activities are a subcategory of the processes. Processes and activities in the system are exactly the same as the processes and activities of the projects conducted by K6.

K6: "You define a process and each of the processes has activities; which are an extra nugget of knowledge and the elements of this activity... This nugget is catalogued according to the activity in which you were participating today in the knowledge base; aligned with this particular activity. This is not thrown into some general knowledge, where it would get lost."

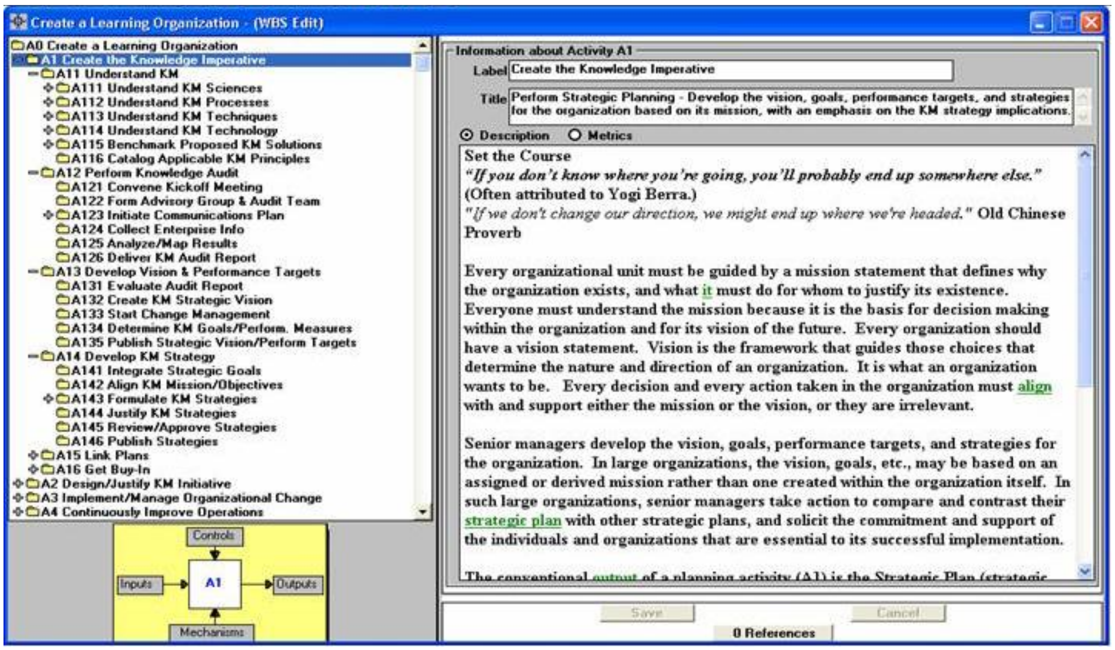


Figure 7.15: The process-based system of project knowledge   Sources: KM Institute

Classifying project knowledge by project may not seem important in certain types of projects, and this is not the case in construction projects. This is indicated by the whole of the participated construction organisations; as all of them locate the knowledge of each project together. This method could be necessary in construction, because in some cases, there is a need to have a full picture of the project. Taking information out of the context in a construction project may mislead in some cases, as the required knowledge in a certain area may differ according to the type, size and location of the project.

Sub-dividing the project based classified information into a phases or stages driven category of project knowledge is considered much better than having no category. This type of category could help in accessing the required knowledge by going to the particular stage/phase section when needed. Nevertheless, a stage/phase in a typical construction project could have many of the processes and activities (see section 3.3), and this may reflect how much time it could take in some cases to find the required data about a particular task.

The other way of sub-categorising the project knowledge in the first major method seems to provide a more robust solution. Sub-categorising the knowledge of a project based classified project knowledge by the processes is deemed more precise than by stages or phases. Which could mean more organised contents, and that it is easier to find especially when searching in many project profiles.

The second major method of project knowledge classification (business → project→ process) may not be needed in SMEs that are only focused on one major business. The majority of SMEs in the construction industry are unlikely to have more than one major business. If an organisation is participating in one major business, then it would not need to classify the project knowledge based on the business. Both of the participated companies that use this method of classification are multidisciplinary international organisations.

Although there was no given evidence to prove that the business driven classification work with SMEs, it could be said, this does not necessarily mean a multi-business or small or medium organisation cannot get the use of a business driven classification of knowledge. The participated organisations are a percentage of those applying advanced KM practice, and what they do is considered amongst the best in current practices.

Logically, an architect working in a multidisciplinary organisation is more likely to have interest in the information related to their work. Therefore, a business driven classification is a solution to make the content project knowledge more customised to a particular discipline. Therefore once a small or medium construction organisation has more than one business; then using this method of project knowledge classification could be an advantage.

If the knowledge is codified to be reused, then the third method of project knowledge classification (by processes) is deemed to be the easiest method. In the project driven classification (used in both methods 1 and 2) we may have to come across many project profiles to find the required data. By contrast, the processes driven classification save time as the desired information can be found by going to the exact process→activity, which will have the accumulative knowledge from previous projects.

However construction projects are not the same and knowledge coming from one project may not be applicable to other projects. This is why all the participated construction organisations are using methods 1 or 2 which are project driven classifications. However, construction projects will still have similar processes and activities, and will always have common knowledge. Therefore, using a processes driven classification beside the project driven classification can provide the right information to the right person in a shorter time. However using a processes driven approach in isolation may not be enough in construction.

It was thought that the best practice of knowledge codification would include providing an opportunity to those participants not included in the project review the opportunity for feedback on the codified knowledge and comment on the project if they wished. It was thought that in some cases, such participants may have experience on the subject, and thus could enrich the process. This feedback can subsequently be reviewed and may be used to update the review.

However none of the participated organisations (including the KM institute (K6) and the project-based company (T7) have been found to use the on-system feedback method. This could be because it is not considered a functional method, in the way that it makes the codified knowledge a discussion board, the reader cannot therefore distinguish the reliable information. It may also be because it is assumed that the participants are experts, and there is no need to examine their reviews.

However, an alternative solution was found in C4. It has been to validate the codified knowledge that has been added by individuals by reviewing the contents by experts and marking those contents.

> ***C1**: "We have a system where, it is called branding. We try to put a symbol next to a reference with some information, which gives people an idea of whether it is something, which has been through a very thorough review process. So that the best brains have looked at it and said, "Yep, this is good stuff."*

This branding system is only to be used with the individual entries that have not been reviewed; and does not include the project review which has assumed to have been already reviewed by a group of experts.

> ***C1:*** *"This is C1 advice that gets all the best symbols done to assist somebody's opinion. Think hard before you follow it because it may have been right for him; but it may not be right for you."*

A similar method is used by C2, whereby every member of the organisation could add content to the system; but entries have to be approved before they can be published and disseminated.

> ***C2:*** *"Adding information must be approved by the Line Manager. It's a kind of check to make sure that the quality of information is consistently good and usable."*

The above mentioned quotes in addition to the information provided in section 7.22, indicate that participated construction organisations give permission to individuals to add contents to the system; but such contents are catalogued as general knowledge and not placed within the project knowledge. Since all the participated construction organisations classify the contents of the project review by project, therefore, each project will have its own profile. This means that additional entries by individuals outside the context of the projects cannot be located within the profile of a project.

If a company allows additional entries by individuals to the project after the project review, the question may arise relating to where this entry should go to; to project 1 or project n! Whilst in the practice of the KM institute, individuals could add contents to the project knowledge because the captured knowledge of all projects was available in one place based on the processes and activities. This in turn does not lead to any problems in adding information to the project knowledge-base as far as the entry is added to the right activity.

- ***Structure of project knowledge***

The classification of the captured project knowledge can be considered as a way of structuring the captured data. However additional criteria for better structuring were found in the participated companies. C3 suggested that the criteria of writing should consider: 1) following one outline 2) avoiding idiosyncrasies.

> ***C3:*** *"There is uniformity in structure of the added contents to guarantee the sort of input that you need. We ask people to take into consideration the idiosyncrasies of the individuals."*

A clear and standardised structure can be found in the organisations that use commentary forms or templates to conduct the project review, as any addition is added to the pre-identified points in the form, and sometimes you may only need to select between available options as in C2:

C2: *"The questions are already pre populated with the information we are looking for; and you enter the information either freehand or from drop down lists of options. Around the world people are filling in the same way."*

Despite this T7 save the knowledge of each project in a separate file; the content is classified based on PM processes and this helps in giving more precise and practical classification to the content of the project review.

> ***T7:*** *"You might find the same principal across all projects. Even if the methodology often does not sound the same, you will find the initiation process, the controlling and monitoring and the implementation, etc."*

7.25. Knowledge Retrieval

The methods of project knowledge retrieval that are available in the participated construction organisations can be grouped into two categories. The first method uses a search engine. Once you type the keyword; you obtain the related knowledge of the previous projects. All the construction companies use the search engine method.

> ***C4:*** *"It is prompting me for various key words, and I can search on this; and a PDF which opens up straight away. It is quite useful, isn't it? We found that very quickly, it was pretty good."*

The second method of retrieving project knowledge is by navigating and selecting the desired project. This method is practiced in C1 and C2.

> ***C1:*** *"You click on something called 'C1 Projects', and it says, 'what project would you like to learn about?'. You can either search for the project like key words or if you know the name of the project or the project number, you can feed that straight in. Up it comes and then there is some basic information and links to other bits of*

information, which may be stored in Australia or Germany or other places. It is a route map to get you to the information wherever it is."

C2: *"You put in the information online about the project you are interested in and you can choose from a list of other projects which might be relevant for comparison. Then it runs a program to compare the relevant data and then you can drill through the intranet for more information."*

The KM institute is also using the second method. As shown earlier, the taxonomy of project knowledge in K6 is catalogued according to the processes and activities that simulate the project. Therefore what is required to retrieve the desired knowledge is to go directly to the targeted activity in the knowledge base.

K6: *"You don't need a search engine, you just need to know what your processes are, and you enter into the knowledge base, regarding whatever activity you are dealing with, by a search based on the activity."*

Using a search engine to retrieve the desired information from the previous projects is most likely to be essential for construction organisations. This is due to the fact that in some cases the exact location of the desired information may not be known and the search engine could be the easiest way to help in such cases.

Moreover, finding this, all of those participated KM-matured construction companies using a search engine may give an indication of its importance. It was also found that the project-based organisation (T7) was using a search engine. The expression of the chairman of KM Institute: "They don't need a search engine" does not necessarily mean that he does not support the use of search engine, but it certainly means that it is not the most appropriate method from his point of view.

C1 and C2 may also agree with K6 as they both use the 'navigate and select' method as the primary way of retrieving the required information. It is not easy to favour one method over the other unless the way of project knowledge taxonomy is known. The content without taxonomy or with a very broad taxonomy (e.g. relay one project alone, on the stage or phase) may seem appropriate to be retrieved by the search engine method. Whereas, the content with precise taxonomy based on activities, or small tasks, could be retrieved faster by navigating to the exact needed activity, work or task.

In the search engine method results will always be obtained faster, but not always with the right information; or results could contain the right information after filtering. Conversely it is very likely to find the right information easier and faster when using the 'navigate and select' method.

> ***C4:*** *"At the moment I suppose the weakness of our systems is they often ask you a question and you are provided too much information, which you then have to filter. A slightly more intelligent system I think would be able to reduce the amount of information that is supplied back to you and that you have to process. Yes at the moment there is a bit too much and people add to it every day."*

Whilst there was a lack of evidence revealing that people should not start with the system, some indications showed, when there is a need for an answer, the system should be the first place to look. Some of the participants did not identify where to start first when requiring information about a particular ask; but their answers relating "how do you retrieve knowledge of projects" may show that the system has the priority to start with.

> **C1:** *"People are very quick to go to the electronic systems to get a solution."*

> ***C2:*** *"Again it's captured. We get the information back through the intranet through the systems we have set up."*

> **C5:** *"There is intranet and the database is associated with this. There is also word of mouth you know whereby people pick up a telephone and talk to each other."*

The answer of the participants from the project based organisation also shows that if the information has already been captured then the system is the place to go to. The same thing happened in the KM institute.

> ***T7:*** *"If it is something, somehow already done, then for sure we can rely on the portal (system)."*

Nevertheless, what if the required knowledge has not yet been captured? What should happen in such a situation? It is worth mentioning that, when they were asked about the sources of retrieving knowledge, all of the interviewees pointed out that people are the major source of knowledge. The non-captured knowledge cannot be retrieved, therefore if the desired knowledge has not yet been captured, the right way to find the desired information, as suggested by the participants, is by finding the right person in the organisation.

Apart from C5, construction organisations have yellow pages or an expert directory. In addition, K6 and T7 also use an expert directory which provides information about people in the organisation and their areas of expertise (see Table 7.4- section 7.22.2). Therefore an expert directory is an appropriate method for finding the right person to ask.

> ***C1:*** *"*You go to another system we have called C1 people. Everybody in C1 has their own personal internal web page where they can write what they like about themselves under certain headings and the first heading is subjects which I would expect people in C1 to phone me up and ask me about . The next one is, subjects in which I have a developing interest, and there are a couple more, so you can expand it and I can be trusted to ask about this., I might be able to help about that, so you can get to the C1 people and you type it in. I don't know, reinforced concrete, corrosion in the Middle East and get some names there."

> ***C3:*** *"Professional details, skill experience we have to know about ourselves, and that's all part of knowledge management. Anything I have shared should be on there, and that sort of detail about me. All these different elements people are asked to fill in when they join the company. They have skills."*

More detailed practice has been uncovered in the C1 which has shown the order of what to do when looking for an answer. As discussed above the procedure may start with looking into the captured knowledge in the system. Subsequently if the required information has not yet been captured in the system, people in the team and in the C1 (the expert directory) should be used to finding either the desired information or the expert person. Indeed, no information was provided which shows whether to start with the expert directory or with people in the team.

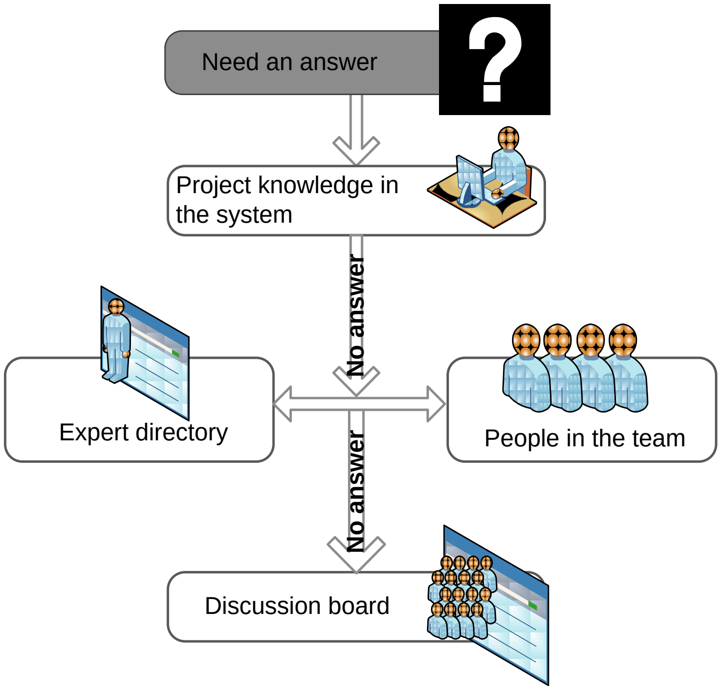


Figure 7.16: Procedure of project knowledge retrieval in C1

In case there is no answer found within the system, associated with the expert directory and people in the team, the C1 network (discussion board) which is accessible by people at all levels of the organisation can be used.

> ***C1:*** *"What you should really do is speak to an engineer sitting next to you, or find a senior colleague who is more experienced, and ask them if they have come across this or do they know somebody who has. You really need to start with your immediate team. If they cannot help because they do not have experience or knowledge, then you can turn to the electronic networks. If it is a technical problem, for example, a structural engineering problem, you can go to the structural skills network and even say, "I have this problem, can anybody help? As the sun rises around the world, you can see people waking up, coming into the office, and reading the question and firing in their answers."*

The practice of retrieving knowledge in the KM institute starts by looking at knowledge related to the task associated with the knowledge-base (the system – the captured knowledge). It should be considered that, the knowledge base may ascertain who has the answer.

K6: *"A knowledge nugget could just be a list of two or three people who you should go talk to, if the knowledge base doesn't have an answer"*

In one of the unpublished documents given by the Chairman of the KM institute, additional details were found about the procedure of knowledge retrieval suggested and practiced by the KM institute. It was found that in this case there was no answer in the knowledge base, and therefore the knowledge seeker should ask for help.

Help can be provided in two forms: it could be provided by a particular person expert in the required area; or by part of the community of the practice group. The community of the practice group as discussed in literature (see section 4.11) can be formed in either a formal or informal way.

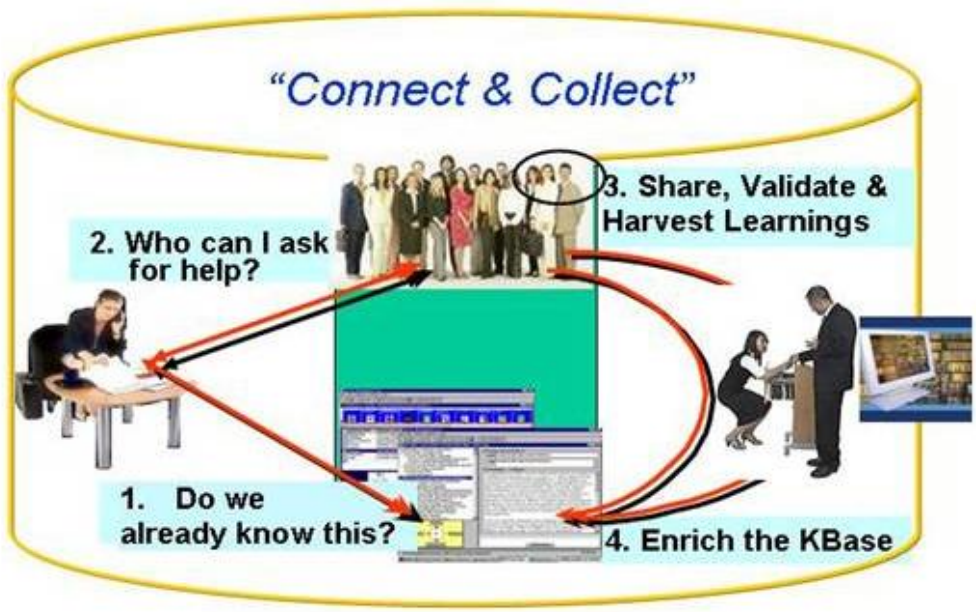


Figure 7.17: Project knowledge retrieval approach in the KM institute[4] *Douglas Widner, KM Institute.*

When the answer is given, it should be shared and validated by the experts. Finding the answer and sharing and validating it could be done through an electronic discussion board. When knowledge is validated by a discussion group, a volunteer may summarise the answer and form it in a way which could be beneficial to the knowledge base. New

[4] Douglas Widener gave written permission to use the graphic in Figure 7.17.

knowledge has subsequently to be posted to the knowledge base manager for verification in order to be located to the the exact place, so that future problems can be alleviated by those experiencing the same problem unable to find an answer in the knowledge base. This whole approach is called ‘connect and collect’.

It may be clear that participated organisations employ the same practices when it comes to alleviating problems. However the participated organisations may have no clear or structured procedure about how to achieve this when there is no answer in the system. This may be due to the claim that it is only common sense to find the most suitable person in the organisation to ask. However, the advanced practices of knowledge retrieval provided by C1 and the KM institute may have shown the benefits in identifying a step by step procedure in order to retrieve the desired knowledge. C1 and K6 approaches may be viewed the same when neglecting the used terms and viewed from the functional perspective. The only difference could be that, in the KM institute, when the desired knowledge is found outside the knowledge base, it should be shared, validated and posted to the right place in the knowledge base. This step is to guarantee that any problem which has been solved should not be left without codifying it in the way it could be reused.

In C1 the knowledge may get codified when the solution is harvested from the discussion board; and subsequently there is no direct way to reform and place this knowledge in the right place in the system in order to reuse it again in the future. However, there is a C1team in charge of collecting the usable project knowledge and posting it to the system. In addition everyone could post knowledge which they think is needed. The validation of this added knowledge is by using the branding system.

> ***C1:*** *“We have a system, it is called branding, we try to put a symbol next to a reference to some information, which gives people an idea whether it is something, which has been through a very thorough review process so the best brains until now have looked at it and said, “Yeah, this is good stuff.” This is Arup advice that gets all the best symbols done to assist somebody’s opinion. Think hard before you follow it because it might have been right for him, but it might not be right for you. So this exercise of branding is a very important one.”*

The practice of knowledge retrieval has shown how it is strongly linked with knowledge sharing; particularly when there is no answer to the problem in the system. Both C1 and K6 use the electronic discussion board as a means of asking for help and knowledge sharing. It may be obvious that the discussion board can be used in the construction industry, and C1 is not an exceptional case.

However what about using the electronic discussion board in organisations with a limited number of people such as SMEs? In fact none of the participated SMEs use the discussion board. In the analysis of the survey in Chapter 6, it was found that only two SMEs (2%) out of 91 companies used the discussion board; whilst 8 companies (16%) out of 48 large companies used such media. Furthermore it has been ranked eighth out of ten IT tools by SMEs in term of effectiveness; whereas it has been ranked the second most effective IT tool by large organisations. Therefore the discussion board is not popular in SMEs within construction and ineffective when compared with large organisations. This is because the number of discussion board members actually matter.

These results may not necessarily recommend avoiding the use of the electronic discussion board in SMEs; but may suggest deploying other methods of knowledge sharing such as discussion groups - which have been deemed more popular and effective (see section 6.7.2). The discussion board can be efficient for the SMEs if the organisation has more than one firm; and in this case can enrich the knowledge sharing practice, instead of limiting knowledge sharing to the people in the same location.

7.26. **Hierarchy**

Before commencing the interview process hierarchy was not considered in the agenda. However the first two participants mentioned it, which may be relative to knowledge capture and retrieval. It was subsequently decided to ask the following interviewees about the hierarchy of their organisations.

Apart from C3 all the participated construction organisations considered the hierarchy of their organisations to be flat.

> ***C1:*** *"It is as flat as we can make it. Globally C1 is run by a small global board of about 8 people and they lead the whole organisation. Then we organise ourselves in a matrix system by geography. We also organise ourselves by business sector."*

C4: *"It is quite flat."*

The number of hierarchical levels in those organisations ranged between three and six levels. However C3 did not provide any number of levels; but has been described as a hierarchical company.

Table 7.9: Depth levels of organisations hierarchy

Hierarchical Depth	
Case	Number of levels
C1	4
C2	3
C3	Hierarchical
C4	3
C5	6

C3: *" It is actually a very hierarchical company."*

The flat hierarchy seems to be an effecting factor that facilitates knowledge and communication between people in the organisation. This has been supported by the chairman of the KM institute:

K6: *"Hierarchy needs to be flat. This would help the communities. I believe strongly in flat organisations."*

The Chairman has also recommended the numbers of hierarchical levels appropriate for knowledge sharing. In addition he suggested the number of people than can be administrated.

K6: *"The recommended depth is only five levels between the CEO and the personal (plant person). Your span of control, how many people you can supervise is ten not forty-seven. If you do all those things you're probably been enriching the communities. You are certainly giving more responsibility. The activity level is deep."*

7.27. **Culture**

One of the interesting results in this study is that, even if an organisation has a vertical hierarchy, the organisation still can overcome the problem of knowledge communication that may occur in a hierarchical company. An open culture and social networks enable members of an organisation to access everyone in the hierarchy. Furthermore, an open culture may act as the engine that powers knowledge sharing, and therefore knowledge capture and retrieval.

> ***C3:*** *"Everyone learns from everyone else. It's like life. A company is no different than life. We can learn from people, and people can learn from us."*

> ***C2:*** *"It is a very open organisation. I sit out in the open floor plate with everyone. One of my members of staff recently contacted the Chairman of the organisation to ask something about pipe banners and some other things. We encourage open communication between everyone in the business."*

> ***C5:*** *"It is a pretty open organisation."*

The design of the workspace is also considered as a factor that can help to improve the open culture.

> ***C4:*** *"We've been working in one big studio upstairs and then we use this downstairs area for meetings. Everyone is in one space, and historically we have been small enough to be able to hear what's going on. So that's a very basic level of the work place design."*

In the project-based company (T7), an open culture formed an environment where everyone was happy to offer help.

> ***T7:*** *"What I found interesting was that people are very helpful. They don't close the doors by saying, "Okay, come on, don't ask me this type of question." They are helpful, to share what they know, to share their experience, to share how they do things, etc. There is an openness that may be derived from the culture."*

Culture could be a key factor to the successful KM application; as the Chairman said "it is about culture". If there is a fertile ground that enables people to connect with each other freely (knowledge sharing); then knowledge could be collated (captured) easily. This is the concept as seen by the KM institute, and is about connecting people and collecting knowledge.

> ***K6:*** *"It is not all about IT, it is but a culture, change management, and working with people; these big things we pretty well know. The model described, that I feel very comfortable with is: 'connect and collect'. It's really a combination of knowledge nuggets and in a collection we call a knowledge base, and connecting people together, with common practices. Having the best help for each other and we want to enrich that help. That's another one of future things that are absolute, that's where it's going."*

The following sections highlight the components of an open culture practiced by the participated organisations.

7.28. Motivation

As the participated organisations show, there is a need to have a motivating strategy to guarantee that knowledge is always shared, and therefore can be captured and reused. Several methods of motivation have been illustrated by the participants. Nevertheless, it seems that the most important method is by demonstrating the benefits of knowledge sharing to both the organisation and individuals themselves. Three of the participated construction organisations use this method, in addition to the KM institute:

> ***C2:*** *"The best thing about encouraging people to use knowledge management is when they see the benefits of it. If it's a one way street where they just submit information, but they don't see what comes back from this, then you would have a very hard job getting people to complete the information. I think the systems do learn from this, and they do make it ask for data only once, and use it well and people can see the benefit of it."*

> ***C3:*** *"You have to impress individuals the benefits of sharing... I actually take them around the whole company, I show them what's behind every door here, I take through the system, and I explain this whole way of working and explain the value of it."*

C4: *"We have to believe that we have to share knowledge."*

K6: *"You need to convince people something that is definitely true, and that when you share, you are improving your own knowledge. As much as you are helping another person, you are improving your own knowledge. The expression I'd like to use to describe this very quickly is, "You don't know, something until you teach it. Sharing your knowledge is absolutely increasing your own knowledge."*

Another method used by the participated construction organisations may be called feedback-based motivation or that which focuses on the demand side relating to what individuals actually want. It is to ascertain why people are sharing knowledge or not and their opinions about the KM approach. It is also to show them that the top levels of management are aware and looking for continual improvement.

C1: *"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."*

C3: *"If people are not sharing knowledge, why are they not sharing the knowledge? This is the approach that I take. If they keep it to themselves, what is the reason for this?"*

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

C2: *"We run an internal staff recognition scheme in addition to the bonus scheme. When people do a particular 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 really appreciate it when people go out of their way to do something that is very good."*

The project-based company (T7) motivation is at a strategic level, as knowledge sharing is considered one of values of the company.

T7: *"In the values we have described, we have defined knowledge sharing as part of the company values."*

All the identified methods of motivation centre around one concept, and this has been summarised by the Chairman of the KM institute by illustrating that people will think in the way that "what is in it for me".

K6: *"We have to convince them that it is advantageous for 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."*

7.29. **Communities of Practice (CoP)**

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 2.9.1). These two forms of CoP were found in the construction organisations.

C4: "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 "

C2: "Every month we have a staff meeting where I go through the news and any developments."

C3: "We ask people when they find these snippets of knowledge; not just to share with team individuals, but to share with everybody. We have the facility for this which is also based on mutual respect."

C5: "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."

T7: "We have one or two-hour session of Questions and Answers. In this Q and A session, we present the subject, and encourage attendance. Participants can have a sandwich and spend 5-10 minutes, asking their question. If you want to learn from

> *the other questions you can also stay with us." The objective is to answer specific questions they may have."*

CoP can also be built through technology as in C1 and the project based company (T7).

> ***C1:*** *"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."*

> ***T7:*** *"Technology allows us to do, Instant Messaging. Whereby you can determine whether a person is in or out of the office. They can type a question instead of sending an e-mail; and they type the question and send it to a particular person"*

7.30. **Social networks and activities**

The participated organisations also consider having social activity and evolving social networks which are a means of strengthening the relationships between individuals, and build trust so they can know each other well (see section 4.11). This in turn can make it easier to share knowledge between individuals.

> ***C4:*** *"Every Friday we take turns to have a 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."*

> ***C5:*** *"The social structures are very amateur at the moment, but they are getting better as they should; but they are pretty new."*

> ***C2:*** *"I took everyone through this on a monthly basis and then we obviously had the lights out and the Christmas party and things. We tend to be more social than actually looking at the processes we have as part of our day job."*

> ***C1:*** *"We do have a social network."*

T7: "To build good relationships and to create social networks we have defined an annual event, which is an annual conference. This could be in Malaysia or wherever; where these people can meet together and is an opportunity to see the faces of each other. Then there are the team building plans as well, so you can get to know someone better and this creates a good atmosphere. So this is a good way."

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

K6: "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 C1 provides a coffee shop with a seating area whereby everyone in the organisation can come at any given time for free. In addition C4 has a tea point, where people can meet and talk. During the director meeting at the C1, the seating area was found to be very popular with people drinking and chatting.

7.31. **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 pointed out that it was very important that leadership had to stand behind the application of the KM and support it.

C2: "We are supportive. I think it is the C2 way and it is very much around the encouragement of people to do what is expected of them."

In C1, leadership has to show everyone in the organisation that KM is everyone's responsibility.

C1: "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 the KM.

> ***K6:*** *"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."*

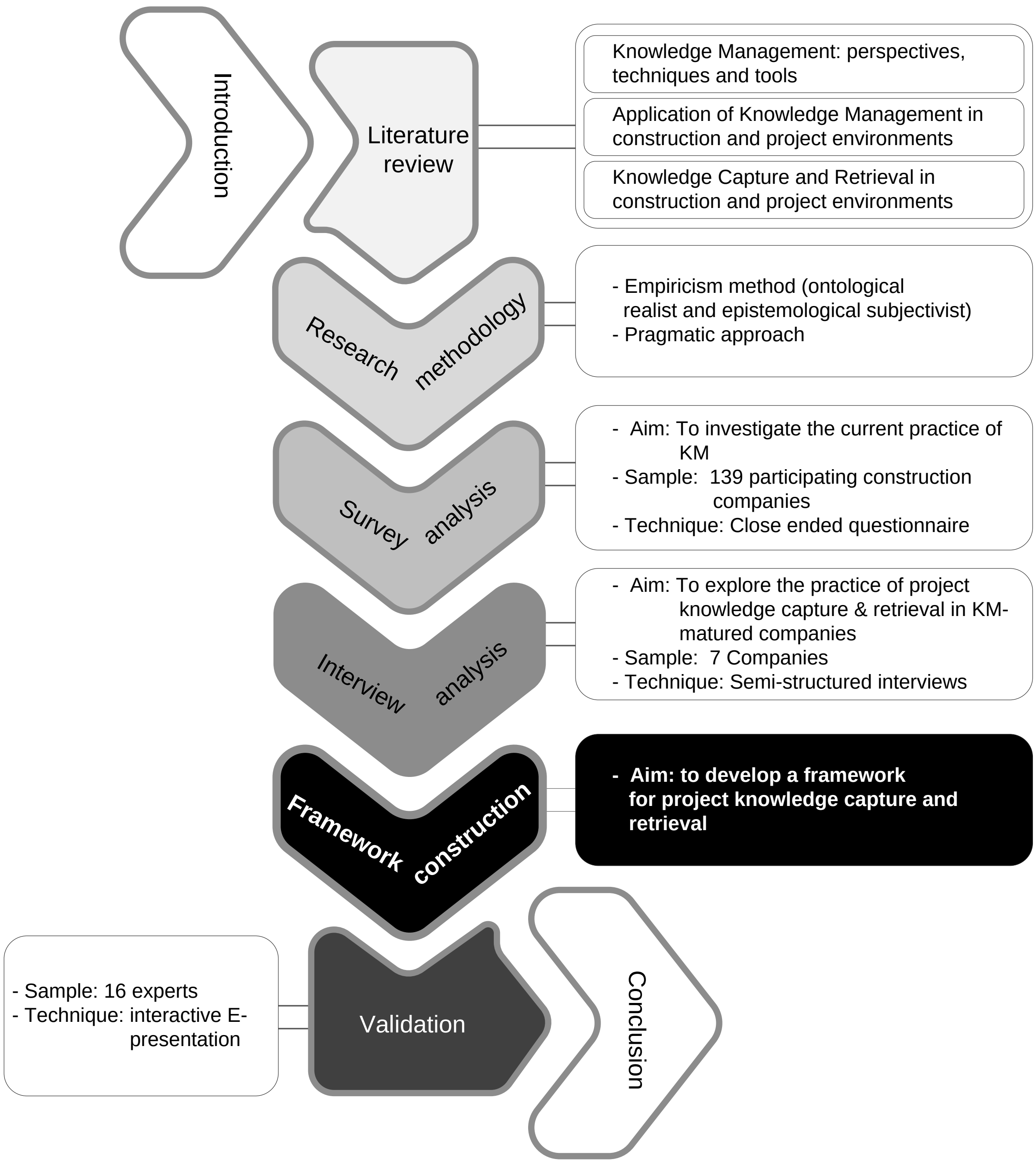
7.32. **Summary**

This chapter set out to explore the best practices of project knowledge capture and retrieval (PKCR). Data is collected from seven cases based on semi-structured interviews. The following conclusions can thus be drawn from the data analysis. Generally the successful application of knowledge capture and retrieval is determined by the deployed method, processes, and technique. However, other factors including open culture, motivation, social networks and social activities, structure of the organisation community of practice and work space design are regarded as vital to PKCR application. In addition, 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 PKCR.

One of the key significant findings to emerge from this study is that the project review is the major method for capturing project knowledge. A number of techniques is therefore deployed in 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 is considered practical and reusable when short (on average, five to twelve pages) and in the form of checklist and instructions. As well as it should be available in live pages on the system. Categorising project knowledge based on both project→processes, and processes with no link to project, appeared to maintain the context and make knowledge retrieval fast and straightforward during the course of 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 PKCR in construction.

CHAPTER EIGHT: DISCUSSION AND FRAMEWORK CONSTRUCTION



8.1. **Introduction**

This chapter presents and discusses the findings obtained from chapters six and seven, in order to construct a framework for knowledge capture and retrieval to be used in construction projects. The approach to developing the framework is based on the induction method, using processes modelling, decision support modelling and revealed causal mapping. The chapter has been divided into four parts. It begins by detailing the method applied for constructing the framework. The second part presents and discusses the findings of the research. In the following section the framework will be presented and explained. Finally, the framework elements will be combined and then demonstrated diagrammatically.

8.2. **Theory building**

Concepts or theories are developed to explain phenomena in a field, or to provide a structure or framework to apply to acquired knowledge in a field (Davis and Parker 1997). Theory building is typically driven by the desire to explain something; before there is a theory, there is usually a theoretical problem (Shoemaker *et al.* 2004). Collecting data and analysing it without linking findings together and concluding in terms of a meaningful concept is not sufficient to build an awareness of the result. As Handfield and Melnyk (1998 p: 321) state: "Without theory, it is impossible to make meaningful sense of empirically-generated data, and it is not possible to distinguish positive from negative results". Theory can take the form of statements, models (Bacharach 1989) or frameworks (Carlston 1994; Rumelt 1994).

It was essential to move beyond the broad principles outlined in the literature to provide more structured and precise tools for understanding best practice. Instead of building models, the approach determined upon was to build framework. A framework such as PKCR seeks to capture much of complexity of actual best practice. The theory embodied in frameworks is contained in terms of included variables, the way variables are organised, interactions among variables, and the extent to which they aggressively reduce the learning curve (Rumelt 1994). As is the case with all theories, this framework was built of four elements: (1) definitions of terms or variables, (2) a domain where the framework applies, (3) a set of relationships of variables, and (4) specific predictions (factual claims) (Wacker

1998). Three questions were considered when building the framework: What are the key variables? What are the relationships between these variables? Why should these relationships exist? (Voss *et al.* 2002). Statistical analysis (chapter 6) and content analysis (chapter 7) is used to identify and narrow down the variables and constructs; reveal causal mapping is used to identify the relationships between variables and constructs.

8.3. **Approach to Framework Building**

The data collected has previously been analysed using statistical analysis in chapter six and content analysis in chapter seven. The purpose of this chapter is to put the results together, identify relationships and consequently build the framework. Framework building will rely on inductive reasoning (Upham 1841), processes modelling (Karagiannis *et al.* 1996), decision support modelling (Wright and Bolger 1992) and reveal causal mapping (Huff 1990). PKCR includes a number of variables and constructs; each construct (or theme) will be presented and discussed separately and the appropriate technique (processes modelling or and decision support model) will be used to present the conclusion, where required. Finally all the variables and constructs will be put together using the causal mapping technique.

8.4. **Reveal Causal Mapping**

Revealed causal maps represent cognition as a system of cause-effect relations for the purpose of capturing the structure of human cognition from a text, which is either archival or interview generated (Narayanan and Armstrong 2005). It is a means of representing a person's assertions regarding a domain (Axelrod 1976) by linking specific empirical findings with theoretical categories, and then linking categories into a network of causal relations (Nelson *et al.* 1999.). This method is widely deployed in the field of social science (Huff 1990), and has been used in theory construction and testing (Nelson *et al.* 2000). To avoid complexity in representing the framework (because the number of variables and constructs is high), it was decided to consider the reliability of the causal map by using islands of themes (clusters), accounting for hierarchy, using nubs and potent, and simplifying concepts through emergent proprieties (Bryson 2004). This will help here by allowing for the whole framework to be presented in a single, which will minimise any difficulties in reading the framework.

8.5. **Required Information**

In order to best facilitate decisions during the course of the project it is important to have several forms of information available. This study considers what knowledge will provide the best practice for performing the work required for the project. This knowledge can be called *project insight*. It was found that in some cases project insight can be better understood if it is supported by other forms of information, such as *project data* and *project correspondences*, which together form what can be referred to as *project portfolio*. The project data includes data such as scope, procurement, parties, cash flow, schedule etc. Meanwhile project correspondences refer to the codified telephone notes, emails, and forms that are related to the project (sections 7.23 and 7.24.1).

The other type of necessary information relates to details of organisational members, or the *expert directory*. This data makes it easier for project members to find the right person to ask when necessary, as discussed in sections 7.22.2 and 7.25.

8.6. **Knowledge Capture**

Two major methods for capturing knowledge were reported from the interview analysis; by individuals and through project review. Individuals are encouraged to codify newly acquired knowledge in a short form, considering that desirable knowledge is related to a particular project management process/activity; therefore it can be located appropriately and be easily elicited in the system. Moreover, knowledge can also be filtered from the electronic discussion board where experts discuss and share knowledge (see section 7.23). In addition, when a member of a project searches for an answer to a problem he is facing, when he or she finds the desired answer, this answer is to be captured and located in the right place in the system (see section 7.25). In the survey analysis, knowledge codification is considered a statically effective technique in both industry and top companies. It is also deployed by 58% of those in the industry, which indicates that the industry is to some extent familiar with this technique (see section 6.10.1).

Prior studies have identified the importance of knowledge capture, the identification of the desired knowledge, and the location the codified knowledge in the system (sections 2.9, 4.3, and 4.7). However the scenarios of knowledge capture mentioned above provide precise ways of capturing project knowledge. In addition, the manner in which the knowledge retrieval task might end in a knowledge capture task has not previously been described.

8.7. **Project Review**

Project review was found from the interview analysis to be the primary technique used for knowledge capture (section 7.24), and the most popular technique in the industry (Survey analysis: section 6.10.1). This confirms the findings in the literature review (see section 4.8). However according to the literature, project review is considered as a method of project knowledge capture whereas it is the most effective method of knowledge capture in both the industry and amongst top companies as the survey analysis shows. The findings of the interviews analysis and literature are in agreement, in which the project review should fill the purpose of capturing project knowledge; however, half of the companies reported that they are still not using project review for this purpose, as revealed by the statistical analysis. The detailed practice of project review in construction organisations, KM institute and project-based organisations provided three components for the project review with each component performing a particular function. Those components are the checklist, the 'three processes' approach and the brainstorming technique. The approaches described are supported by interviews and presentations, which can be beneficial in this particular situation.

The study has gone some way towards enhancing our understanding of the matured practice of project review. Before the start of the project review, a checklist of the subjects that need to be discussed should be prepared in order to guarantee that participants do not neglect any point. The aim of the project review is to generate information to show what has been learned from the project. To achieve this aim the project's performance must be tracked, by comparing between what has been planned and what has actually been carried out. The answers to these questions lead to identification of a gap between the project plan and the actual work. After these results have been determined a brainstorming technique can be employed to analyse why successful aspects of the project went well and what could be learned from this successful experience. In contrast, finding out what went wrong will highlight reasons behind any mistakes that were made, and subsequently lessons can be learned from analysing these reasons. This new learning should be codified and located in the appropriate place in the system.

Prior studies have noted that project review is most likely to be conducted in a cooperative meeting (section 4.8). The survey results (sections 6.8.3 and 6.10.4) have also confirmed that 71% of the industry conducts project reviews in a meeting based environment. Several studies showed that the checklist technique is a popular method used in project review (section 4.8); in the survey over half (52.2 %) of companies were found to use a checklist in their project review process (sections 6.8.3 and 6.10.4). This indicates that the techniques used in this study to conduct project review are already deployed and popular to some extent in the industry, making it easier to implement this approach.

8.7.1. ***Interviews***

Despite some or all external parties being involved in some of the project reviews, in some cases project review is usually conducted internally with no coordination with other parties (sections 4.8 [literature], 6.8.4, 6.9.4 [Survey analysis] and, 7.24.3 [Interviews analysis]). In this case interviews with selected key players in the project, from other parties when possible, are used to collect some of the looked for knowledge from other parties. Opinions of experts from other parties involved in the project can add value to the project knowledge (see section 7.24.2). In the literature, the interview technique is used for knowledge mapping: to map knowledge, skills, and areas of expertise of the people in the organisation, as personnel are one of the organisation’s intellectual capital resources. Interviews reported in the literature had nothing to do with the capture of project knowledge.

The interview process was also found to be conducted with the members of organisation for the purpose of enriching the content in the expert directory. Because of the nature of direct interactions, face-to-face discussion can elicit the desired information more effectively than alternatives, such as asking people to fill in forms (section 7.24.2).

8.7.2. ***Time of Project Review***

In the literature (section 4.8) it was stated that a project review can be conducted once at the end of the project (post-project review), at the end of stages, as a time-based review (e.g. daily, weekly, monthly, every three months) or 1 to 2 years after project completion. After stages and end-of-project review were found to be the most popular methods of review timing in the construction industry. In addition, time based reviews are deployed by a third of the industry (see sections 6.8.2 and 6.10.3). However it was found that these are more effective when conducted both on a monthly basis and at the end of every project stage, providing that a stage review is a review of the whole project (see section 7.24.4). The time lag between action and review will always be shorter in monthly-based reviews. This in turn minimises the possibility of learning being lost during the work. At the end of the stage, project review provides a more strategic view of the project. Reviewers can generate new learning from a wide angle to the previous monthly reviews of the current stage. The results of the survey analysis indicate that using more than one timing approach is applicable in the industry as 35% of industry already does this.

8.7.3. ***Participants of Project Review***

It was established that those people participating in the project/work are the most appropriate staff to attend project reviews, because they know most about what has been accomplished and as a result they should know what lessons have been learned (section 7.24.3). It was also recognised that the involvement of senior experts in the organisation can add value to the project review. But it should be considered that if non-project members were participating in project review, a presentation would also be needed (see section7.24.2), as the non-project members need to know precise details about the project and what has been achieved. Statistical evidence shows that construction companies conduct some of their project reviews in coordination with other project parties (section 6.9.4). Among construction organisations 78.6% conduct project review involving coordination with some external project parties (see 6.8.4) so project review can benefit from sharing opinions with other parties.

However, as indicated in the survey analysis (section 6.8.4) and interviews analysis (section 7.24.3) participants from other companies may only attend one or a few of the project reviews, but if there are participating members from other companies there will still be a chance to interview key players in the project from other companies.

8.7.4. *Outcome of Project Review*

One of the dilemmas associated with project review in literature is determining the final outcome of the project review. This is because it produces a lesson learned report (section 4.8), which can be very long and stored in either a *paper* or an *electronic file* (sections 4.6 and 4.12). The matured practice of project review should result in short, to-the-point knowledge nuggets/comments on tasks/activities (project insight). Good practice revealed that the average amount of project insights resulting from a project review can range from five to twelve pages. Instructions and checklist were found to be the appropriate forms of project insight (section 7.24.5). They provide the person performing the same activity in future projects with the best practice related to that activity. Project insight has to be codified in live page/s rather than in a paper-based file (section 7.24.6), and has to be catalogued in the right place (see section 8.12 for further details) in the system so it can be easily located and retrieved in future. As found in the literature (section 4.8) and survey analysis (sections 6.10.2 and 6.8.1) project review was also used to measure and track work performance, which is very helpful in generating project insight (section 7.24.1). However, data related to project tracking should be codified separately to ensure that people can find the project insight straightway without the necessity of examining huge files with a surfeit of data.

8.8. **Taxonomy**

The traditional method of structuring a project review is to have all the data of a project in one file. This file would then be divided into sections such as project audit, cost and time studies, human resource aspects and performance study (section 4.8). However this scenario does not match the matured practice revealed in this study (section 7.24.6). The insight of every project has to be classified based on the project and works/activities. Therefore it becomes easy to access insights on precise pieces of work in a project. However, it was also found that another method of taxonomy is required: the classification of insights according to work/activities with no link to the project. This method of classification groups all the insights of a particular activity that have been learned from previous projects in one place. It allows people working on a project to access accumulated experience and learning related to the activity they are currently performing. Contents inside the work insight are the same as those inside the project insight; in addition to the insights that are added by individuals and have approved by experts (for more details see section 8.12).

A number of the large and medium organisations in the construction industry are engaged in more than one field of business, for instance, architecture and project management. In this case it would be essential to classify both project insight and work insight based on each business (section 7.24.6).

8.9. **Knowledge Retrieval**

Navigation and search engines are two tools of knowledge retrieval that are described in the literature (section 4.10) and presented in this study. However, it should be mentioned that navigation, in this study, is a straight-forward task, as the work insight is already placed in a well-organised hierarchy. Content with precise taxonomy (like that in this study) based on works/activities (processes/activities), could be retrieved faster by navigating to the exact work required. The search engine method is considered appropriate when the location of the desired information is unknown (section 7.25).

Interestingly, a decision support model of what to do when seeking an answer has been simulated based on best practice. The person looking for answers should start with the knowledge base (system), navigating to the targeted work. If no answer is found, then they should either use the expert directory to find an expert in the desired field or ask colleagues in the immediate team. If no answer is found from either the expert directory or the team, then it is time to ask members of the organisation who have an interest in the same field (community of practice (CoP)). In SMEs this is likely to be through direct face-to-face interaction. In large organisations the electronic discussion board has proved to be an effective method for CoP, in addition to face to face interaction. Discussion board has been ranked eighth out of ten IT tools by SMEs and only 2% of SMEs deploys it. Therefore it would not be appropriate to use it for SMEs (section 6.7.2)

When the answer is found, it is good practice to share this answer, so people in the future can benefit by using it. Sharing this new knowledge is accomplished by adding an entry in the appropriate place in the knowledge database. This entry would be flagged as invalid until an expert looks at it and approves it for general use (section 7.25).

8.10. **Leadership Support**

While literature suggests that leadership is a determining factor for successful knowledge capture application (section 4.11), this study emphasises that leadership has to fully stand behind KM, providing full support for its application. If the leadership does not support the application of project knowledge capture and retrieval then, there is no chance of success. The support starts by linking strategic values with knowledge sharing. Motivating people to share and capture knowledge was also found to play a major role in leadership. All the necessary resources to facilitate knowledge capture and retrieval have to be in place so as to ensure that there are no barriers to prevent people from accessing the required resources. Leadership is also required to make clear to everyone in the organisation that it is everyone's responsibility to share and capture knowledge (sections 7.27-7.31).

8.11. **Open Culture**

An open and cooperative culture is affected by three major elements. The next sub-sections identify and discuss these elements.

8.11.1. ***Organisational Structure***

The results of this study indicate that organisational structure is relevant to knowledge capture and retrieval, because it affects knowledge sharing. It is, and is recommended to be, flat. This is due to the fact that fewer levels between top and bottom help in facilitating wider communication between people. Very little was found in the literature on the relationship between organisational structure and knowledge sharing (section 4.11). The recommended depth of hierarchy levels ranges from three to six levels, between the CEO and the plant personnel (section 7.26).

8.11.2. ***Social Network and Community of Practice***

Another factor that influences knowledge sharing, and therefore knowledge capture and retrieval, is the social network (section 7.30). This finding supports previous studies in the literature (section 4.11) that a strong social network allows for better communication between members of the organisation. This initiates and maximises the movement of knowledge sharing in an organisation. However, one of the most interesting findings was that social networks can shadow the formal hierarchy and provide everyone with access to everyone else in the organisation. Social networks grow with the support of a leadership that establishes social activities. This study suggested some ideas and activities for enriching the social network, such as having weekly lunches together, informal gatherings on Friday evenings, informal talk sessions, celebrating seasonal events such as Christmas and communal coffee/tea points. It was also found that workspace design affects communication between people; an open workspace design leads to better interaction (section 7.27).

As mentioned in the literature (section 4.11) organisational leaning depends on a community of practice (CoP). Nevertheless, this study shows that CoP can be developed *naturally* because of common interests or can be *formally created* by the management of an organisation. The findings suggest a variety of CoP forms: best practice groups, monthly meetings to discuss news and development, Q&A sessions, and for large organisations an electronic skills network (e-discussion board) (section 7.29).

8.11.3. ***Motivation***

As expected, a motivational strategy has to be in place to guarantee continuous sharing of knowledge. The findings of this study provide further detail and support to other studies that considered motivation as key factors for successful knowledge management applications (sections 4.9 and 4.11). Several approaches to motivation were identified in this study. However, a clear emphasis on one particular approach regarded as important emerged from the interview analysis: the demonstration of the benefits of knowledge sharing for the organisation and for individual themselves. Individuals also need to recognise that when they share knowledge they are improving themselves. As the chairman of the KM institute put it; “You don’t know something until you teach it.” Another approach to motivation focuses on the demand side, asking people what they really need and what they think of the current method; instead of focusing on the supply side (providing people with what top management thinks is right). This method is conducted via what might be referred to as feedback-based motivation. In addition, recognition and bonus schemes were found to be practical. This method was found to be very popular in the literature, and it was therefore predicted that it would be applied in all seven cases; however it was only implemented in one case. The last method links the motivational; strategy with the strategic values of the company, and considers knowledge sharing as part of the company's values. This in turn creates awareness for individuals of how important it is to share knowledge (section 7.28).

8.12. **System**

This study produced results which corroborate the findings of a great deal of the previous work in this field (sections 4.6, 4.9 and 4.12). Implementation of a system was found to be an important enabler of KM. As all the seven cases deploy a system to capture and retrieve project knowledge (section 7.22). However the analysis of this study indicates that a system could not be effective unless it had the proper tools and correct content catalogued in an appropriate order. It was also found that the system has to be built on an intranet network, and viewing access should be given to everyone in the organisation. In addition, the ability to add content is required in some sections of the system, such as with work insights and the expert directory. Due to confidentiality some information restrictions may apply to some of the contents (section 7.22.1).

The matured practice of project knowledge capture and retrieval requires the system to include four components. The first is to manage the knowledge of projects, and should include the ability to classify content. The taxonomy of the content inside this component has to deploy the findings in section 8.8. In addition, the component has to include search engine and keywords/tags features. The content of this component is shown in live pages. The second component is intended to manage the profiles of the organisational members. It should have three sections: i) personal details, including contact information and bibliography of the member; ii) area of expertise; and, iii) area of interest. This component is termed the expert directory and makes it easier to find the right expert when needed. The third component is an e-mail client; this was found to be used in all of the seven cases as a media for knowledge sharing and for project correspondence (section 7.22.2). However, it was found useful to capture the project correspondence inside the project portfolio in the first component, so it can be accessed to provide perception of project insights if necessary (section 7.23). Lastly, a system should include a component that provides the right environment for discussion about practice. This component acts as a media for the CoP, and is an alternative means of finding an answer to a problem.

8.13. **Framework**

The findings of the analysed elements discussed in the previous sections could result in more than one perception. To avoid biased conclusions results need to be interpreted with caution. Therefore, careful attention has been paid to every single finding and the relationships between these findings have been established. The following sections provide thorough and deep understanding of the framework of project knowledge capture and retrieval.

8.13.1. ***Strategic View***

Taking an onlooker's view of the findings of this study has assisted in the identification of major categories and the establishing of cause and effect relationships. One of the key issues that emerged from these findings was that knowledge cannot be captured and retrieved without fertile ground in which the sharing of knowledge can be supported. It is true that knowledge capture and retrieval has to be conducted according to supposed best practice approach, but no matter how effective the approach to knowledge capture and retrieval is, in the absence of a knowledge sharing environment the application will not be successful. Despite the fact that it was not on the study agenda, knowledge sharing has become one of the most frequently used terms in this study. The right environment for knowledge sharing was found to be affected by two elements: the co-operative culture, and the existence of required resources. Those two elements demanded the full support of the leadership. Figure 8.1 below demonstrates the strategic concept that resulted from this study.

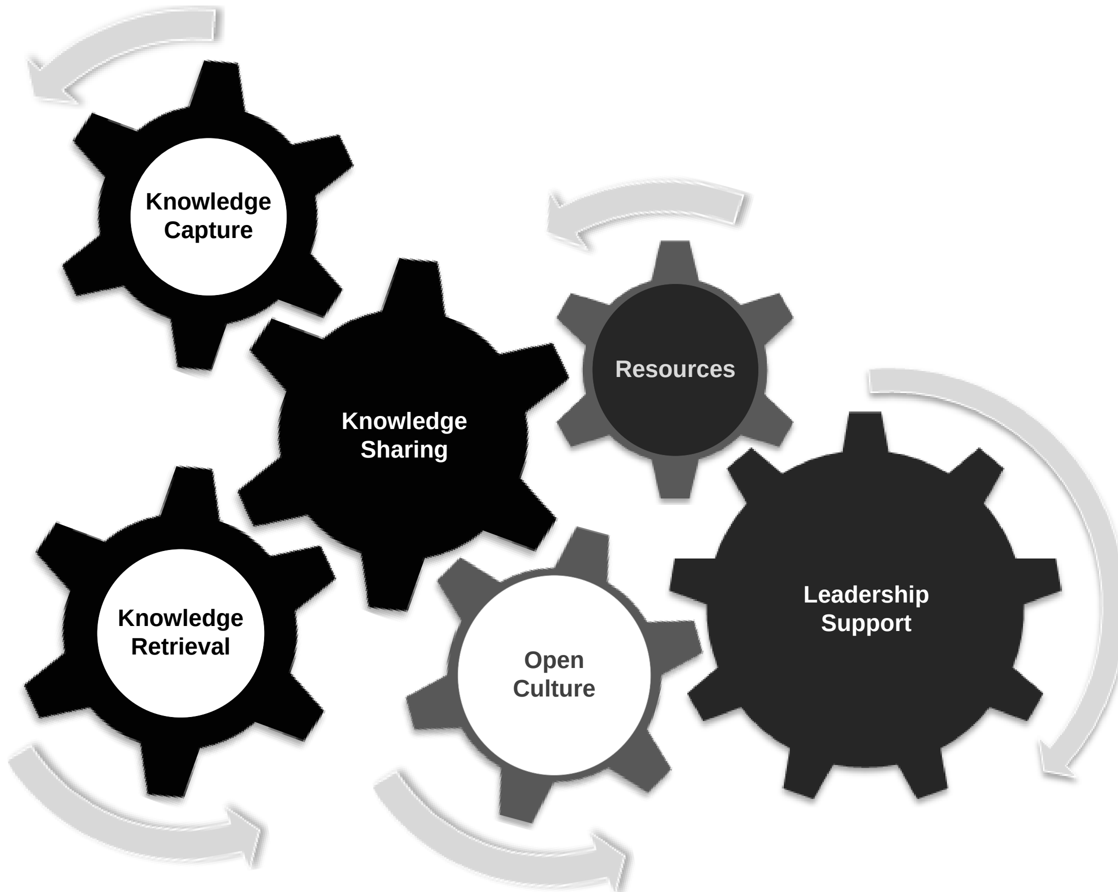


Figure 8.1: Strategic framework for knowledge capture and retrieval

It was also found that an open culture will increase trust between people and connect them together, therefore facilitating the activity of knowledge sharing. However this is not enough in isolation if the knowledge is to be captured and retrieved effectively. Without a robust method, a well-built taxonomy of knowledge, and a system with the appropriate features, then too much knowledge could be lost. The right environment for knowledge sharing can provide us with a huge amount of information, but without distinguishing what is important and what is not it can lead to an overload of information that could potentially act as a barrier to knowledge retrieval.

8.13.2. ***Knowledge Sharing Environment***

It is the role of leadership to, i) provide support for creating the open culture, and ii) make available all the required resources that facilitate knowledge sharing. Open culture requires established approaches and activities that contribute to creating a cooperative culture, the culture that inspires everyone to share knowledge. The study has shown that cooperative culture can be achieved by establishing several approaches and maintaining them.

- **Motivation for knowledge sharing:** This can be mainly done by demonstrating the benefits of knowledge sharing for the organisation and for individual themselves. In addition, using feedback-based motivation, through recognition and bonus schemes, and by setting knowledge sharing as intrinsic to the company's values.

- **Flattening the organisational hierarchy:** It is recommended to have a flat hierarchy. This is due to the fact that, fewer levels between top and bottom help in providing wider communication between people. The recommended depth of hierarchy levels between the CEO and the plant personnel ranges from three to six.

- **Creating social networks:** Connecting people together is the only way to share knowledge. To do so, there must be a network/s of strong relationships between people in an organisation. The way a social network is created is influenced by social activities and resources. Social networking will also overcome the barrier of a vertical hierarchy, and work to gives everyone access to each member of the organisation.

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- **Maintaining Social activities:** To enrich social networks, regular social activities must take place. This study has suggested some ideas and activities for enriching the social network, such as holding weekly lunches, hosting informal evening gatherings or events and informal talk sessions, celebrating seasonal events such as Christmas, and having coffee/tea points or shared common areas where people can meet and chat.

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- **Forming communities of practice:** The quality of the shared knowledge will always depend on the experience and background of those people sharing the knowledge. The role of the CoP is to link people with the same interests or fields of expertise, therefore increasing the chance of enhancing the pool of knowledge. It can be formed by creating best practice groups, holding monthly meetings to discuss news and development within the company or Q&A sessions. For large organisations, and some of the SMEs, an electronic discussion board can be an effective method of setting up a CoP.

8.13.3. *Knowledge Capture and Retrieval*

Knowledge capture: Project review is the main method for ideal capture of the desired knowledge. Two additional scenarios that can also provide effective methods for capturing project knowledge are:

- When finding an answer to a problem that has not been previously codified, an individual could add this new knowledge to the system.

- Knowledge can also be filtered and generated from the discussion board.

In these two scenarios the knowledge has to be approved by an expert before it can be seen by everyone.

Project Review: This consists of three components; each component performs a particular function in the project review. Those components are checklist, the "three processes" approach and the brainstorming technique. This approach is supported by interviews and presentation. Interviews are to be conducted with key members from the external parties involved in the project. (It should be considered that interviews are only applicable in the case that external parties are not involved in the project review). Presentation is deemed to be an efficient technique in cases where non-project members are participating in the project review. The major participants of project review should be the project members, because they are the best qualified to provide what they have learned from this experience.

As described above; before the start of the project review, a checklist of the subjects that must be discussed and included to guarantee all points are covered should be prepared. To emerge with a useful result a project review should first determine the current status of the project, by asking what was planned and what has actually been achieved. The answer to these questions allows identification of the gap between the project plan and the actual work. Consequently, it becomes easier to know what has been carried out correctly and what has gone wrong.

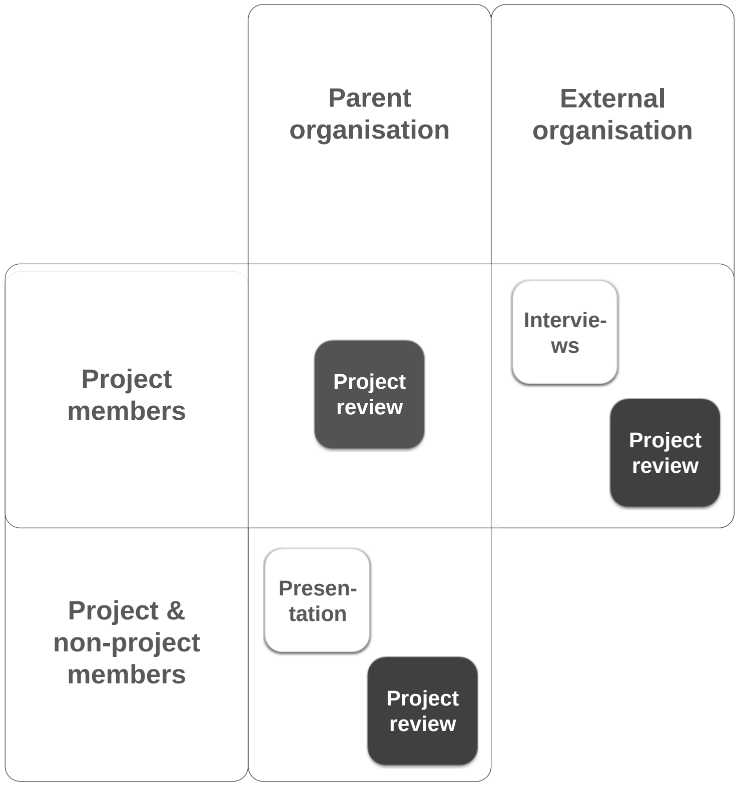


Figure 8.2: The use of project review techniques in relation to participants

Following this assessment it is then appropriate to use the brainstorming technique in order to discover what could be learned from these experiences. Discovering what went well enable us to identify what can be learned from successful experiences. In contrast, reviewing errors in the project will ideally highlight reasons for these, and thus provide fresh information.

After the review any thing that has been learnt should be codified and located at the correct point in the system. Finally, it has been determined that project review should be conducted on a monthly basis, providing that one or some of these monthly reviews should take place at the end of every stage, and after project completion.

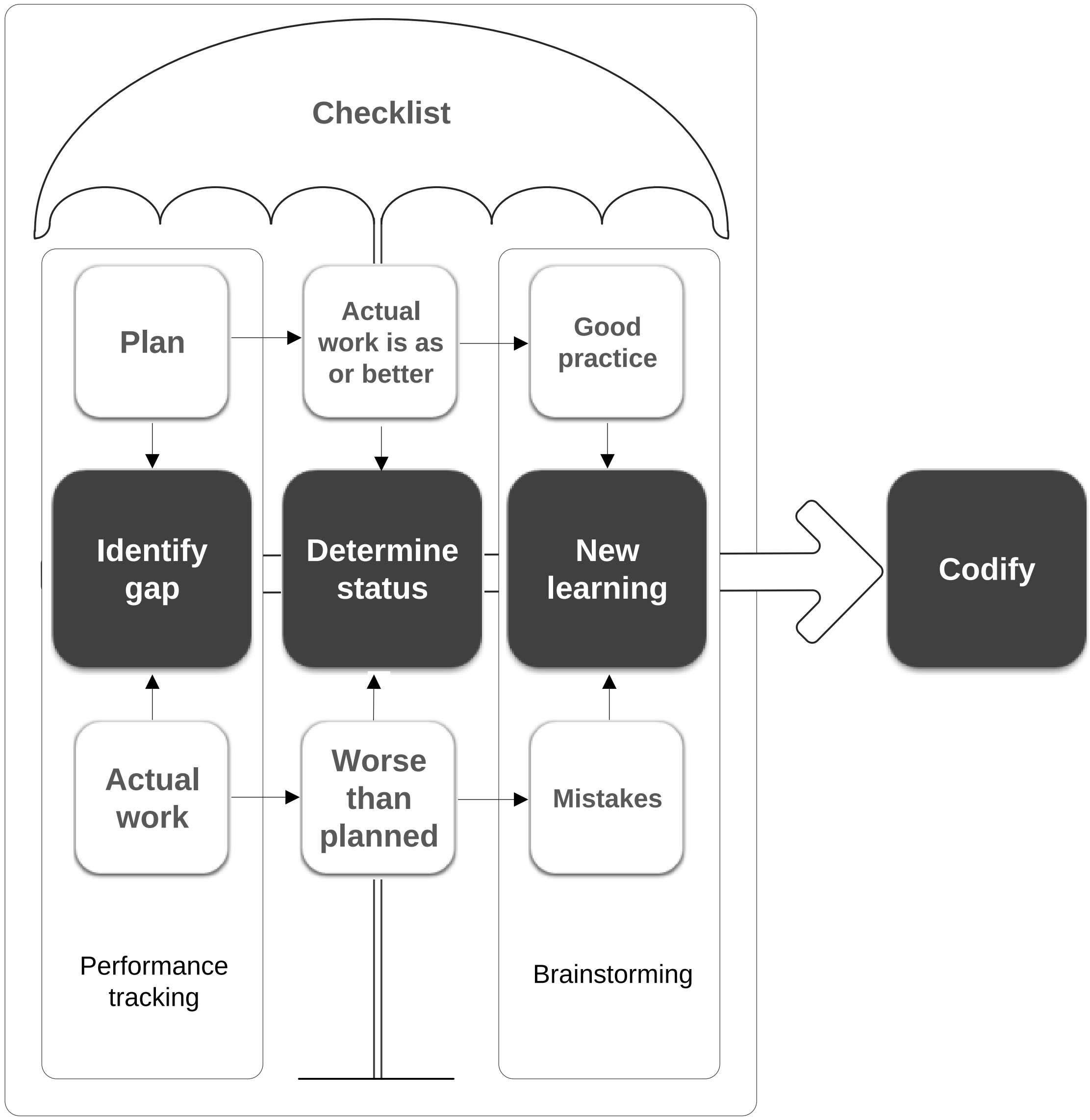


Figure 8.3: The method of project review

Knowledge Structure: Work insight (captured knowledge) has to be either included in instructions or in checklist form and should be short and to the point. The knowledge has to be classified in the knowledge base in two ways; project→works (Figure 8.5) and works without links to projects (Figure 8.4). In addition, business-based classification (Figure 8.6) is necessary for companies with more than one business. Every work insight has to be positioned in the exact place in the knowledge base. This will make it easy to find the right work insight when needed in future.

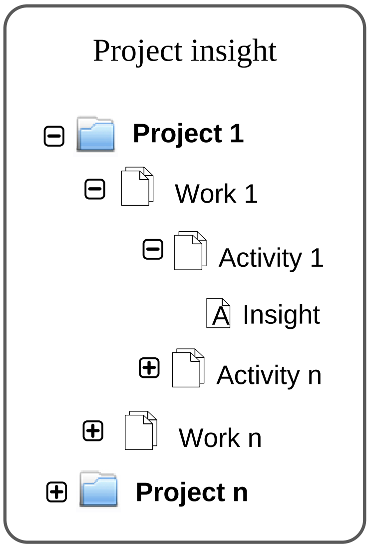


Figure 8.5: Work based taxonomy

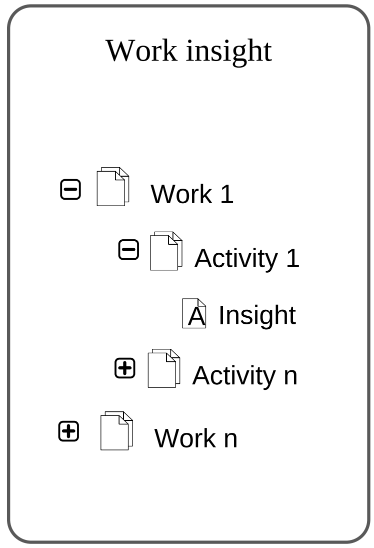


Figure 8.4: Project based taxonomy

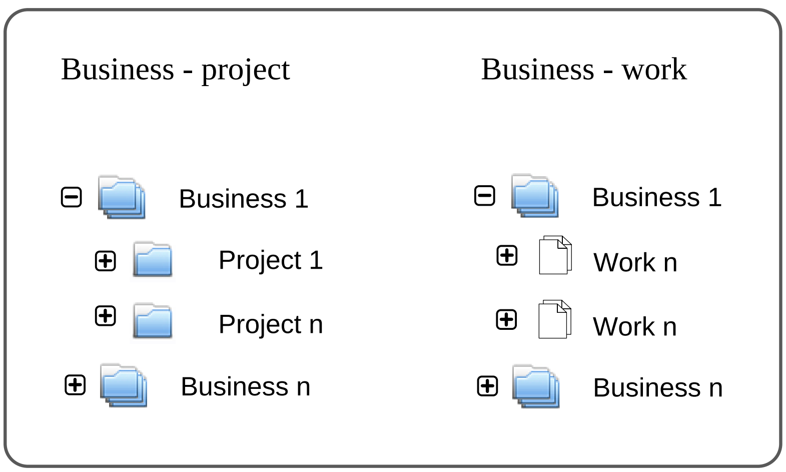


Figure 8.6: Business based taxonomy

Knowledge Base: it is an intranet-based system that provides access for everyone in the organisation to view content. It also provides everyone the ability to add content in some sections. The knowledge base consists of the following areas:

- **Projects:** To manage project insight. It is capable of classifying content according to the taxonomy in the knowledge structure section. This component is divided into two sections, project and work insights. The project section includes project insights and the project portfolio for codifying project data. In addition, it includes a search engine and keywords/tags features and is shown in live pages.

- **Expert Directory:** To manage the profiles of organisational members. It has three sections, i) personal details ii) area of expertise, and iii) area of interests.

- **E-mail Client:** A media of communication, which includes project correspondences. Project correspondences have to be captured in the project portfolio in the first component.

- **Skill Network:** This component acts as an electronic media for the CoP to share knowledge (discussion board). It is also an alternative way of finding an answer to a problem.

The integration of the total findings of the required functions and the proposed knowledge structure and taxonomy leads us to a particular architecture for the system, as shown in Figure 8.7.

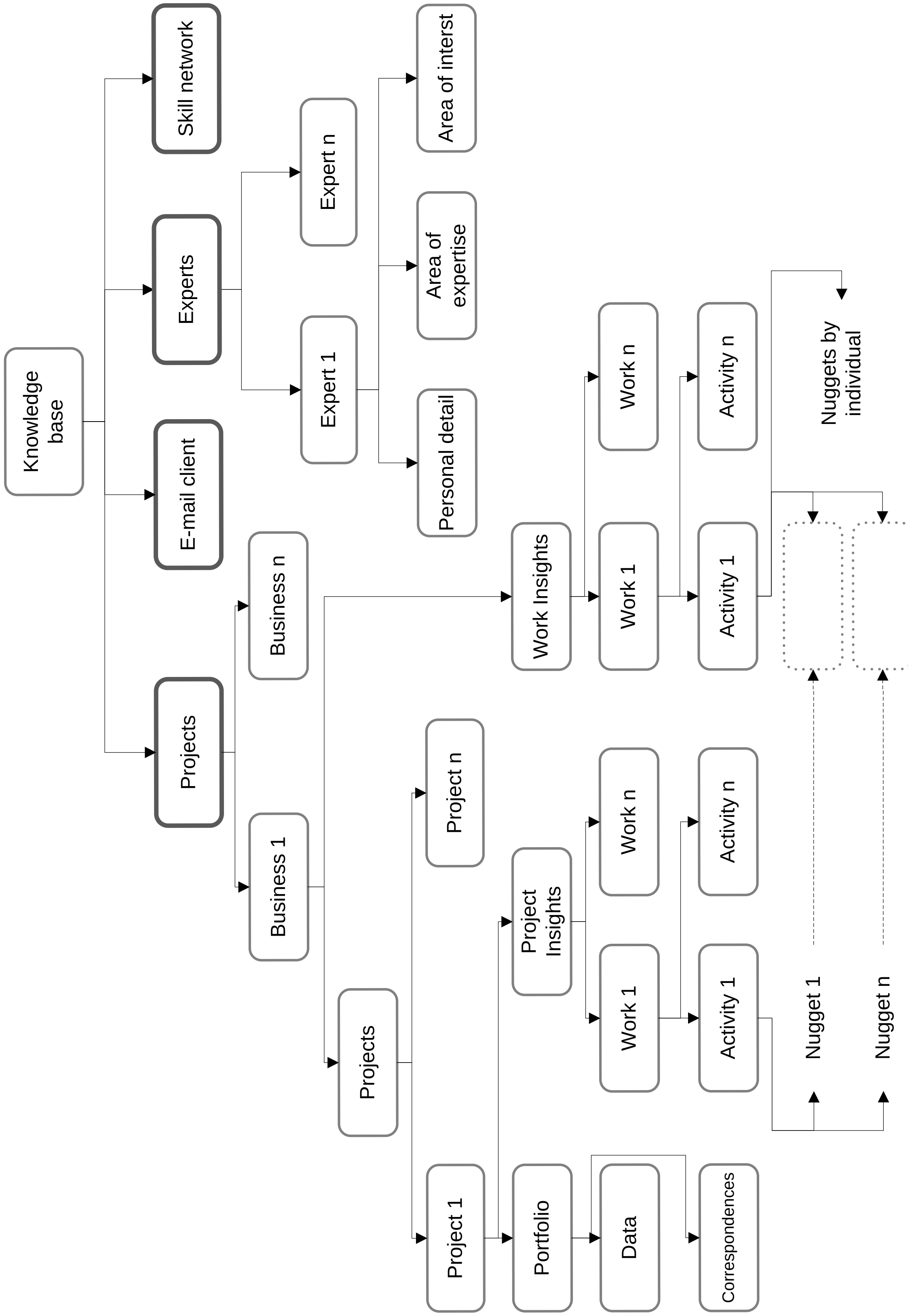


Figure 8.7: Architecture of the knowledge base

Knowledge Retrieval: Knowledge can be retrieved 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 is not known. If no answer is found then the expert directory can be used to identify an expert in the desired area, otherwise an answer could be found by asking colleagues from the immediate team. If this approach fails then the query can be put to members of the organisation who have an interest in the same field (community of practice). In SMEs this is likely to be through direct face-to-face interaction; in large organisations an electronic discussion board is an efficient method for querying the CoP. If a solution is discovered it can then be shared by adding it to the appropriate section of the knowledge base.

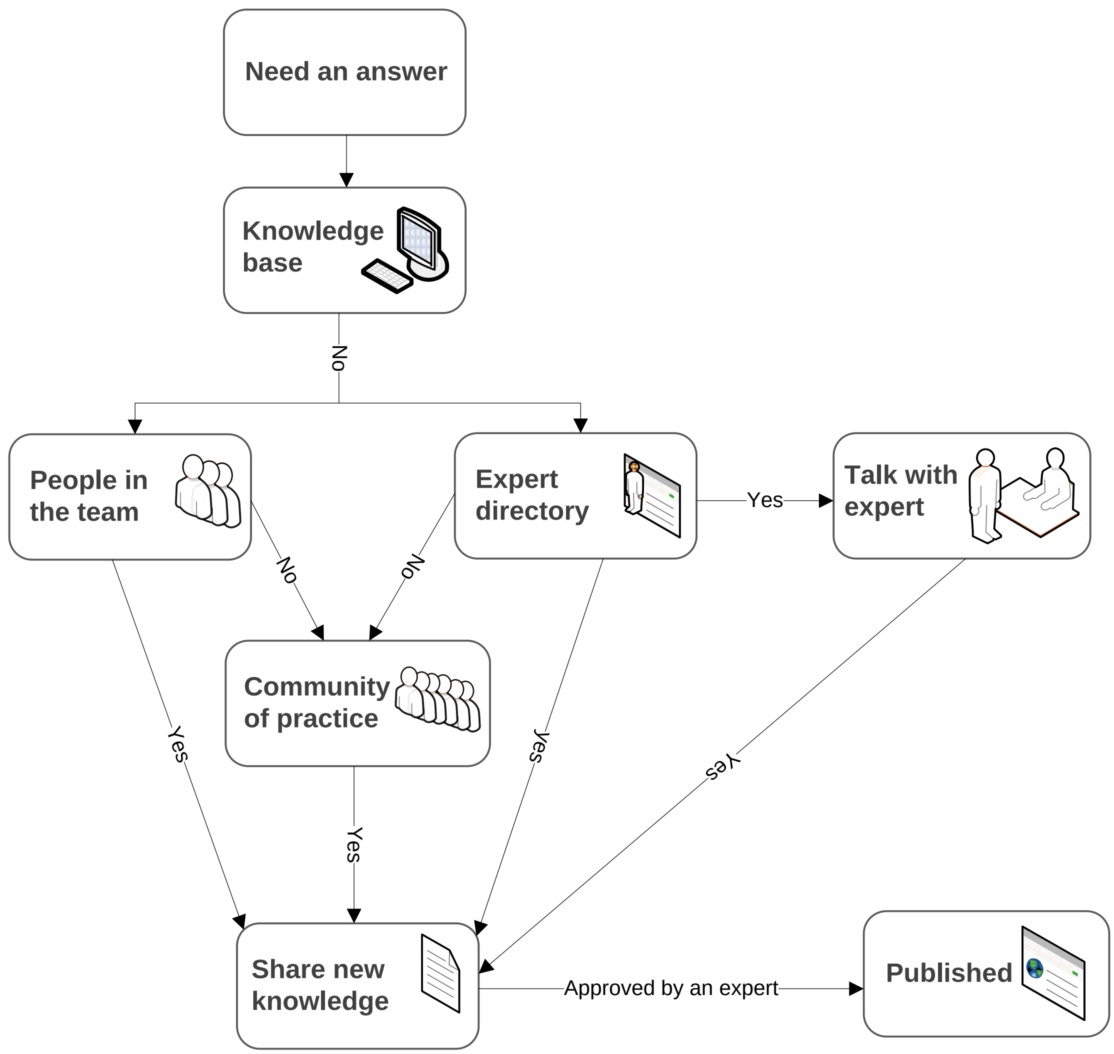


Figure 8.8: Decision support model for knowledge retrieval

The integration of the knowledge capture and retrieval approaches within a system provides us a wider picture. Figure 8.9 shows the relationship between the three components.

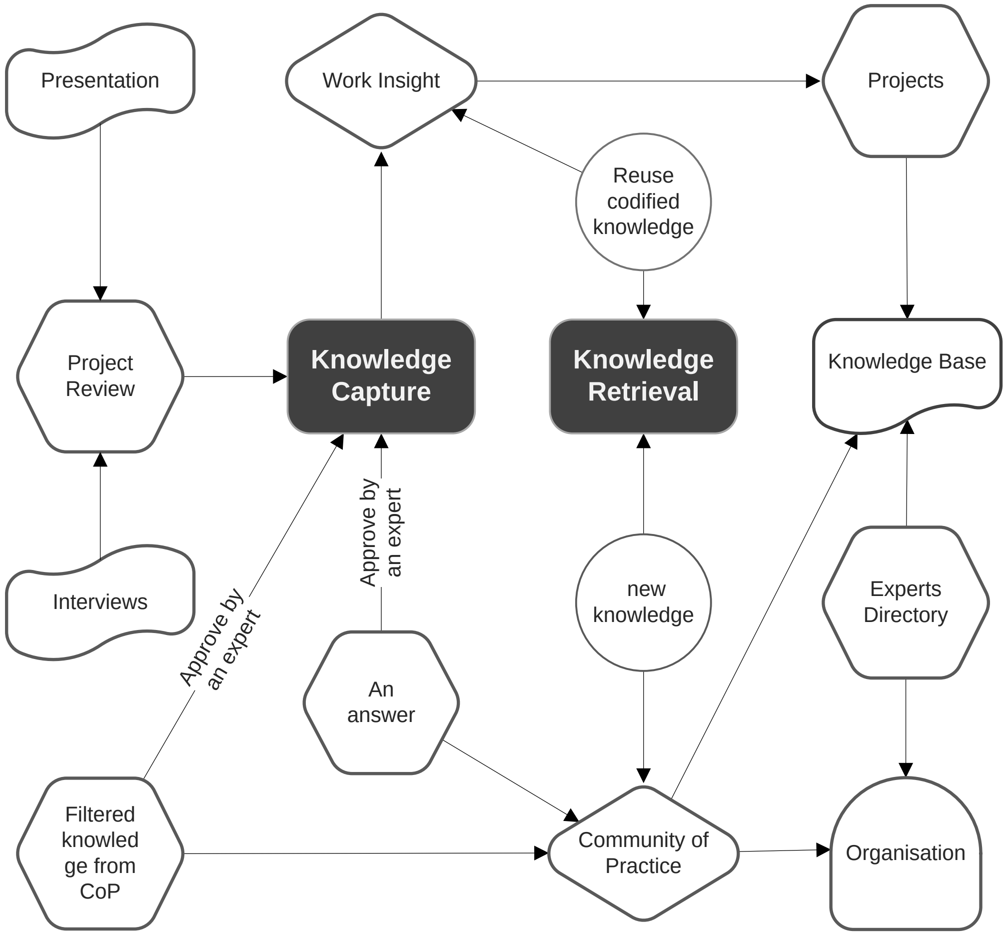


Figure 8.9: Integrated model of knowledge capture and retrieval

8.14. **Expanded Framework Map**

Combining concepts and models of the framework in one map is not an easy task when there are many variables and constructs, with relationships among them. However, incorporating all major concepts in one map is certainly helpful, as is putting pieces together to allow the whole picture to be viewed. On the basis that the framework has already been described in previous sections, this section integrates and presents the framework elements in a diagram. In order to minimise the complexity and difficulty of reading the expanded framework, it was decided to provide foreword diagrams. The framework is firstly presented at the strategic level (Figure 8.10) and then at the tactical level (Figure 8.11). Lastly, following the same colours and shapes of major variables, the operational level (expanded framework - Figure 8.12) is presented.

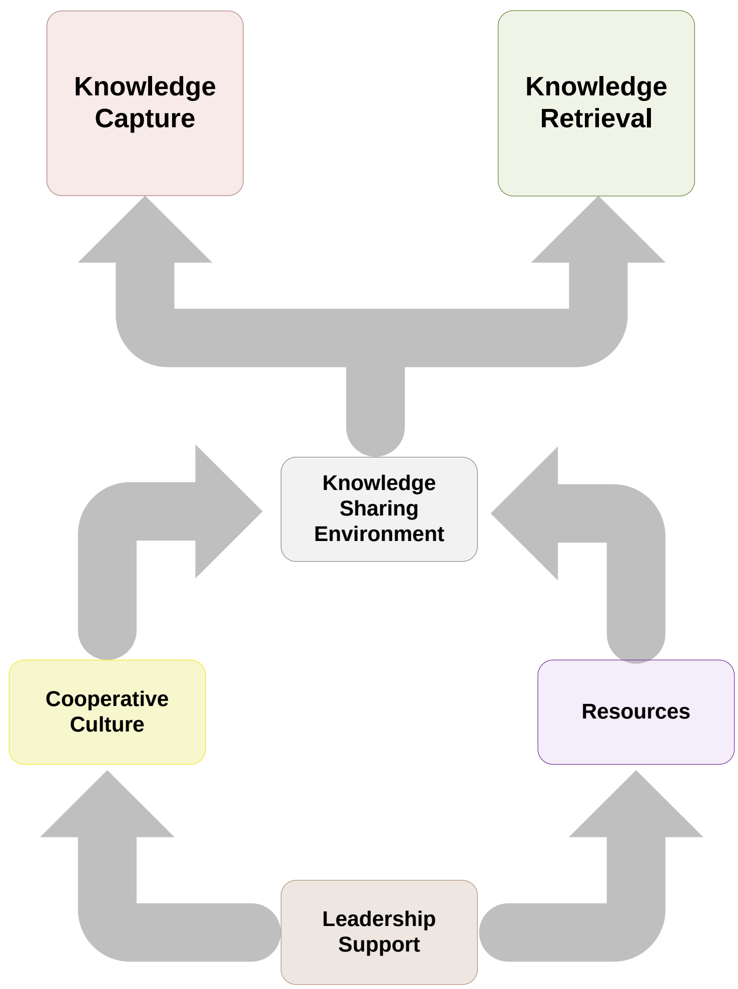


Figure 8.10: Framework at the strategic level

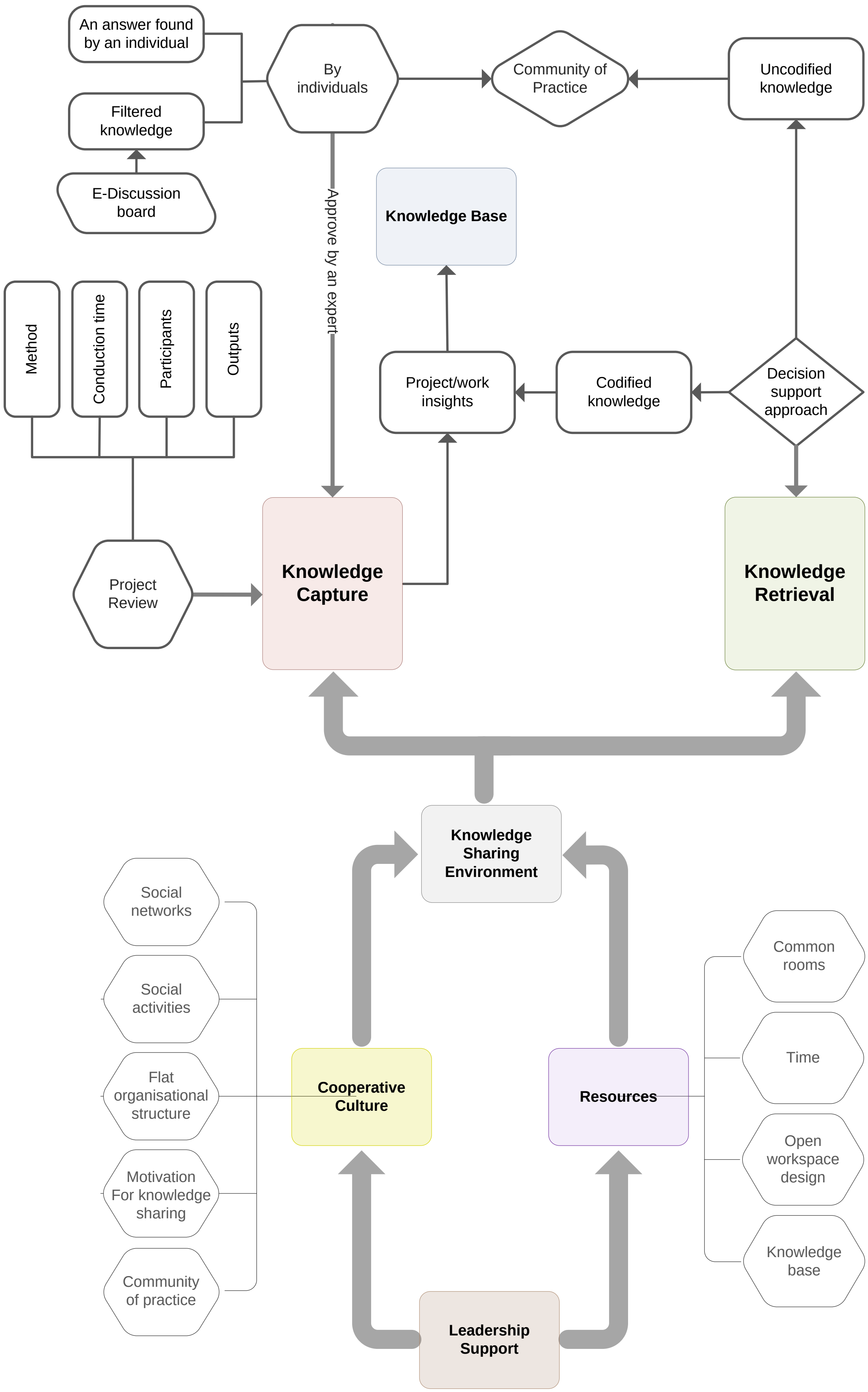


Figure 8.11: Framework at the tactical level

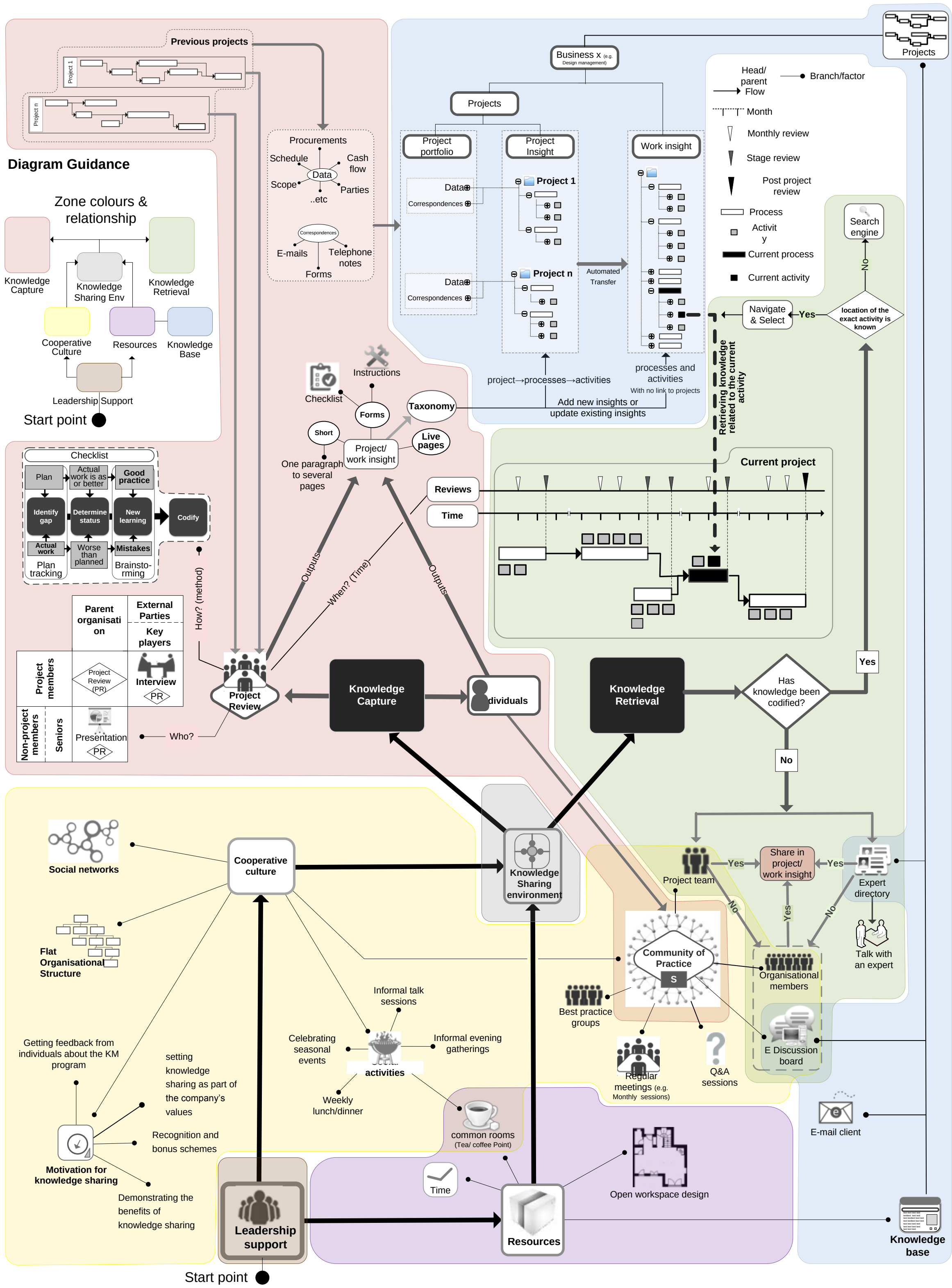
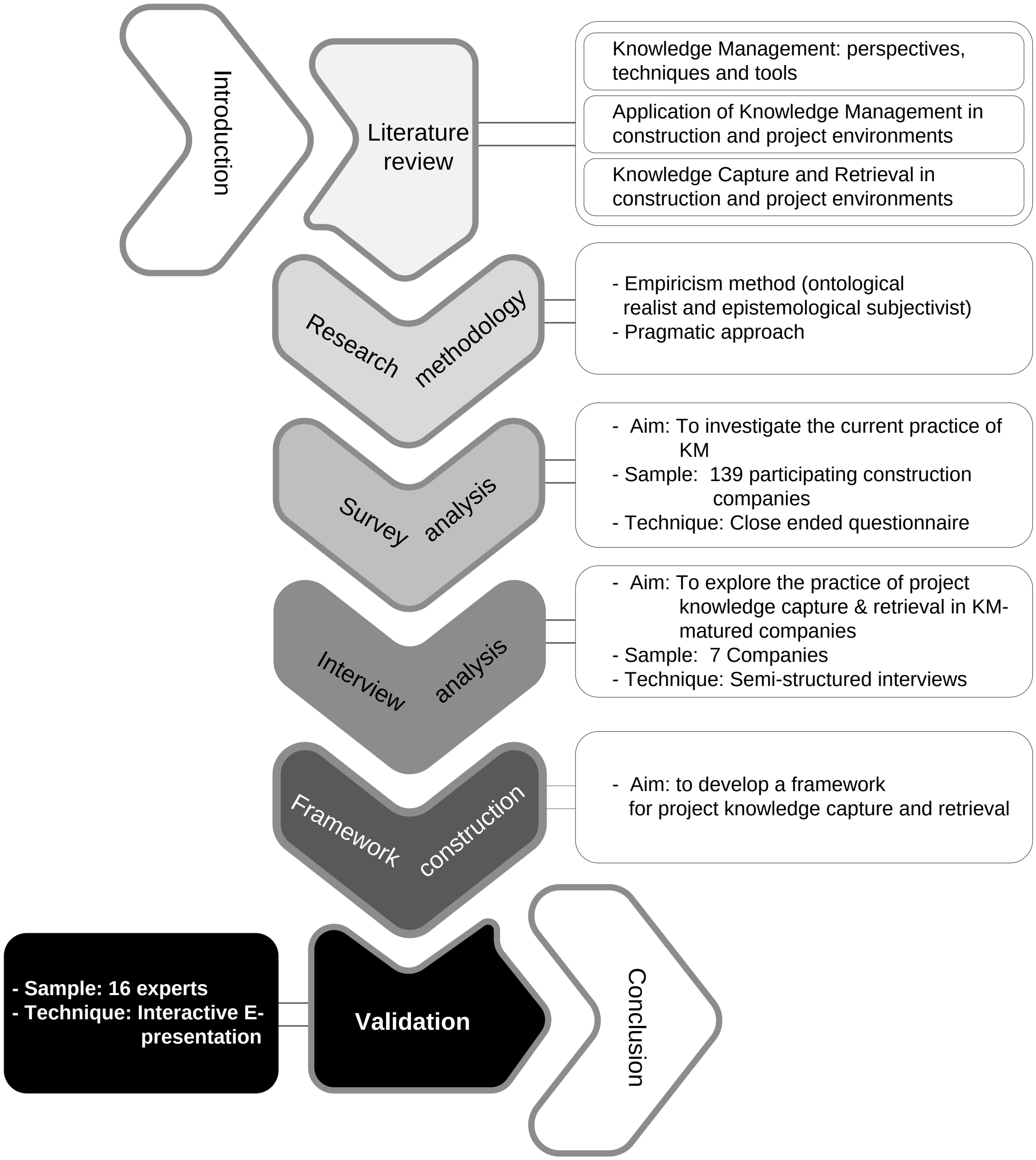


Figure 8.12: Framework at the operational level

8.15. **Summary**

This chapter has introduced the framework for knowledge capture and retrieval based on best practice. The framework suggested particular steps, models, structures, taxonomy and systems. This approach is integrated with a strategic policy to form an accumulative framework. The framework claims that no matter how effective the approach to knowledge capture and retrieval is, without a knowledge-sharing environment the application will not benefit from these methods. The environment of knowledge sharing is influenced by co-operative culture, and the existence of the necessary resources, two elements are dependent on the full support of the organisation's leadership. However this framework is built based on the analysis of best practice, and will need to be validated by experts; this is what Chapter nine will demonstrate.

CHAPTER NINE: FRAMEWORK VALIDITY



9.1. **Introduction**

Building theory when based on a small number of cases, does not necessary mean the theory is applicable to other cases. This chapter will examine whether the purposed framework can be generalised to the construction industry. The first part will discuss the validity of the research and will present the deployed methods to maximise its validity. Eternal validity of the framework will then be discussed. The second and major part of the chapter will present and analyse the results of the framework evaluation. The evaluation has been conducted by expert practitioners and academics, and has measured the applicability and effectiveness of the framework in the construction industry.

9.2. **Validity**

The process of validation started at the beginning of the research, ensuring that the participants, context and measuring instruments were solely achieving the aims of the research. A number of researchers have argued that validity is not applicable to qualitative research, whilst at the same time, have realised the need for some kind of qualifying check or measure for their research (Golafshani 2003). It is obvious that there are no straightforward tests validating qualitative research; however this does not mean that there are no guidelines (Patton 1990). Through the research stages, effort has been made to ensure that: (1) the measuring instrument is actually measuring the concept in question and no other concepts; and (2) the concept is being measured accurately (Bailey 1994). The measuring instruments utilised in both the survey and interview method were the questionnaire and interviews questions; in addition to the method of analysing the collected data and building constructs. Therefore, it was necessary to ensure that all questions were clear and measured effectively. In addition the method of analysis required the provision of correct inferences.

Qualitative research has often been characterised by uncertainty and flexibility, and a tension between rigor and creativity. Therefore critical compromises were considered carefully in the interview analysis and framework building stages (Pyett 2003). The analysis of interviews engaged “a deductive process” whereby the author was “his own most trenchant critic" (Cook and Campbell 1976, p: 229). This is referred to as internal validity. However in this research an open perspective of validity was adopted whereby multiple methods improved the analysis and understanding of knowledge capture and retrieval practice, and led to more valid, reliable construction of the framework (Golafshani 2003). These methods included:

- A critical in depth revision to the data collection instruments and data analysis methods by author.
- Conducting of peer reviews on the questionnaire design and survey analysis, interviews themes and analysis methods.
- Conducting a pilot study; assessing the language of the questions; terms and definitions; clarity of the purposes of questions and questionnaire structure.
- Developing a descriptive and relational framework for the interview analysis to ensure consistency of analysis criteria and accurate interpretation and inferences.

9.3. **External Validity**

Constructing a framework for project knowledge capture and retrieval based on a small number of cases, does not necessarily mean this framework can be applicable to other construction companies. However, researchers are always interested in generalising the findings beyond the investigated cases (Schwab 1999). The rationale for conducting in-depth interviews is that people involved in a mature practice may have insight that would otherwise not be available to the researcher. Therefore it is the quality of the insight that is important, rather than the number of respondents who share it (Wainwright 1997).

Whilst research investigating a small number of cases may achieve excellent validity by providing a profound understanding of the practice in those cases; they have been widely criticised as lacking external validity (De Vaus 2001). External validity refers to generalising of findings to or across target populations (Pedhazur and Schmelkin 1991). There is no systematic or verifiable method to conduct external validation based solely on a single investigation of a research relationship (Schwab 1999). However the ultimate way for assessing the validity of the purposed framework would be to test such principles in reality; but within research practice this is rarely possible (Pyett 2003).

In testing by the application method, it could take several years before fair judgment of the framework validity could be reached. Even if this were to take a short time, there would be a need to access a very large sample (representing the industry) and implement the framework in this sector. However in this specific case this was considered difficult Nevertheless, several other methods were able to maximise the validity of the framework in this study as outlined:

- Randomly selecting a sample of the survey which acts as a representative sample of current practice.

- Selecting example cases (of best practices) from the target population in the interview stage.

- The survey provided a solid ground for understanding the current practice of KM; and therefore it was used as a guiding principle in utilising the best practice to suit the industry, which maximised the generalising or external validity of the framework.

- Seeking the evaluations of the effectiveness and applicability of the framework in the construction industry by experts and academics.

9.4. **Framework Evaluation**

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. An alternative means was to have the framework evaluated by experts. In fact this method was considered advantageous with regards to value, risk, and finance.

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. Consequently, 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 applicability of the framework in the *industry*. The applicability of the framework was not considered sufficient however because the applicable framework did not necessary mean it would add value. For this reason, effectiveness was another criterion the evaluation sought to answer.

9.4.1. ***Participants***

- ***Rational***

Based on their experience, experts can judge the applicability and effectiveness of the framework from the deployed tool techniques, methods and the required resources. They can also estimate the time and effort required to implement the framework and match it with current practice.

Participants in the framework evaluation comprised two groups of experts: practitioners and academics. Practitioners are involved in projects and therefore are aware of the daily work. In addition, their participation in projects means they can work with other companies in the industry and can understand the verity of work environments.

Conversely academics are expected to have deep and methodological views, as they are familiar with observation and analysis. Furthermore, the industry is the major source of information for academics, so does not necessarily mean that they will be isolated. In addition, many academics are involved in the practice[5].

- ***Sample***

Sixteen experts were divided equally between practitioners and academics who participated in the evaluation of the framework. The experience of participants ranged between seven and thirty-seven years, accounting for three hundred and thirteen years of experience in total. The practitioners group included five experts working in consultant companies and three in contracting companies. Six of the expert practitioners were from SMEs; whilst two

[5] Further discussion about academics by Will Hughes is available in his blog: http://will-hughes.blogspot.com/2011/01/academics-vs-practitioners.html

belonged to larger companies. The diversity of the participating experts allowed for better testing in a variety of environments: contractors and consultants and small, medium and large companies. The focus on practitioners was on those in top managerial positions, because it was likely that they would have a better understanding of the practice. Conversely participating academics were from seven UK universities, working in construction management departments.

Table 9.1: Characteristics of participating experts in the framework evaluation.

Experts		Job title	Year of experience
Practitioners	Contractors	Construction Manager.	35
		Materials & Corrosion Engineer (Projects).	7
		Director.	6
	Consultants	Regional Director.	20
		Head of Planning Department.	13
		Managing Director	23
		Director.	15
		Director.	37
Academics		Lecturer.	7
		Lecturer.	25
		Senior Lecturer.	30
		Lecturer.	25
		Lecturer.	31
		Research Associate.	12
		Research Associate.	6
		Reader.	21

Because evaluation required watching an online presentation, this process was considered to be long and it was expected therefore that response rate would be low. Therefore, it was decided to reach the target number of participants by increasing the numbers of invited people. The total number of forwarded invitations was 642 of which 103were forwarded to academics; 184 to consultants and 355 to contractors.

9.4.2. *Evaluation Method*

Email was used to invite experts and included:

(1) Brief information about the project.

(2) Request to evaluate the framework for the purpose of validity.

(3) A link to the presentation explaining the framework.

(4) A link to the questionnaire to provide evaluation (see appendix 3).

The framework was explained in an online presentation (available in the CD attached to the back cover) of 25 minutes duration using ‘Articulate Presenter 09’ software. It was an interactive presentation in which experts lessened the explanation; whilst diagram parts were moved accordingly. The presentation was designed into nine slides which followed a narrative sequence of logic, since it started by explaining the components of the framework separately and then presented the strategic framework. An easy to remember domain name was selected as an addresses to the hosted presentation (i.e. KM-Framework.co.uk).

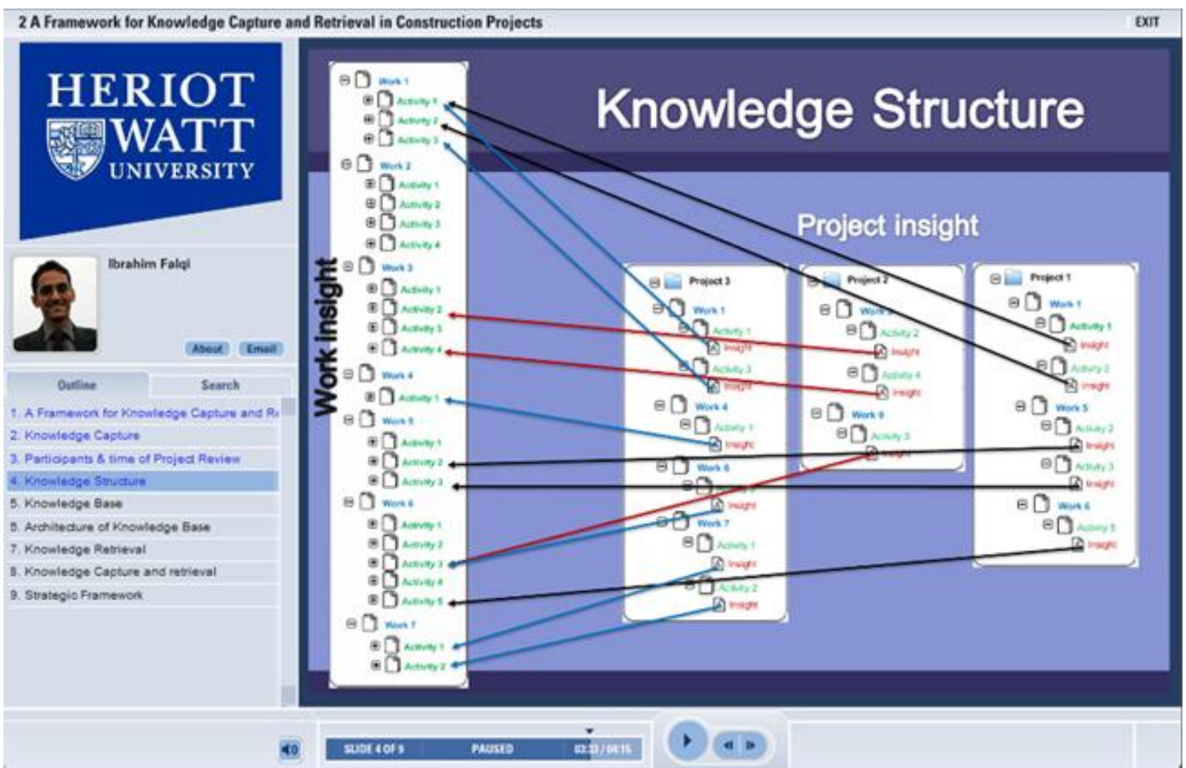


Figure 9.1: A screenshot of the online interactive presentation.

The questionnaire was designed and hosted using the online service provider: ‘Survey Monkey’ and consisted of two parts. Firstly, details about participants including name, organisation, job title, business and size of organisation.

Secondly evaluating the framework and this was included in two sections:

(1) Score based questions to rate the applicability and effectiveness of the framework and;

(2) Open ended questions seeking the opinions regarding the advantages, shortcomings and way of improving the framework.

The number of respondents stopped at nine participants. Therefore it was decided to provide the framework by means of diagrams at strategic, tactical and operational levels. Therefore respondents could save time instead of watching the full presentation. The presentation provided a greater in-depth description; however diagrams were forwarded firstly to four Ph.D. students to evaluate their readability, and the results confirmed that such diagrams were able to deliver the concept and details of the framework if the reader had a background in construction management. One of the PhD students who participated in the pilot study was a physician, dissociated from construction management, who found the framework difficult to read, although he understood the major concept. Respondents were also provided with a link to the presentation in case they required further details. An additional seven responses were received after using the diagrams. Refer to appendix 3 to view the questionnaire form.

9.5. **Results**

9.5.1. ***Applicability of Framework Components***

Participants were asked to indicate their rate of applicability for each of the framework components; where 1 meant inapplicable and 5 applicable. The analysis of the answers revealed that the levels of applicability for all approaches were considered far above the ground.

In Table 9.2, the lowest mean value is 3.75 out of 5 for the architecture of the knowledge base. Although its value does not indicate that the architecture of knowledge base is 100% applicable, it does show that it is likely to be more applicable than inapplicable. The situation with regards to knowledge capture, retrieval, and structure approaches are much better as they are all scored 4 out of 5. The negative values of the skewness measures also indicate the mass of the distribution to be concentrated on the applicable side.

Table 9.2: Applicability of the framework components.

		Knowledge Capture	Knowledge retrieval	Knowledge Structure	Architecture of Knowledge Base
N	Valid	16	16	16	16
	Missing	0	0	0	0
Mean		3.9375	4.0625	4.0000	3.7500
Std. Deviation		.85391	.85391	.89443	1.00000
Skewness		-.605	-.863	-.639	-.343

As shown in Figure 9.2, the majority of experts gave a 4 or 5 rate of applicability to all components of the framework. Even with regards to the architecture of the knowledge base; only two experts rate the applicability under 3 (i.e. 2). The normal curve also demonstrates

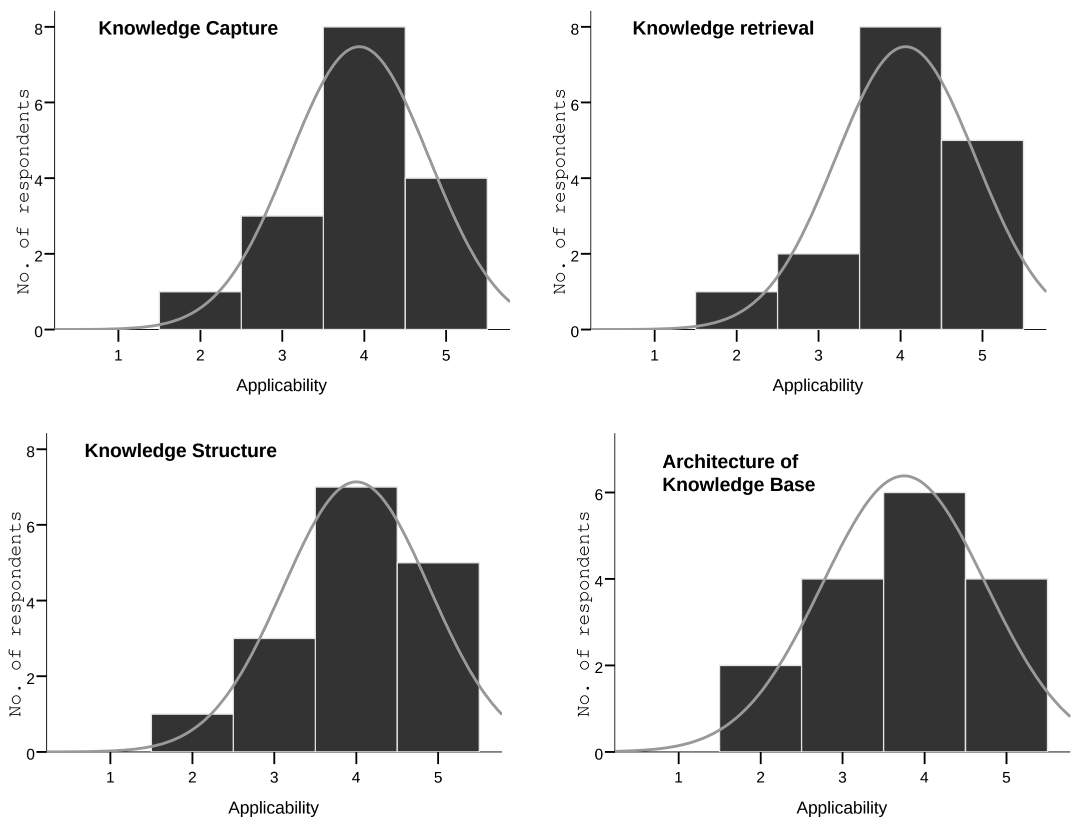


Figure 9.2: Applicability of Knowledge Capture, Knowledge Retrieval, Knowledge Structure and Architecture of Knowledge Base.

that the approximation of the average of all components almost lies in the 4 rate of applicability. All the indications provide evidence that those components are applicable in the construction companies.

9.5.2. ***Effectiveness of Framework Components***

Participants were asked to indicate their rate of effectiveness for each of the framework components; where 1 meant ineffective and 5 effective. As shown in Table 9.3, the mean score of effectiveness for all components are above 3.75 and range between 3.87 and 4.18. In addition, all values of skewness measured are negatives, meaning that the mass of the distribution is concentrated on the effectiveness side.

Table 9.3: Effectiveness of the framework components.

		Knowledge Capture	Knowledge Retrieval	Knowledge Structure	Architecture of Knowledge Base
N	Valid	16	16	15	16
	Missing	0	0	1	0
Mean		4.0625	4.18750	3.9333	3.8750
Std. Deviation		.85391	.910586	.79881	1.02470
Skewness		-.863	-1.019	-.842	-.571

The histograms shown in Figure 9.3 indicate that the majority of experts evaluated all comports to a score 4 or 5 rate of effectiveness. Knowledge retrieval thus appears slightly more effective than the other components. The normal curve also makes obvious the approximation of the average rate of all components which almost lies in the 4 rate of effectiveness. All the indicators together provide evidence that those components will be effective when implemented.

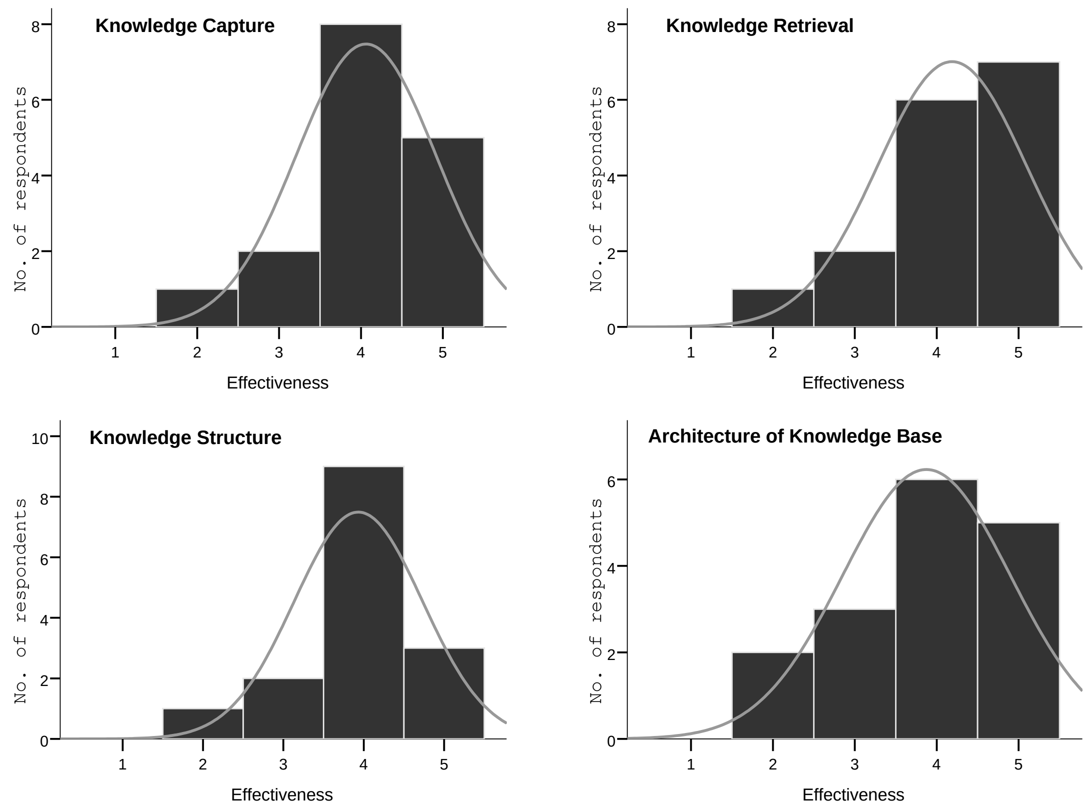


Figure 9.3: Effectiveness of Knowledge Capture, Knowledge Retrieval, Knowledge Structure and Architecture of Knowledge Base.

9.5.3. ***Applicability of the Entire Framework***

Participants were asked to indicate their rate of applicability for the entire framework using the same criteria as mentioned above. As shown in Table 9.4, the mean value of applicability (3.93) and the negative value of the skewness measure provide an encouraging indication for the external validity. The pie chart in Figure 9.5 shows that the majority of experts (62%) rate the applicability 4 out of five; and the vast majority (81.3%) are either giving the framework a rate of 5 or 4. In addition, the histogram in Figure 9.4 shows that only one expert gave a rating of applicability under 3 (i.e. 2). Therefore, the indications of applicability are positive and reveal that this framework is considered applicable.

Table 9.4: Applicability of the entire framework.

		Applicability of the Entire Framework
N	Valid	16
	Missing	0
Mean		3.9375
Std. Deviation		.77190
Skewness		-.881

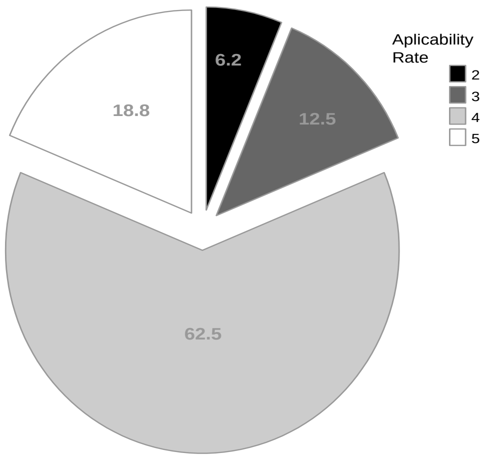


Figure 9.5: Proportion of applicability rates Of the entire framework.

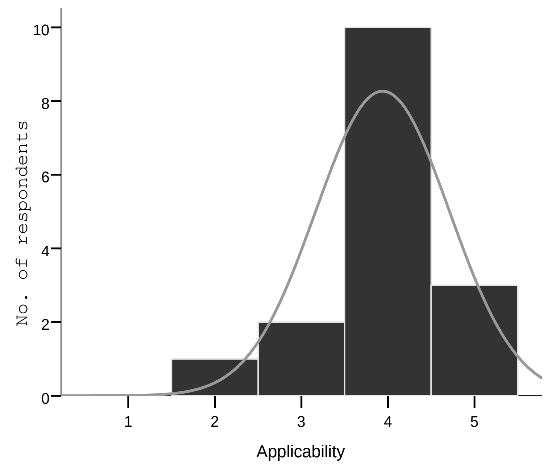


Figure 9.4: Frequency of applicability rates of the entire framework

9.5.4. ***Effectiveness of the entire framework***

Participants were asked to indicate their rate of effectiveness for the entire framework using the same criteria as mentioned above. The mean value (4) and the skewness measure value (negative) shown in Table 9.5 indicates that the framework is evaluated to be effective. Figure 9.7 shows that a third of the experts suggest a full mark of effectiveness; and 40% gave the framework a rate of 4 for effectiveness. However, as shown in Figure 9.6, three experts rate it a 3 and one a 2. However, the normal curve is pointing to an approximation of effectiveness at the rate of 4. Generally, indications suggest that the framework is effective.

Table 9.5: Effectiveness of the entire framework.

		Effectiveness of the Entire Framework
N	Valid	15
	Missing	1
Mean		4.0000
Std. Deviation		.92582
Skewness		-.623

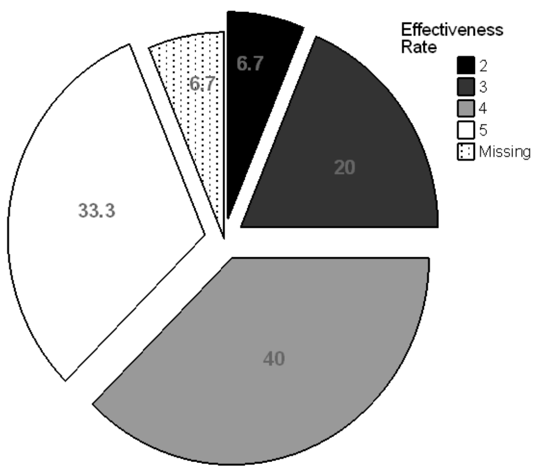


Figure 9.7: Proportion of effectiveness rates of the entire framework.

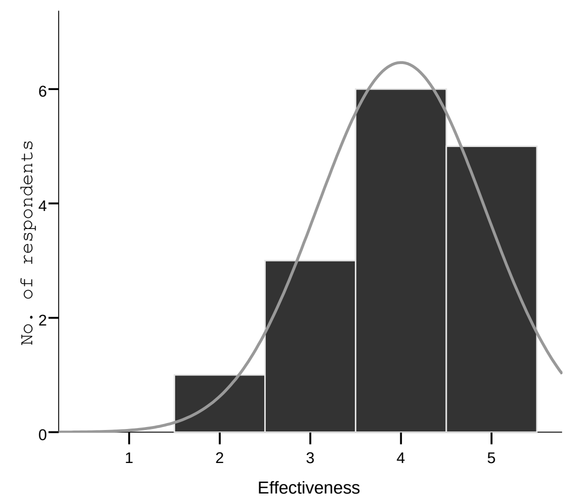


Figure 9.6: Frequency of effectiveness rates of the entire framework.

9.5.5. ***Open Evaluation***

Experts were asked to express their opinion about the framework in terms of effectiveness, applicability, advantages and shortcomings. This could provide additional assessment not covered in the closed ended questions. Twelve of the feedbacks were received and have been shown in the list below:

- It looks good to me. The challenge is to make it happen in practice!
- I like the model, particularly knowledge forms and the categorisation; this will save time when searching for knowledge.

- I thought the overall presentation was brilliant and captured a lot of the things we do not consider as worth pointing out in our every-day project delivery implementation.

- It is quite difficult to make a judgement on these key issues only based on a presentation. However I am quite impressed with the knowledge capture approach. Although the presentation is very good, but the information, it provides is inadequate.

- It seems very general.

- The framework works well in effectiveness and applicability; and in use of collaboration tools, intranet tools with knowledge management within organisations. It is essential in a large organisation that staff are able to find and utilise answers as well as gaining access to subject matter, experts and sharing information on similar projects and programmes. The advantages are that knowledge is shared rather than lost or protected by individuals. The saying that knowledge is power is true of individuals; but is clearly more so in organisations that are able and willing to capture knowledge and share this with the wider team rather than isolating it with individual project members.

- The framework is effective and applicable in many areas and an insightful and logical structure. There is some duplication but that would seem to be inevitable.

- Leadership support is vital, with top-bottom commitment. Co-operation/sharing is not always a "natural" inclination in individuals.

- The framework seems a highly advanced one, and seems in need of an IT system to facilitate its processes and to encourage people to use it. If all members of the organisation are contributing positively to the framework; and most of them have the ability to capture, retrieve, and then re-use the captured knowledge, then the system will be for sure highly effective. In reality I think we share the knowledge "some-times" but even when we do so, we do not document and/or capture this knowledge in a proper way. As a result, we lose whatever we have shared as we cannot capture, structure and re-use all the knowledge captured by only relying on our brain capabilities. We are in need of such a framework to help us to better understand the knowledge so we can use it where applicable. From an overall perspective, I admire you for this excellent presentation and it was informative and well structured. We have learned a lot from this insightful presentation about knowledge management. There is no doubt that this framework is essential for business success.

- Although the framework seems complicated on its operational side; I am sure that if the KM operation is based on this model, the outcome will be applicable and highly efficient.

- The framework makes sense from a project management standpoint. However, knowledge capture and retrieval are complex and resource intensive activities and can be onerous to the project team if proper incentives are not aligned with the leadership's expectation of knowledge sharing.

- 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.

The issues mentioned in the comments can be grouped into four categories: Firstly, those which highlight the role of knowledge capture and retrieval.

Secondly, those which emphasise the need for such a framework, due to the awareness of the problem, and thus confirm the motives for this study.

Thirdly, indications that the framework may require huge effort 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 retrieval side. To minimise the problem the project review was used as a main technique for knowledge capture which already exists in projects, instead of introducing a new approach. In addition, 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.

Fourthly and most importantly, an applicable and effective 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 necessary guarantee successful application.

Finally, an expert has stated the framework to be very general. In fact the framework is considering a particular area to investigate, related to knowledge capture and retrieval of project management processes, in the context of the project. Models inside the framework have provided precise details regarding what to do in particular scenarios. In addition, knowledge capture and retrieval cannot be tackled in isolation from issues such as leadership support and cooperative culture. It is worth mentioning that this expert selected the rating of 2 for all of the 10 rating-based questions which is considered statistically biased. However it was thought that, this academic expert provided his personal details and these matched the tracking information. Therefore it was considered a valid response, and his opinion was appreciated.

Other points were also considered related to the advantages of the framework; and impressions about the presentation.

9.5.6. *Framework Improvement*

Another question which was asked was related to how the framework could be improved. The list below presents the feedback received by experts:

- By trial and error.
- Improvement comes after application.
- I did not critically analyse the presentation to make a rational input in this direction.
- I would be interested to read the whole thesis and then make my suggestion.
- What issues should be addressed? Time, profitability and teamwork?
- The knowledge frameworks can always be improved and there is no such thing as the perfect knowledge framework. Evolvement of a framework can be made by learning the lessons of previous projects; receiving constructive criticism and using good management techniques such as benefits and stakeholder management. In addition being clear about the benefits of knowledge capture and retrieval, with the onward transmittal/access of results by stakeholders, communication and using the framework communication channels for optimum use. The framework is excellent for understanding the needs and requirements in this age and that knowledge should be shared for the benefit of all within an organisation; rather than being kept and possibly lost by the few, when the project team is dissolved or re-assigned.
- Show an example of how it will operate in practice.
- Linking it with the IT system which facilitates its process and records all captured knowledge after structuring it.

- It would maybe be a good idea to test the framework on a geographically distributed and functionally complex organisation.

- Labels of “must-have”, “should-have” and “good-to-have” can be used to distinguish between compulsory and optional activities and sections. This might make your framework more flexible for application as I think organisations will differ in their capabilities and implementation levels.

The answers can be categorised into four major groups:

Firstly, improvement is a continuous process and the most appropriate way to improve the framework is through application.

Secondly, improvement can be achieved by addressing time, profitability and teamwork which have already been addressed in this study. Profitability is a significant factor that can declare the importance of knowledge capture and retrieval of the project and is therefore one of the areas to be embarked upon. However, the development of a model in order to measure economic profit alone is enough to do a research project.

Thirdly, the exertion of effort in linking the IT system with knowledge capture and retrieval approaches. The knowledge base is a component of the framework, and there is a need to train people on the use of the knowledge base which links knowledge capture and retrieval approaches.

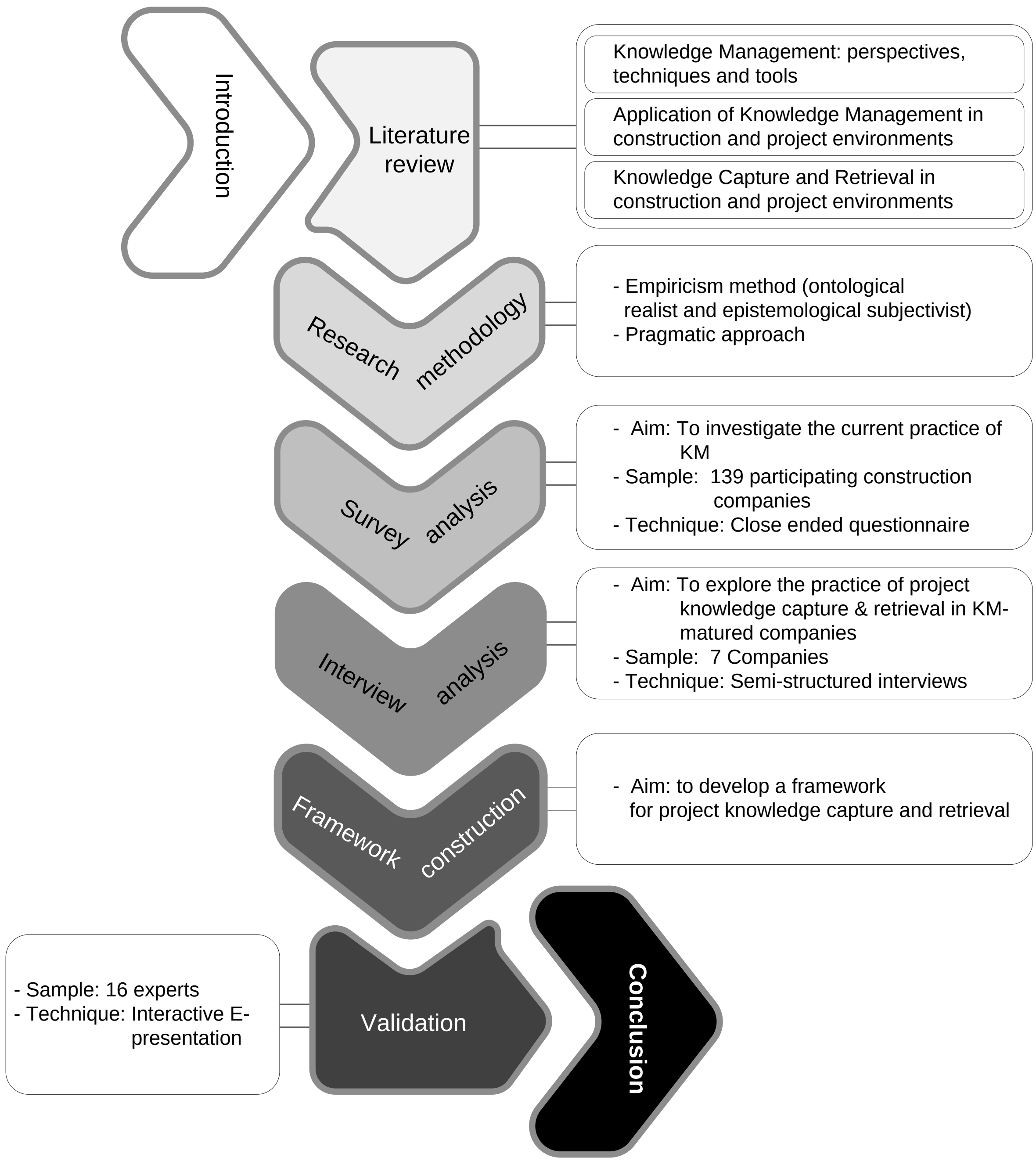
Finally, the use of labels to distinguish between compulsory and optional activities and resources. This has been presented differently in this research as the majority of the activities and resources were thought to be important if knowledge was required to be captured and retrieved successfully. It was decided only to emphasise activities or resources that were suggested but not deemed necessary.

9.6. **Conclusion**

This chapter has set out to determine the validity of the framework. It has demonstrated that validity relies on of the inherent validity of the methods of data collection, analysis, and the inferences leaded to construction of the framework. Critical in depth revision, piloting, peer reviews and a fixed framework for analysis were the methods used in this research to maximise its validity.

For the purpose of generalising (external validity) the framework, a number of factors were considered early on in this project. These included using a randomly selected sample in the survey; choosing a sample of best practice from the target population and comparing the results of best practice with the current practice obtained in the survey to assess the ability of and utilise the solution for the target population. Further steps were taken to test the generalisability of the framework by inviting practitioner and academic experts to evaluate its applicability and effectiveness. The results have indicated that the framework and its components are applicable and effective.

CHAPTER TEN: CONCLUSION AND RECOMMENDATIONS



10.1. **Introduction**

The aim of this research has been to build a framework that minimises the loss of organisational project knowledge and facilitates the straightforward retrieval of appropriate knowledge during the course of a project. This aim has been achieved through the completion of the five stages detailed in the thesis. This chapter serves to summarise the evolution of the research and emphasise the major findings. It concludes the research and details the findings obtained in terms of the stated objectives. In addition it presents the limitations of this research, and makes recommendations for future research. Finally, the contributions to the field of knowledge are highlighted.

10.2. **Research Background**

There are many research that deal with diverse areas of KM. While considerable attention has been paid to the implementation of KM in project-based organisations, little effort has been made to address the management of knowledge in the projects themselves. Some studies have considered the significance of either the knowledge of particular construction phases or the knowledge of the overall project in general. The focus in both cases was on either the product-oriented knowledge (Fruchter 1996; Koch and Thuesen 2002; i.e. Brandon *et al.* 2005; and Fruchter and Demian 2005) or the project knowledge in general (Maqsood *et al.* 2003; Maqsood *et al.* 2004; Mohamed and Anumba 2004). Nevertheless, there is still a lack of studies that specifically addresses both knowledge capture and retrieval of project management knowledge in construction projects. The practice of project review (PR) which considered a major technique for project knowledge capture suffers the relatively lengthy time lapse between the learning event and captured time, absence of project-related personnel, in some cases it is carried out by an external party who may not identify the knowledge obtained from the project, and the final format of the PR which primarily intended for project performance tracking, and it comes in large report. The studies that attempted to overcome the problems associated with PR, such as the activity-based approach (Tserng and Lin 2004) and live capture approach (Kamara *et al.* 2005) lead to additional demanding work to construction and/or the absence of the pre-determined time of knowledge capture.

10.3. **Methodology**

Five major stages were designed to achieve the aims and objectives of the research: (1) literature review, (2) survey (to investigate current practice), (3) interviews (to explore best practice), (4) framework building and (5) framework validation. Ontologically the research views that the phenomena (i.e. processes of capturing and retrieving project knowledge) is an existing fact and that knowledge comes from experience. In terms of epistemology, and how we obtain the research data, collecting the data regarding this phenomenon from those people involved in the process is considered appropriate (subjective). The primary data regarding current practice (Stage 2: survey) and good practice (stage 3: interviews) is collected from experts. This combination, ontological and epistemological assumptions, forms the philosophy of empiricist research. Empiricism is appropriate since the study is building a theory based on experience/good practice.

10.4. **Meeting the Aim and Objectives**

The research was intended to develop a reliable and valid framework for organisational project knowledge capture and retrieval in construction. The aim has been achieved through meeting four objectives. As shown in Figure 10.1, each objective is assigned to a separate stage and presented in a specific chapter.

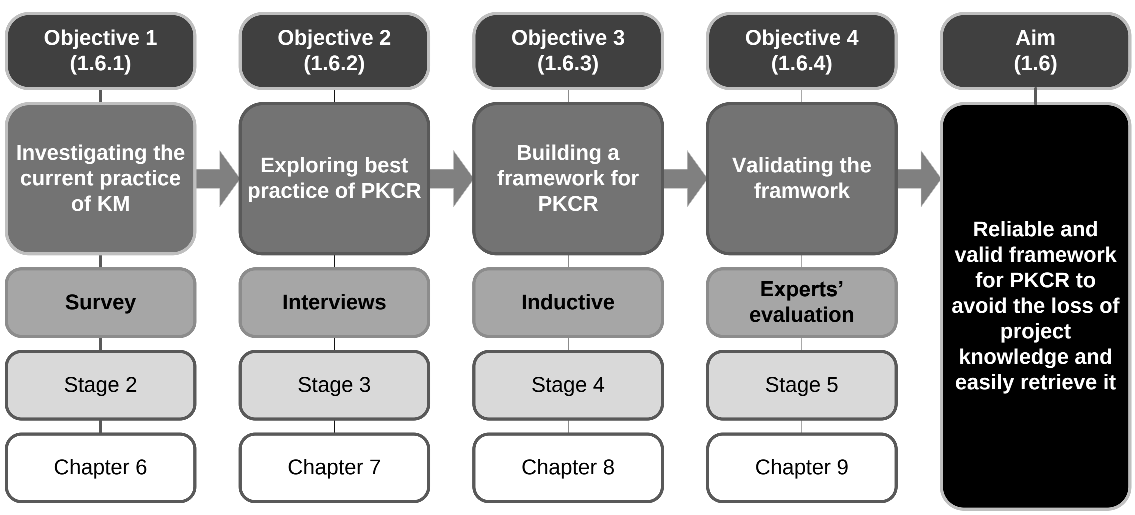


Figure 10.1: Research objectives in relation to the stages and chapters

10.4.1. ***Objective One: Investigating Current Practice***

Due to of the lack of reliable large scale studies on KM practice, and because more needs to be known about certain elements related to KM practice before they can be used reliably in subsequent tasks, there was a need for a survey to be conducted. An effort can be made to develop an applicable framework that matches the capability and resources of the industry. In addition, this was a good opportunity to identify companies at advanced levels of KM, so they can be contacted to participate in the third stage of the research, which will investigate the best practice of knowledge capture and retrieval. The answer was provided by the 139 participating companies using a close-ended questionnaire survey. The evidence from this study suggested that 91% of the companies were mainly distributed amongst the first three levels of KM maturity (i.e. pre-awareness, start-up and take off stages). Furthermore, at least 60% of UK construction companies have not started the practice of KM, and are still at the first two stages. This provides a solid foundation and a robust motivation for undertaking this study. The second major finding was that top companies are more mature than randomly selected companies in relation to KM. The mean level of KM maturity in a top company is at the third level (take-off stage), while it is at the second (Start-up stage) in randomly selected companies. Therefore, it would appear that paying some attention to top companies at the next stage (i.e. exploring the best practice) would be advantageous. It was also shown that as companies' levels of maturity increase the number of KM techniques and IT tools deployed also increases. A number of KM techniques were found to be effective; however, some of the more effective techniques and tools are available at low percentages at randomly selected companies.

One of the most significant findings to emerge from this stage is that PR was found to be the most popular, and effective KM technique throughout the industry. This indicated that PR would be an appropriate key theme for the next stage of the research. The results from investigating the practice of the PR show that half of the companies use PR to capture desired knowledge, which was an unexpected finding. In addition, three PR timing approaches were deployed in the industry, and more than a third of the companies use more than one PR timing approach. Generally, construction companies were found to conduct PR in coordination with some or all parties involved in the project. Finally *cooperative team meetings* and *checklists* were found to be popular in the practice of PR.

10.4.2. ***Objective Two: Exploring Best Practice***

This stage set out to explore the best practices of project knowledge capture and retrieval (PKCR). Data was collected from seven cases based on semi-structured interviews. The interview carried out for this study relates to three major themes: knowledge capture, knowledge retrieval, and PR. To enrich the study and acquire the most effective results possible, it was decided to interview three types of participants: five construction companies, a project-based company, and an idealistic view representative organisation. Strict criteria for selecting the appropriate companies and the right experts at those selected companies were identified. To avoid bias, a fixed framework was designed for the interview analysis; it was based on a number of previous studies in the field of qualitative analysis and they compromise three major processes: (1) conceptual analysis, (2) relational analysis and (3) selecting the appropriate approach/es.

The following conclusions can thus be drawn from this stage. Generally the successful application of knowledge capture and retrieval is determined by the deployed method, processes, and technique. However, other factors including open culture, motivation, social networks and social activities, structure of the organisation community of practice and work space design are regarded as vital to PKCR application. In addition, 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, locate experts (experts directory), and share knowledge (discussion board) saves effort and time and enables enhanced PKCR. A knowledge base has to be built on an intranet network and provide access to organisational members.

One of the key significant findings to emerge from this study is that the PR is the major method for capturing project knowledge. A number of techniques are deployed in PR to achieve a variety of functions. These include 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 PR are considered practical and reusable when short and in the form of a checklist and instructions. In addition it should 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 retrieval fast and straight forward during the course of project. It was also stressed that knowledge retrieval should start with the system by either searching or navigating the desired activity. Using the community of practice, either by using a project team made up of the right people from within the organisation or using the e-discussion board, providing that e-discussion could not be the right technique for SMEs unless the number of people is large and/or there are a number of branches for the SME.

10.4.3. *Objective Three: Framework Construction*

The framework was constructed based on the results obtained from the survey analysis and interview analysis. The building processes commenced with the presentation of the conclusion for each and every theme. The approach to developing the framework is based on the induction method, using processes modelling, decision support modelling and revealed causal mapping. The framework is presented on three levels: strategic, tactical, and operational. It suggested particular steps, models, structures, taxonomy and systems. This approach is integrated with a strategic policy to form an accumulative framework. The framework claims that no matter how effective the approach to knowledge capture and retrieval is, without a knowledge-sharing environment the application will not benefit from these methods. The environment of knowledge sharing is influenced by co-operative culture, and the existence of the necessary resources, two elements are dependent on the full support of the organisation's leadership.

PR in the framework is the main method for ideal capture of the desired knowledge. Two additional scenarios can also be implemented to provide effective methods for capturing project knowledge: capturing found answers and faltering knowledge from the discussion board. The developed PR model consists of three components; checklist, the "three processes" approach and the brainstorming technique. Each component performs a particular function. This approach is supported by interviews and presentation. It was also fund that PR has to be conducted on a monthly basis, providing that one or some of these monthly reviews should take place at the end of every stage, and after project completion. The final format of PR or any captured knowledge has to be either included in instructions or in checklist format and should be short and to the point (on average, five to twelve pages of PR). The knowledge has to be classified in the knowledge base in two ways; project→works and works without links to projects. On the other hand, it was found that the knowledge base must include four components, projects (to mange project knowledge), expert directory, e-mail client, and skills network (for knowledge sharing). A decision support model was design to assist in retrieving project knowledge. Knowledge can be retrieved 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 desirable knowledge, considering there is a precise order for approach.

10.4.4. ***Objective Four: Framework Generalisation***

Since the framework was primarily built based on a small number of cases, it was necessary to find out wither it can be generalisable (applicable and effective) to the industry. A number of factors were considered early on in this project. These included using a randomly selected sample in the survey; choosing a sample of best practice from the target population and comparing the results of best practice with the current practice obtained in the survey, to assess the capacity to utilise the solution for the target population. Further steps were taken to test the generalisability of the framework by inviting practitioners and academic experts to evaluate applicability and effectiveness. The results have indicated that the framework and its components are applicable and effective.

10.5. **Limitations of the research**

Good research usually focuses on a particular area, evaluating a pre-determined context, seeking to accomplish thorough understanding of the subject matter. The proposed framework has a number of constraints:

- It is limited to the *capture and retrieval of knowledge*, therefore the other processes of knowledge management (e.g. knowledge creation and knowledge sharing) are only considered for the purpose of understanding the context.

- The framework is *project-based*; hence, it is not applicable for managing organisational knowledge.

- Projects are limited to *construction* projects, any other kind of projects are not considered in this research.

- Knowledge in the framework is the knowledge of *project management processes*. Any other type of knowledge, such as product oriented knowledge (e.g. knowledge of designing) is not included.

- The framework was built based on primary data collected from the *UK* construction industry, and the framework was validated by experts from the UK. Therefore the framework would not be guaranteed valid for use in other countries. Due to the availability and effect of the techniques and approaches used, the structure of the organisation, its culture, the approaches to motivation, organisational resources, etc. results may differ from country to country.

10.6. **Value of the Findings**

The empirical findings in this study provide a new understanding of project knowledge capture and retrieval. As such, it provides a cumulative perspective on the issue of knowledge capture and retrieval in the project context, by linking leadership, culture, resources, and organisational environment with methods of knowledge capture and retrieval. The findings of the research are interpreted in the framework as the basis of the final outcome of the research project. The empirical benefits of the framework are as follows:

- Provide a tool for construction companies, enabling them to minimise the loss of project knowledge and avoid the need to reinvent the wheel for future projects.

- The suggested precise form and format of work insights (project knowledge) eases the practice of knowledge codification; it becomes straightforward, simple and practical while at the same time produces valuable and reusable knowledge. It is designed to overcome the demanding work of knowledge codification, and motivate and advance the practice of knowledge capture.

- The processes-based and project-based taxonomy of the captured knowledge allows for a quick retrieval process when specific knowledge is required. This in turns saves the time spent by project members when searching for a particular piece of knowledge during the course of a project.

- Knowledge that is valid at one particular time may not be valid at another time. The application of the framework leads to establishing a project knowledge database, which gets updated with every project conducted. Invalid knowledge will be replaced with the most up to date knowledge to avoid the hassle of information overload.

- Although the framework relates to knowledge capture and retrieval, the attention paid to the cultural, and knowledge sharing factors, initiates the process of knowledge creation and therefore innovation.

- The integration of approaches to knowledge capture and retrieval with the organisational factors such as the culture, resources, motivation, and leadership provides a sustainable level of effectiveness, strength and workability, minimising the chances of failure.

- Despite the value that the framework contributes to projects, it does not add an additional heavy workload during the course of the construction project. Instead of developing a completely new approach; the framework develops the resources, tools and technique already available, and relies mainly on the project review technique, which has been found to be the most popular KM technique in the industry.

- Providing that construction project management is knowledge intensive work. This framework intends to enrich and mature the company's knowledge, and motivate knowledge creation. Consequently avoiding project delay and cost over run, and increase the financial benefits.

10.7. Contribution to Knowledge

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

- Developing a framework for knowledge capture and retrieval during a construction project, minimising the loss of project knowledge. It is the first framework/model that has considered both the capture and retrieval of project management 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.

- Measuring the level of KM maturity in the industry is based on a 5 stage measurement. This shows precisely where the industry stands in relation to KM. Other studies have provided only a general perception. The results obtained provided a clear view of the need for continuous studies to improve the current practice of KM in the industry.

- Construction management research typically limits the data collection to the construction industry, and this is to build a theory that is applicable to that industry. In addition to collecting the primary data from the industry, this research also benefits from the ideas and concepts deployed in other industries. Further procedures have been undertaken to ensure the applicability of the data collected to the industry.

- Providing a deep understanding of the availability and effectiveness of KM techniques and IT tools in practice. It also identifies the most popular and effective KM techniques and IT tools in the industry. This can provide a solid ground for future studies and an understanding of the current practices of KM.

- The literature explains various types of project review that are deployed throughout the industry. However it does not precisely reveal the popularity of methods, their purpose, and the management of time. This study strengthens and furthers understanding of the current practice of PR. It established obvious perceptions to contribute to findings from current practice.

- The study has gone some way towards enhancing our understanding of KM practice in top companies, and comparing this with the standard industry practice. This comparative approach is thought to be new to the field. It assisted in distinguishing the practice of industry and top companies, revealing a considerable difference between the two groups.

10.8. Recommendations for Further Research

During the progress of the research, a number of areas were identified as useful subjects of study. The recommendations made in this section were related to the research issues being investigated and the methodology being adopted. This research has prompted many questions that highlight the need for further investigation. It is recommended that further research be undertaken in the following areas:

- Knowledge capture and retrieval based on a particular processes model such as RIBA Outline Plan of Work (RIBA 2007). This would provide valuable results because processes and activities could then be identified by name. Therefore, the study could further generate precise details of who, how, and when to capture knowledge. In addition, the implication of knowledge categorisation, based on the processes and activities of the determined model could eliminate the ambiguity of knowledge taxonomy. Due to the fact that a number of process models are widely implemented in the industry, it would be possible to conduct the study concerning a number of cases studies already deploying the desired model.

- Developing a model for measuring the financial benefits of KM in projects. This is an area that has not been thoroughly investigated. The system dynamic method could be the appropriate method, as measuring the KM benefit is a complicated process and requires the following of cause and effect relationships. The importance of this study lies in providing a tangible perception of the financial effects of KM on projects. Because the model tracks the performance of KM, it provides indications about the effectiveness of the current KM approach, and hence motivates continuous improvements to KM practice.

- Considerably more work will need to be done to link both the social network analysis and the factors affecting social networks in projects. The linkage between these two related areas offers the opportunity for exploring the results of the social network analysis in *particular cases* and for comparing them with the factors recognised to affect the social network. It is suggested to use a mixed approach for a two stage study; the first of which comprises interviews to determine the factors, and the second uses case studies to both analyse the social networks (using a previously identified model) and identify the available factors. The comparison may lead to the identification of those critical factors that make the difference with regards to strengthening social networks in projects.

A better understanding of knowledge sharing cultures in the project context needs to be developed. Focusing on demand side, instead of the supply side, by collecting data from operational people instead of top management, would be predicted to provide a valuable result. Such study is expected to clarify what motivates people to share knowledge and also the factors and resources that affect the sharing culture in project environments.

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APPENDICES

Appendix 1: Pilot Questionnaire

Appendix 2: Questionnaire Form

Appendix 3: Framework Evaluation: Presentation and Questionnaire

Appendix 4: Survey Analysis

Appendix 1: Pilot Questionnaire

The purpose of this study is to investigate the current practice in relation to capturing and retrieving construction project knowledge.

Please respond to the following questions either by ticking the appropriate box or by writin your answer in the space provided.

Please note:

- The answers should be based on the practice of your construction organisation.
- All information provided will be treated in the strictest of confidence.

Section one – ***Questions related to the organisation's experience.***

1.1. What is your organisation specialisation?

- □ Architect
- □ Consultant Engineer
- □ Contractor
- □ Project Manager
- □ Surveyor
- □ Other, please specify ………………………………………

1.2. What is the size of your organisation?

- □ Small (2– 49 employees)
- □ Medium (50 – 249 employees)
- □ Large (> 249 employees)

Section two – ***Questions related to the knowledge management practice in the organisation.***

2.1. Does your organisation have a formal strategy for managing its knowledge?

- □ Yes
- □ No but there is an intention to do so
- □ No and there is no intention to do so

2.2. The following table lists the techniques and IT tools that can be used in managing knowledge. Please indicate the techniques and IT tools that are available in your organisation by ticking the appropriate boxes related to each of them.

If any of the techniques and IT tools are not used in your organisation then leave blank the appropriate boxes.

Techniques and IT tool	Purpose					Environment				Efficiency		
	capture	**create**	**store**	**disseminate**	**retrieve**	**intranet**	**extranet**	**internet**	**paper-based**	**efficient**	**normal**	**inefficient**
Portal /Content management system	☐	☐	☐	☐	☐	☐	☐	☐	-	☐	☐	☐
Custom-designed software	☐	☐	☐	☐	☐	☐	☐	☐	-	☐	☐	☐
Expert Directory	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Groupware	☐	☐	☐	☐	☐	☐	☐	☐	-	☐	☐	☐
Forum	☐	☐	☐	☐	☐	☐	☐	☐	-	☐	☐	☐
Live discussion	☐	☐	-	☐	-	☐	☐	☐	-	☐	☐	☐
Instant messaging system	☐	☐	-	☐	-	☐	☐	☐	-	☐	☐	☐
e-mail	☐	☐	-	☐	-	-	-	-	-	☐	☐	☐
website	☐	☐	☐	☐	☐	-	-	-	-	☐	☐	☐
File manager	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Communities of Practice	☐	☐	-	☐	-	-	-	-	-	☐	☐	☐
Codification of knowledge	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
External sources of knowledge	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Training	☐	☐	-	☐	-	-	-	-	-	☐	☐	☐
Reassignment of people	☐	☐	-	☐	-	-	-	-	-	☐	☐	☐
Research collaboration	☐	☐	☐	☐	☐	-	-	-	-	☐	☐	☐
Preparation of standard reusable details	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Knowledge team	☐	☐	-	☐	-	-	-	-	-	☐	☐	☐
Knowledge manager	☐	☐	-	☐	-	-	-	-	-	☐	☐	☐
Succession management & mentoring	☐	☐	☐	☐	☐	-	-	-	-	☐	☐	☐
Research & development team	☐	☐	-	☐	-	-	-	-	-	☐	☐	☐
Mentoring	☐	☐	-	☐	-	-	-	-	-	☐	☐	☐
Apprenticeship	☐	☐	-	☐	-	-	-	-	-	☐	☐	☐
Discussion groups	☐	☐	-	☐	-	-	-	-	-	☐	☐	☐
Storyboards	☐	☐	☐	☐	☐	-	-	-	-	☐	☐	☐
Project review	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

2.1. What is/are the level/s of transferring knowledge that are currently in place in your organisation? (you might select more than one)

- ☐ project → project (in parallel)
- ☐ project → project (subsequently)
- ☐ project → organisation
- ☐ organisation → project
- ☐ your party → another project party
- ☐ another project party → your party
- ☐ there is no methodology of transferring knowledge in any level
- ☐ other, please specify ……………………………………..

Section three – ***Questions related to the project review practice in the organisation.***

If your organisation does not practice project review technique, then go to the comment section, and then return your form as requested.

3.1. Why are project reviews conducted in your organisation? (you might select more than one)

- ☐ To evaluate the project activities in relation to time, cost and quality and project team performance. So the appropriate action can be made if there are deviations from the project plan.
- ☐ To capture the desired knowledge and use it in the future stages/projects
- ☐ Other, please specify ………………………………………

3.2. Please indicate the stage that project review are usually carried out (you might select more than one)

- ☐ After project activity
- ☐ After project management process
- ☐ After the completion of project stage
- ☐ On demand (not predefined)
- ☐ Time based (e.g. weekly, monthly)
- ☐ Immediately after project completion
- ☐ 1 to 2 years after project completion
- ☐ Other, please specify ………………………………………

3.3. What is/are the method/s used to conduct the project reviews? (you might select more than one)

- ☐ Checklist method
- ☐ Distributing a survey to the project participants
- ☐ Face to face meeting
- ☐ Documents analysis
- ☐ Cooperative team meeting
- ☐ Other, please specify ………………………………………

3.4. Who usually carries out the review?

- ☐ Project manager
- ☐ Moderators respectively
- ☐ Auditor
- ☐ Facilitator
- ☐ External project review unit
- ☐ Other, please specify ………………………………………

3.5. Does your organisation conduct the project review in coordination with the other parties involved in the project?

- ☐ Yes
- ☐ No

3.6. What is the average number of the pages included in a typical project review?

……………

3.7. What do you generate from project reviews document? (you might select more than one)

- ☐ Lessons learned
- ☐ Best practices
- ☐ Micro articles
- ☐ Learning histories
- ☐ None
- ☐ Other, please specify ………………………………………

3.8. Is it easy for anyone in the organisation to access these reviews or the documents generated from them?

- ☐ Yes
- ☐ No

3.9. Would you like to offer help in future work in this topic area?

- ☐ Yes
- ☐ No

3.10. If you answered yes to question 3.9 please fill the followings:

Your name : ……………………………………...

Department: ………………………………………

E-mail : ……………………………………..

3.11. If you would like to receive a resume of the results of this survey then please tick here ☐

Please add any other comments here:

Thank you very much; your response is highly appreciated.

Please send your response using the attached reply envelope.

Appendix 2: Questionnaire

- ***Postal Questionnaire***

Dear [Name],

Subject: **Current practice in relation to capturing and retrieving construction project knowledge.**

I am presently preparing a thesis on the capture and retrieve of project knowledge as part of my PhD research in construction management.

An important element of the thesis is to carry out a field survey to investigate the techniques and tools of capturing and retrieving project knowledge as experienced by the differing construction parties. The purpose of this study is to investigate current practice in relation to construction knowledge management (KM).

Please find a questionnaire enclosed, and I respectfully ask you to complete it and return the form to me in the stamped and addressed envelope provided. Please note that your name and your company name will remain confidential as far as the results are concerned.

The collected data will be statistically analysed, and conclusions will be finalised. If you wish, I shall be happy to provide you with a summary of the results of the study once finished.

Your assistance and cooperation is highly appreciated

Current practice in relation to capturing and retrieving construction project knowledge.

Please respond to the following questions by ticking the appropriate box. Please note that the answers should be based on the practice of your organisation. All information provided will be treated in the strictest of confidence.

Section one – ***Organisation's experience.***

1.1. What is your organisation specialisation?

☐ Contractor ☐ Consultancy ☐ Other, please specify …………………...........

1.2. What is the size of your organisation?

☐ Small (2– 49 employees) ☐ Medium (50 – 249 employees) ☐ Large (> 249 employees)

Section two – ***Knowledge management (KM) practice in your organisation.***

2.1. From the following table please tick the stage that best describes your organisation's practice in relation to KM?

☐	☐	☐	☐	☐	☐
▪ No awareness of the benefits of KM for business improvement	▪ An awareness of the benefits of KM for business improvement	▪ Developing a KM strategy and a working definition of what knowledge needs to be managed ▪ Leadership, resources, barriers and risks identified	▪ Increased visibility of KM leadership and initiatives ▪ Structured approach to implementation ▪ Change management to address barriers and risks ▪ KM initiatives expanded to other parts of the business	▪ KM integration with performance models ▪ Increased emphasis on using qualitative and quantitative methods to justify KM initiatives and to measure and monitor KM performance	▪ Sustaining performance of KM activities ▪ KM becomes normal routine, diffused in the entire organisation and becomes an integral part of the organisational culture – employees' behaviour, business processes and product development

2.2. The following table lists the techniques and IT tools that can be used in managing knowledge. Please indicate how effective the tools available in your organisation are. If any of the techniques and IT tools are not used in your organisation then leave it blank.

1= Ineffective 2 = Natural 3= Effective

KM - Techniques	1	2	3
Knowledge recording	☐	☐	☐
External sources of knowledge	☐	☐	☐
Training	☐	☐	☐
Reassignment of people	☐	☐	☐
Research collaboration	☐	☐	☐
Preparation of standard details	☐	☐	☐
Knowledge team	☐	☐	☐
Knowledge manager	☐	☐	☐
Mentoring	☐	☐	☐
Apprenticeship	☐	☐	☐
Discussion groups	☐	☐	☐
Storyboards	☐	☐	☐
Project review	☐	☐	☐

KM - IT tools	1	2	3
Portal/Content management system	☐	☐	☐
Custom-designed software	☐	☐	☐
Expert Directory	☐	☐	☐
E-mail	☐	☐	☐
Website	☐	☐	☐
Electronic File manager	☐	☐	☐
Electronic Forum	☐	☐	☐
Groupware	☐	☐	☐
Electronic Instant messaging system	☐	☐	☐
Project Extranet	☐	☐	☐

Section three – ***Project review practice in your organisation.***

If your organisation does not practice a project review technique, then go to the comment section, and then return your form as requested.

3.1. Why are project reviews conducted in your organisation? (you might select more than one)

- ☐ To evaluate the project activities and team performanc*e.*
- ☐ To capture the desired knowledge and use it in the future stages/projects
- ☐ Other, please specify ………………………………………

3.2. When do you usually conduct project review? (you might select more than one)

☐ After the completion of project stage ☐ Time based (e.g. weekly, monthly) ☐ Immediately after project completion

☐ 1 to 2 years after project completion ☐ Other, please specify ……………………………..

3.3. What is/are the method/s used in your organisation to conduct the project reviews? (you might select more than one)

☐ Checklist method ☐ Cooperative team meeting ☐ Documents analysis

☐ Distributing a survey to the project participants ☐ Other, please specify ………………………

3.4. Does you organisation conduct the project review in coordination with the other parties involved in the project?

☐ Yes, with all parties ☐ Yes, with some parties ☐ No

If you would like to offer help in future work in this topic area please fill the followings:

Your name : …………………………………... E-mail: ………………………..

Department: ………………………………………

If you would like to receive a summary of the results of this survey then please tick here ☐

Your e-mail (if not written above): …………………………..

Please add any other comments here:

Thank you very much; your response is highly appreciated.

Please send your response using the attached reply envelope.

- ***Electronic questionnaire***

Dear [Name],

I'm conducting a survey on knowledge management in construction, as part of my PhD research in construction management, and your response would be appreciated.

Here is a link to the survey:
http://www.surveymonkey.com/s.asp?A=173547733E64725

If you think that your work is not concerned in any way with construction, then could you please forward this email to the appropriate person in your organisation.

Thanks for your participation,

I Falqi
3.03 Chadwick
School of the Built environment
Heriot-watt University
Edinburgh EH14 4AS

Please note: If you do not wish to receive further emails from us, please click the link below, and you will be automatically removed from our mailing list.
http://www.surveymonkey.com/r.asp?A=173547733E64725

www.surveymonkey.com/s.aspx?PREVIEW_MODE=DO_NOT_USE_THIS_LINK_FOR_COLLECTION&sm=QsH6JJ7Dif0%2fdBsU4ILmlf7xr8r1O2O6BaZ

Current practice in relation to construction knowledge management

Exit this survey >>

2. Organisation's Experience

*** 1. What is your organisation specialisation?**

- ✓ Contractor
- Consultancy
- Other (please specify)

2. What is the size of your organisation?

- Small (2– 49 employees)
- ✓ Medium (50 – 249 employees)
- Large (> 249 employees)

<< Prev   Next >>

Current practice in relation to construction knowledge management

Exit this survey >>

3. Knowledge management (KM) practice in your organisation.

*** 3. From the following table please tick the stage that best describes your organisation's practice in relation to KM?**

	Your KM practice
No awareness of the benefits of KM for business improvement	
An awareness of the benefits of KM for business improvement	
Developing a KM strategy and a working definition of what knowledge needs to be managed + Leadership, resources, barriers and risks identified	✓
Increased visibility of KM leadership and initiatives + Structured approach to implementation + Change management to address barriers and risks + KM initiatives expanded to other parts of the business	
KM integration with performance models + Increased emphasis on using qualitative and quantitative methods to justify KM initiatives and to measure and monitor KM performance	
Sustaining performance of KM activities + KM becomes normal routine, diffused in the entire organisation and becomes an integral part of the organisational culture	

4. The following table lists the IT tools that can be used in managing knowledge. Please indicate how effective the tools available in your organisation are. Tick "Not Available" to the tools that are not used in your organisation.

	Effective	Normal	Not Effective	Not Available
Knowledge recording		✓		
External sources of knowledge			✓	
Training		✓		
Reassignment of people				✓
Research collaboration			✓	
Preparation of standard details		✓		
Knowledge team		✓		
Knowledge manager				✓
Mentoring	✓			
Apprenticeship		✓		
Discussion groups	✓			
Storyboards	✓			
Project review	✓			

5. The following table lists the techniques that can be used in managing knowledge. Please indicate how effective the techniques available in your organisation are. Tick "Not Available" to the techniques that are not used in your organisation.

	Effective	Normal	Not Effective	Not Available
Portal/Content management system		✓		
Custom-designed software	✓			
Expert Directory		✓		
E-mail		✓		
Website		✓		
Electronic File manager			✓	
Electronic Forum	✓			
Groupware				✓
Electronic Instant messaging system				✓
Project Extranet				✓

<< Prev   Next >>

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Current practice in relation to construction knowledge management

Exit this survey >>

4. Project review practice

If your organisation does not practice a project review technique, then ignore the questions 6 to 9.

6. Why are project reviews conducted in your organisation? (you might select more than one)

- [x] To evaluate the project activities and team performance.
- [x] To capture the desired knowledge and use it in the future stages/projects
- [ ] Other (please specify)

7. When do you usually conduct project review? (you might select more than one)

- [x] After the completion of project stages
- [ ] Time based (e.g. weekly, monthly)
- [x] Immediately after project completion
- [ ] 1 to 2 years after project completion
- [ ] Other (please specify)

8. What is/are the method/s used in your organisation to conduct the project reviews? (you might select more than one)

- [x] Checklist method
- [x] Cooperative team meeting
- [ ] Documents analysis
- [ ] Distributing a survey to the project participants
- [ ] Other (please specify)

9. Does your organisation conduct the project review in coordination with the other parties involved in the project?

- ( ) Yes, with all parties
- (x) Yes, with some parties
- ( ) No

<< Prev   Next >>

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Current practice in relation to construction knowledge management

Exit this survey >>

5. Result summary

10. .

	Yes
Would you like to receive a summary of the results of this survey?	☑
Would you like to offer help in future work in this topic area?	☐

11. If you answered yes to any of the questions above, then please fill the folowing:

Your email	myname@domainname.org
Your name	[First name] [Last name]

12. Please add any other comments here:

<< Prev   Next >>

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Current practice in relation to construction knowledge management

Exit this survey >>

6. THANK YOU

Your assistance and cooperation is highly appreciated

Thank you very much indeed.

<< Prev   Done >>

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Appendix 3: Framework Evaluation: Presentation and Questionnaire

Dear [Name],

I am presently preparing a thesis on the capture and retrieval of project knowledge as part of my PhD research in construction management.

In this research a framework for Knowledge Capture and Retrieval in Construction Projects has been developed. An important element of the study is to validate the proposed framework.

As an expert in the industry, you are invited to watch a presentation, which may be found in this link, that introduces and explains the framework: http://km-framework.co.uk/

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

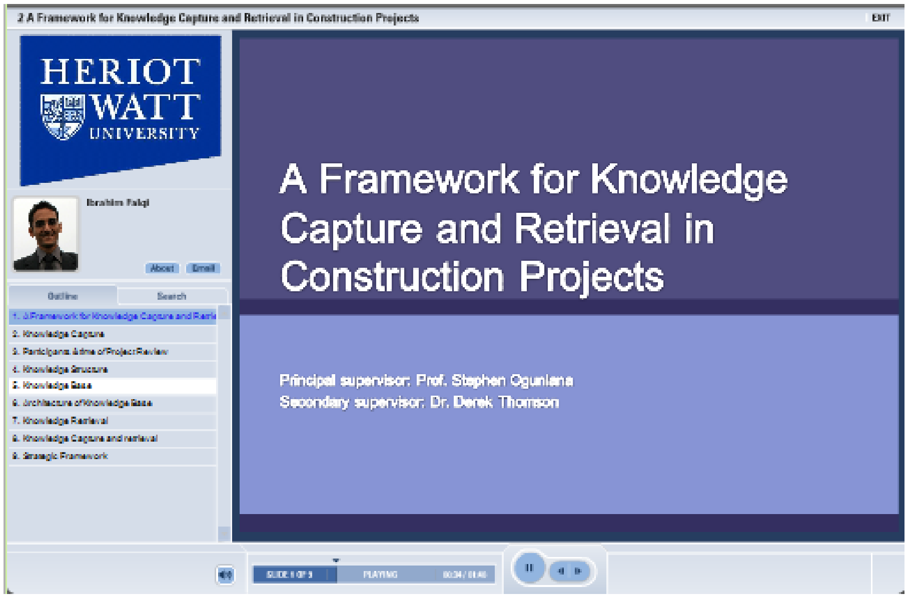
The presentation is about 25 minutes long, and the questionnaire is estimated to take less than 3 minutes to complete.

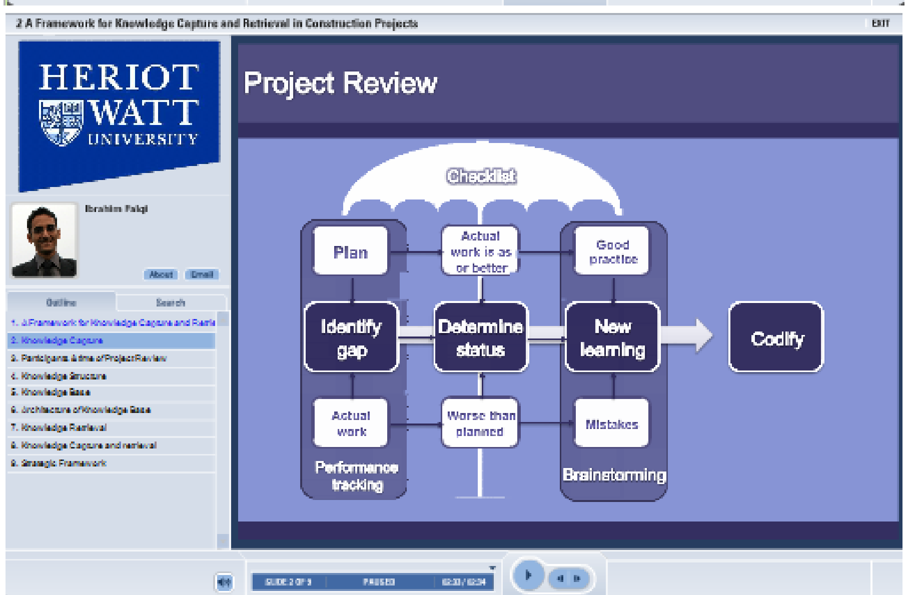
Your assistance and cooperation is highly appreciated.

Yours faithfully,

Ibrahim Falqi
School of the Built Environment
Heriot-Watt University
Edinburgh
EH14 4AS

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


2 A Framework for Knowledge Capture and Retrieval in Construction Projects
EXIT
HERIOT WATT UNIVERSITY
Ibrahim Falqi
A Framework for Knowledge Capture and Retrieval in Construction Projects
Principal supervisor: Prof. Stephen Ogunlana
Secondary supervisor: Dr. Derek Thomson


2 A Framework for Knowledge Capture and Retrieval in Construction Projects
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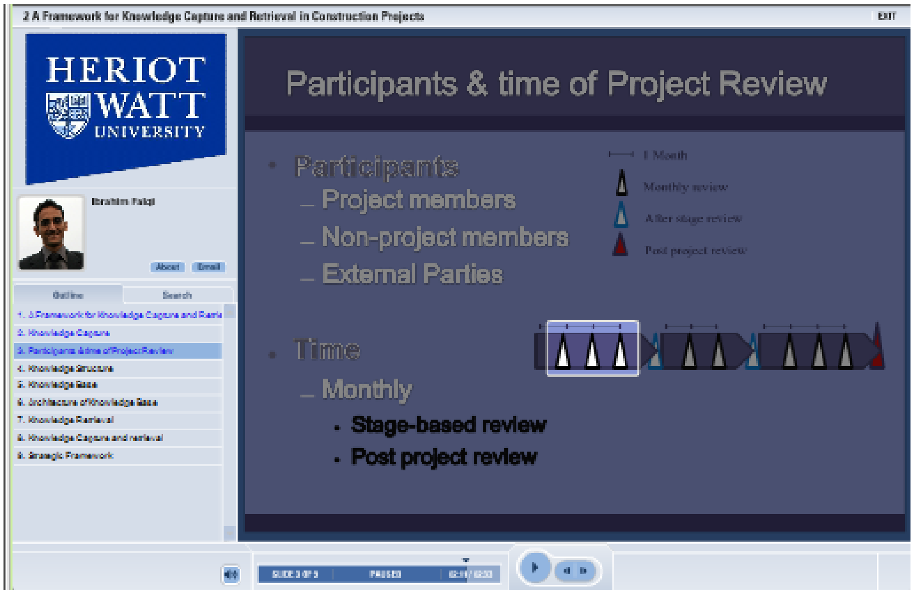
Ibrahim Falqi
Project Review
Checklist
Plan
Actual work is as or better
Good practice
Identify gap
Determine status
New learning
Codify
Actual work
Worse than planned
Mistakes
Performance tracking
Brainstorming


2 A Framework for Knowledge Capture and Retrieval in Construction Projects
EXIT
HERIOT WATT UNIVERSITY
Ibrahim Falqi
About
Email
Outline
Search
1. A Framework for Knowledge Capture and Retri
2. Knowledge Capture
3. Participants & time of Project Review
4. Knowledge Structure
5. Knowledge Base
6. Architecture of Knowledge Base
7. Knowledge Retrieval
8. Knowledge Capture and retrieval
9. Strategic Framework
Participants & time of Project Review
Participants
Project members
Non-project members
External Parties
1 Month
Monthly review
After stage review
Post project review
Time
Monthly
Stage-based review
Post project review
SLIDE 3 OF 9
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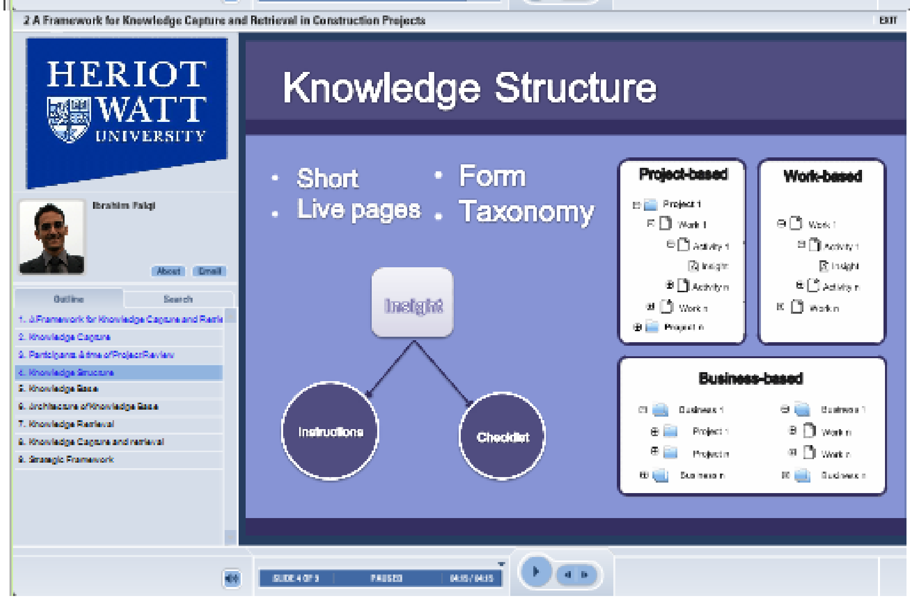
2 A Framework for Knowledge Capture and Retrieval in Construction Projects
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Ibrahim Falqi
About
Email
Outline
Search
1. A Framework for Knowledge Capture and Retri
2. Knowledge Capture
3. Participants & time of Project Review
4. Knowledge Structure
5. Knowledge Base
6. Architecture of Knowledge Base
7. Knowledge Retrieval
8. Knowledge Capture and retrieval
9. Strategic Framework
Knowledge Structure
Short
Live pages
Form
Taxonomy
Insight
Instructions
Checklist
Project-based
Work-based
Business-based
SLIDE 4 OF 9
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2 A Framework for Knowledge Capture and Retrieval in Construction Projects
EXIT
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Ibrahim Falqi
About
Email
Outline
Search
1. A Framework for Knowledge Capture and Retri
2. Knowledge Capture
3. Participants & time of Project Review
4. Knowledge Structure
5. Knowledge Base
6. Architecture of Knowledge Base
7. Knowledge Retrieval
8. Knowledge Capture and retrieval
9. Strategic Framework
Knowledge Base
Environment
Access
Component
Projects
Experts
Skill network
E-mail client
SLIDE 5 OF 9
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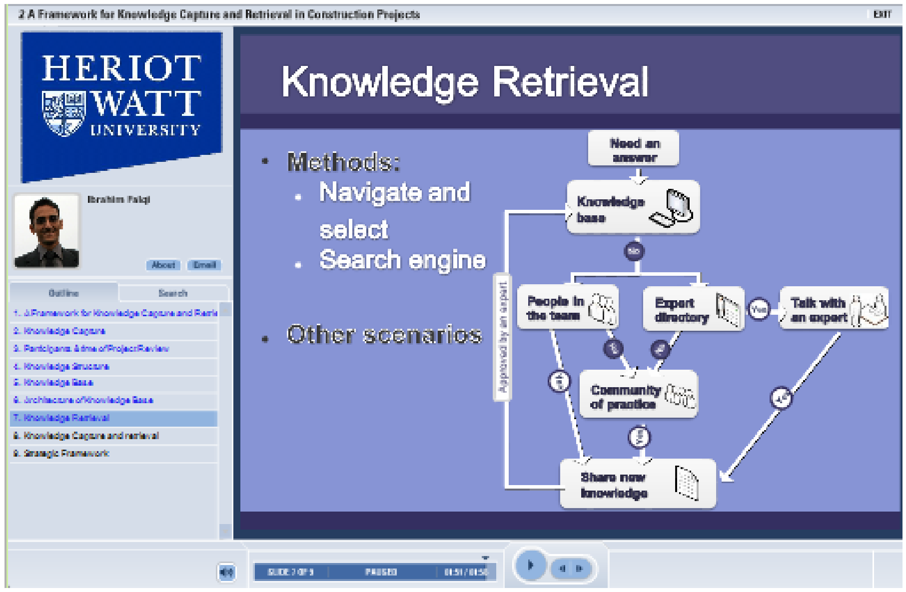
2 A Framework for Knowledge Capture and Retrieval in Construction Projects
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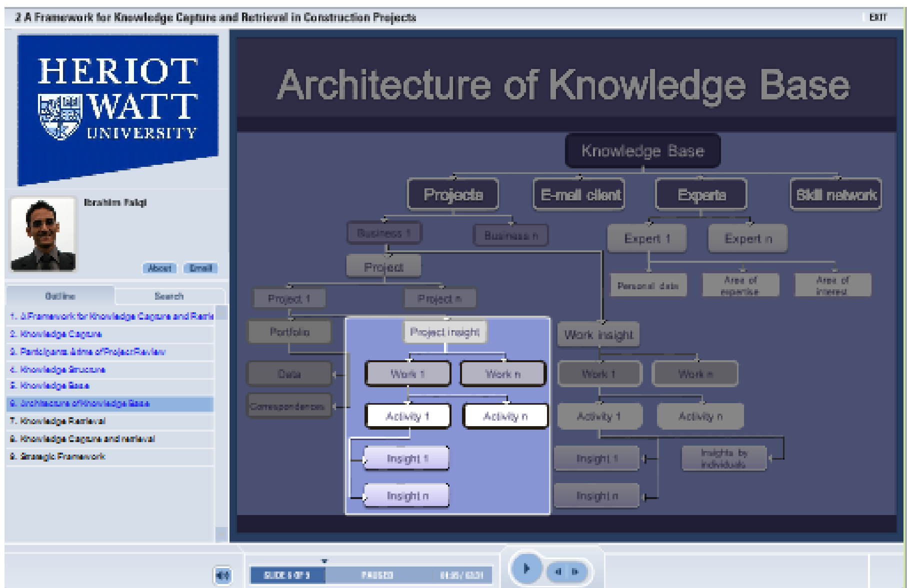
Knowledge Retrieval
Methods:
Navigate and select
Search engine
Other scenarios
Need an answer
Knowledge base
People in the team
Expert directory
Talk with an expert
Community of practice
Share new knowledge
Approved by an expert


2 A Framework for Knowledge Capture and Retrieval in Construction Projects
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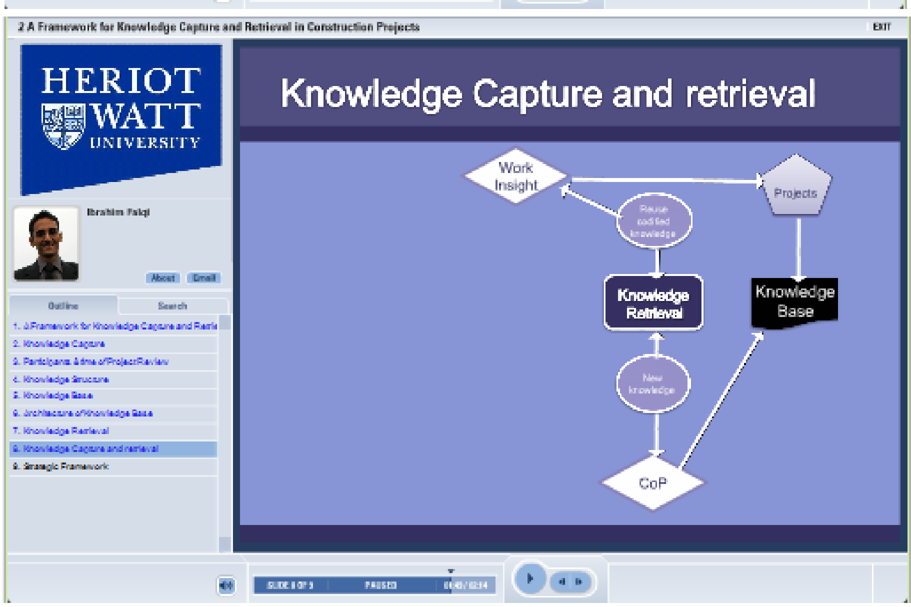
Architecture of Knowledge Base
Knowledge Base
Projects
E-mail client
Experts
Skill network
Business 1
Business n
Expert 1
Expert n
Project
Personal data
Project 1
Project n
Portfolio
Project insight
Work insight
Data
Work 1
Work n
Correspondences
Activity 1
Activity n
Insight 1
Insight n
Insights by individuals


2 A Framework for Knowledge Capture and Retrieval in Construction Projects
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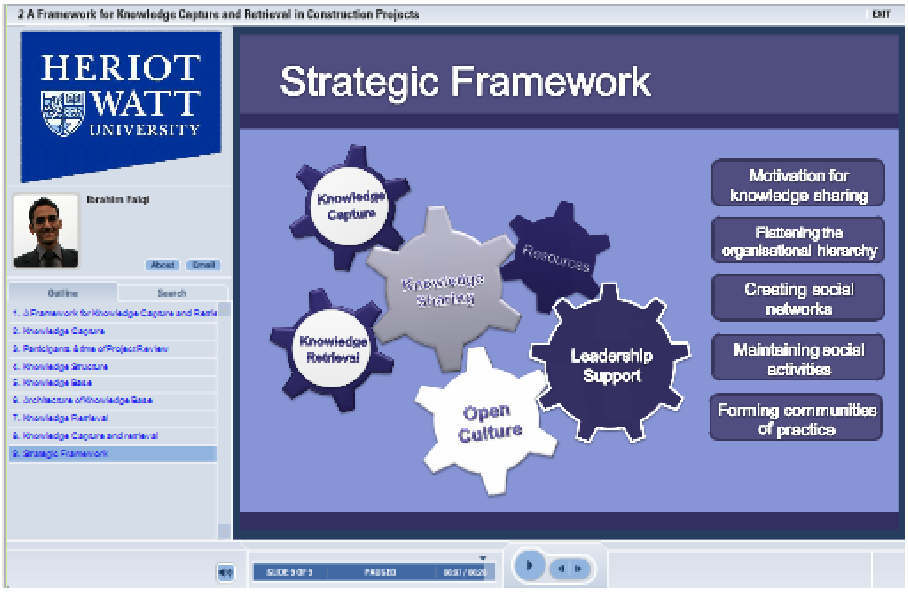
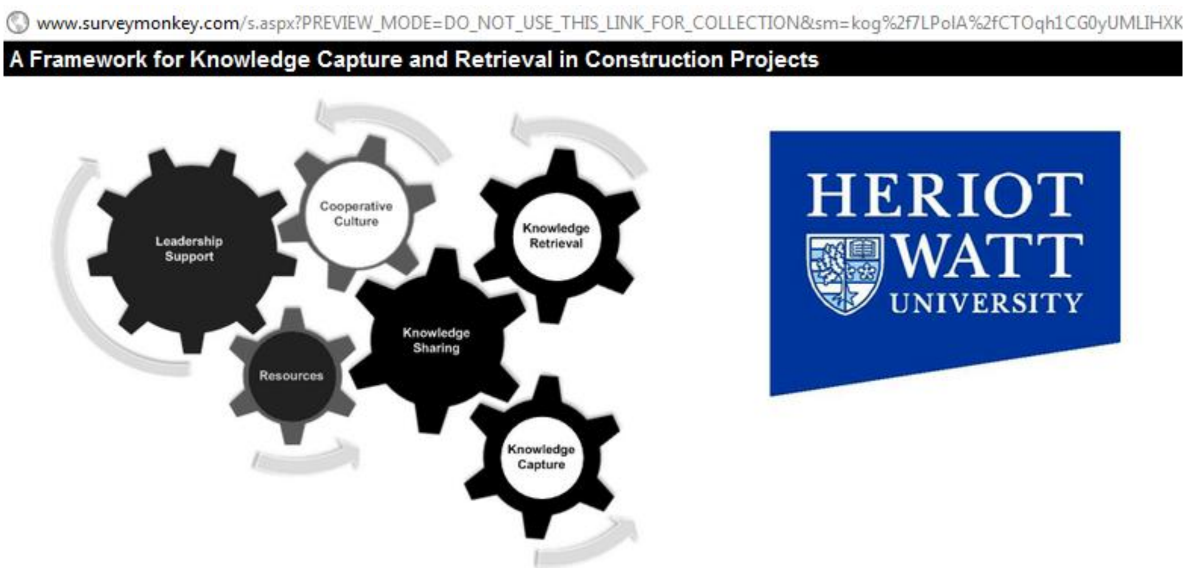
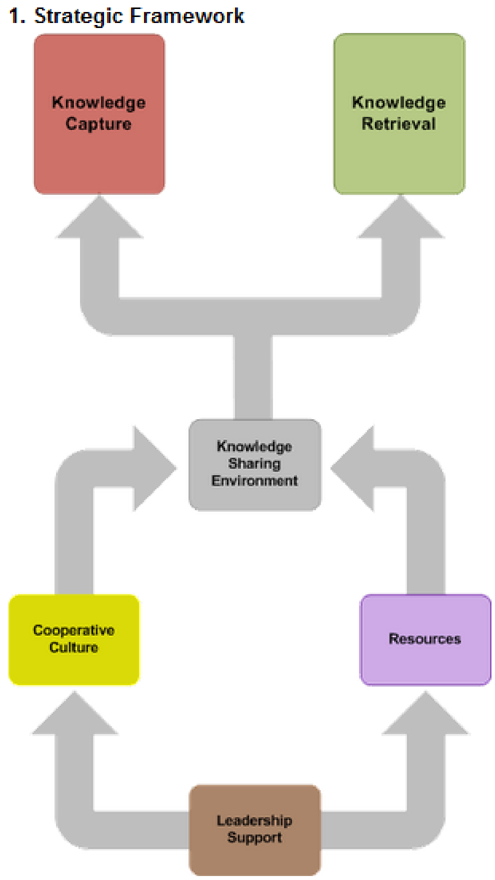
HERIOT WATT UNIVERSITY
Ibrahim Falqi
Knowledge Capture and retrieval
Work Insight
Projects
Knowledge Retrieval
Knowledge Base
CoP



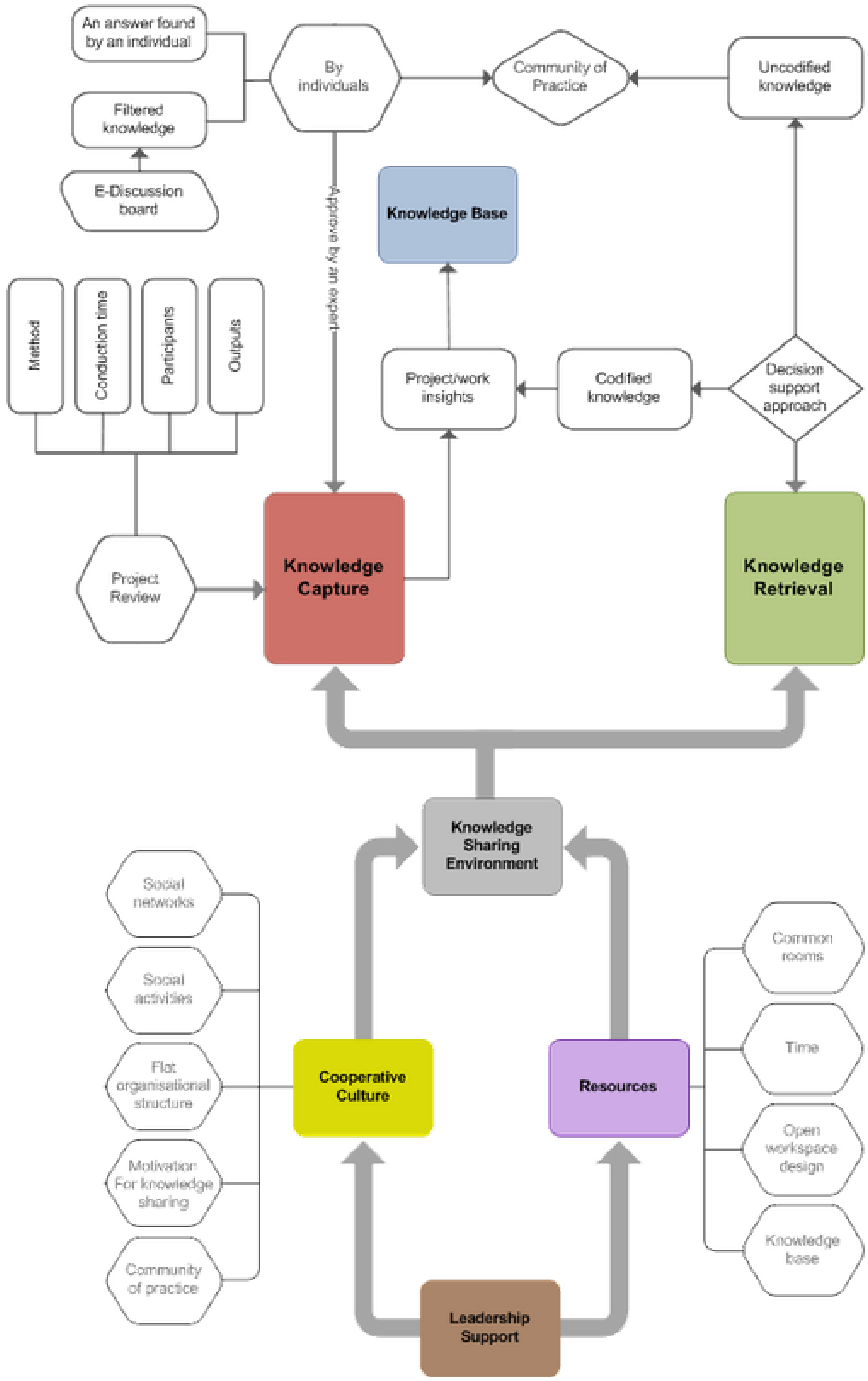


Conceptual Framework for Knowledge Capture and Retrieval in Construction Projects

The aim of developing this framework is to minimise the loss of knowledge in construction projects, and to effectively retrieve the codified knowledge. Knowledge here is related to the project management processes of pre-construction and construction phases. The conceptual framework is presented below in three levels, strategic, tactical and operational. It is important to view these levels in the order in which they are presented. The diagrams may provide adequate information about the framework and may be sufficient for the evaluation purpose. However, **if you require a more detailed description, please refer to the presentation at:** km-framework.co.uk

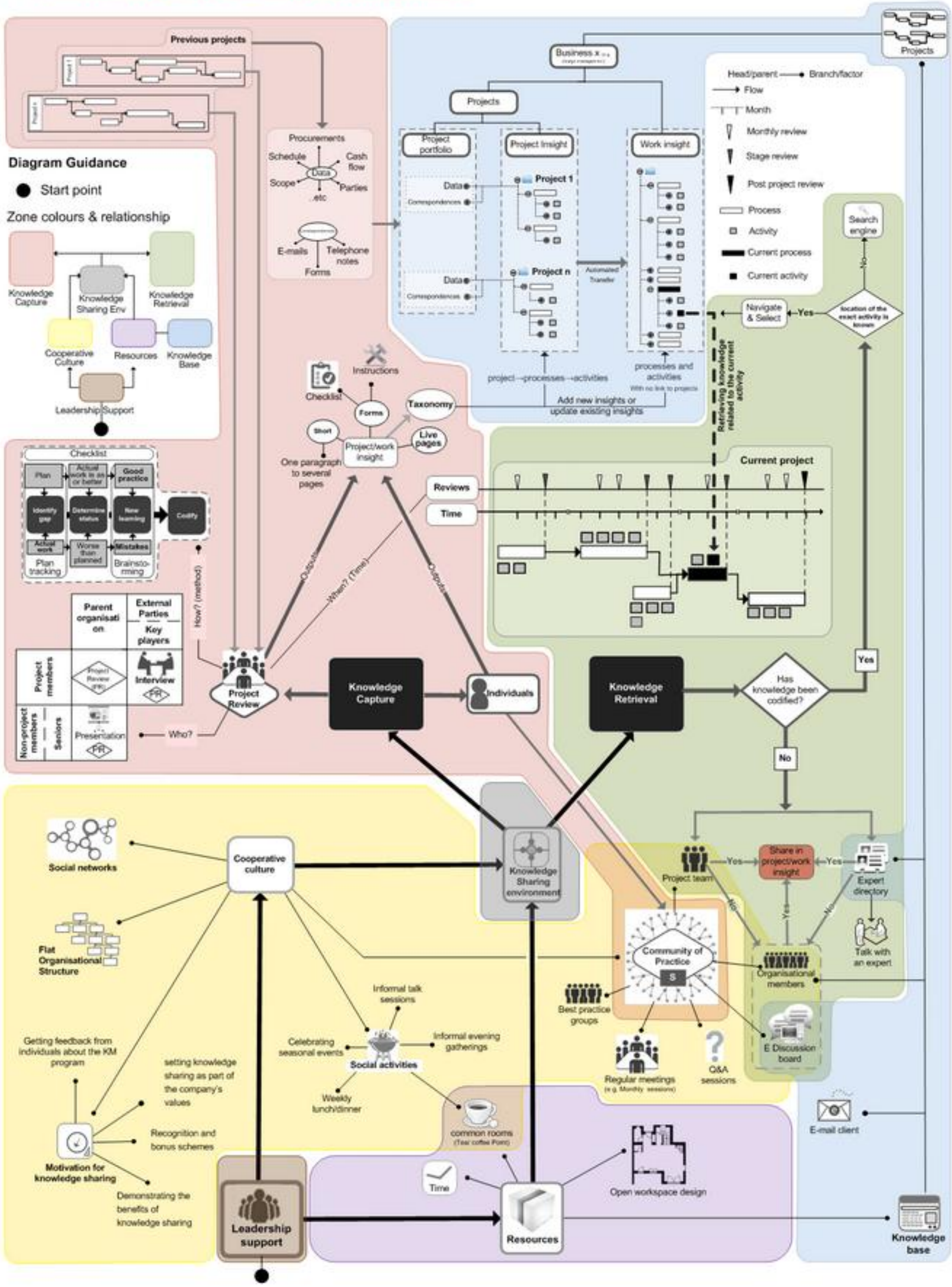

1. Strategic Framework
Knowledge Capture
Knowledge Retrieval
Knowledge Sharing Environment
Cooperative Culture
Resources
Leadership Support

2. Tactical Framework



3. Operational Framework

Note: Please refer to the 'Diagram Guidance' at the top left-hand corner.



Please respond to the following questions by either ticking the appropriate box or typing your answer.

*1. Your name:

*2. Job title:

*3. Years of experience:

4. Name of your organisation:

*5. Business of your organisation:

- Contractor
- Consultancy
- Educational Institution
- Other (please specify)

*6. Size of your organisation:

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

- Yes
- No

*8. Please indicate your rate of applicability for the following approaches. Where 1= Inapplicable and 5= Applicable.

	1	2	3	4	5	Unsure
Knowledge Capture Approach						
Knowledge Retrieval Approach						
Knowledge Structure						
Architecture of Knowledge Base						

*9. Please indicate your rate of effectiveness for the following approaches. Where 1= Ineffective and 5= Effective.

	1	2	3	4	5	Unsure
Knowledge Capture Approach						
Knowledge Retrieval Approach						
Knowledge Structure						
Architecture of Knowledge Base						

*10. Please indicate your rate of applicability and efficiency for the entire Framework. Where 1= Inapplicable/Inefficient and 5= Applicable/Efficient

	1	2	3	4	5	Unsure
Applicability						
Efficiency						

11. Could you please express your opinion on the Framework in terms of effectiveness, applicability, advantages and shortcomings?

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

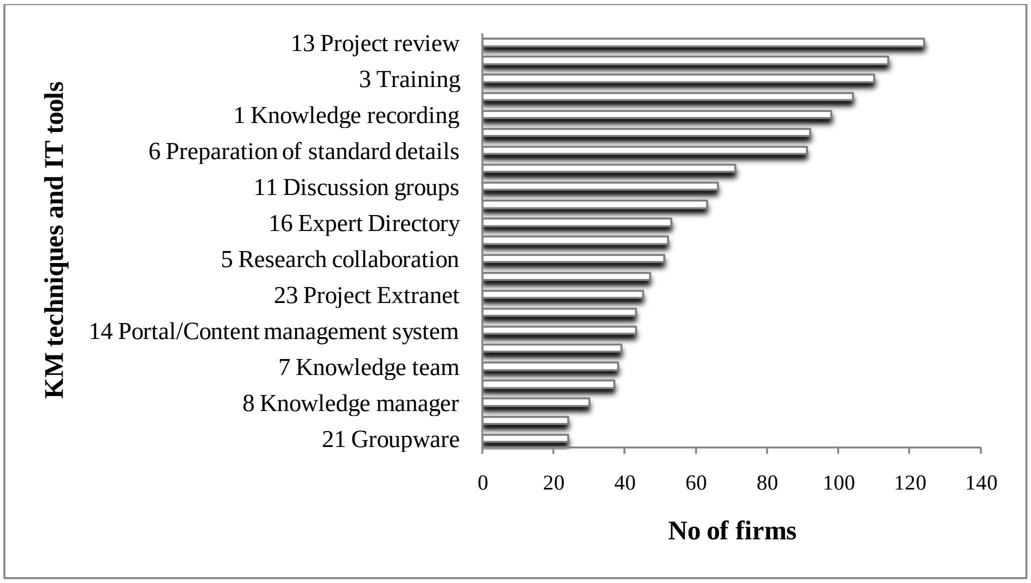
13. Would you like to receive a report of the research result by e-mail, once it is completed?

- Yes
- No

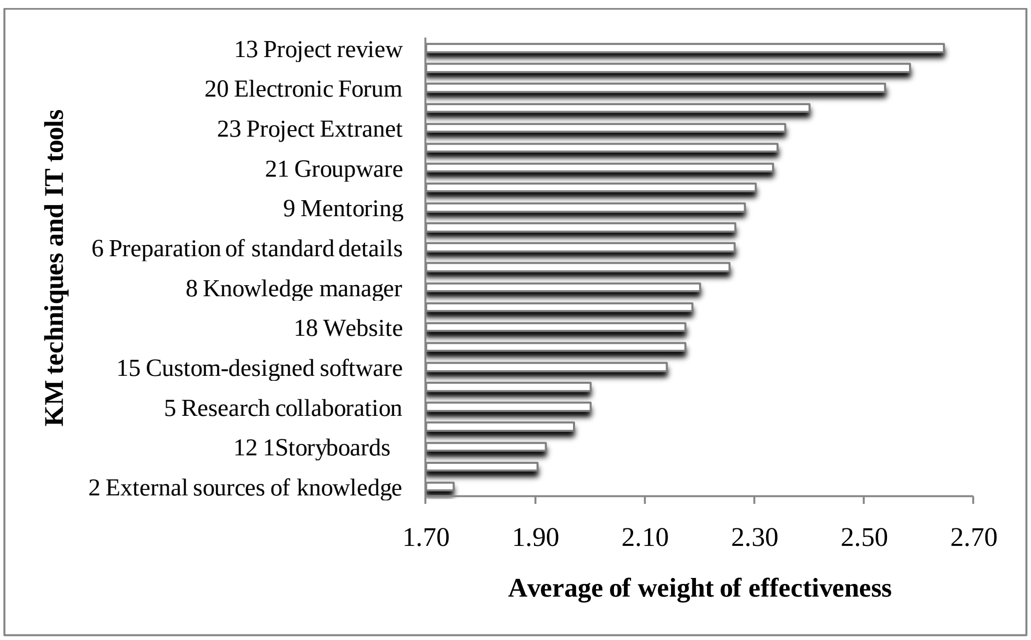
Done >>

Appendix 4: Survey Analysis

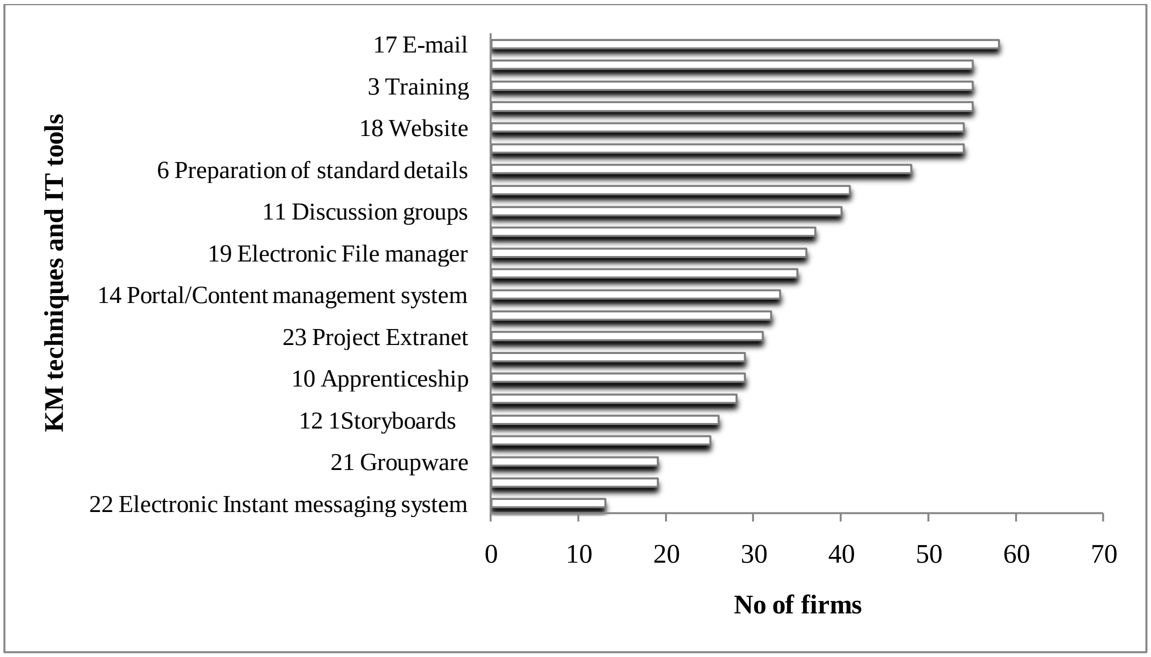
KM techniques and IT tools



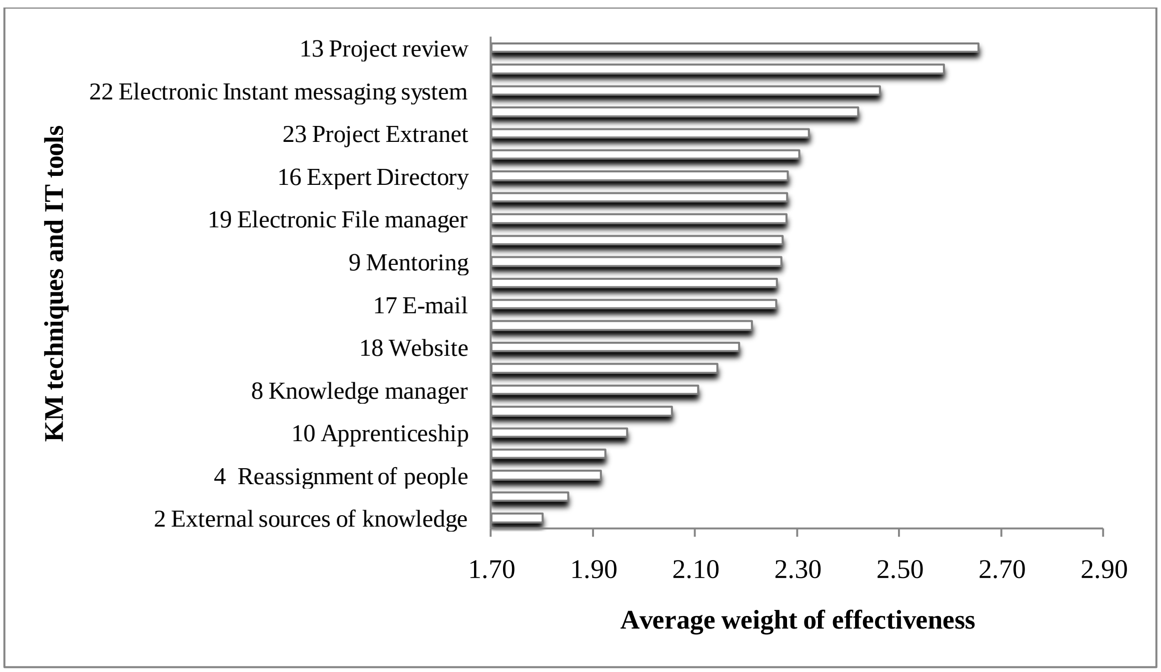
Popularity of KM techniques and IT tools - All participated companies



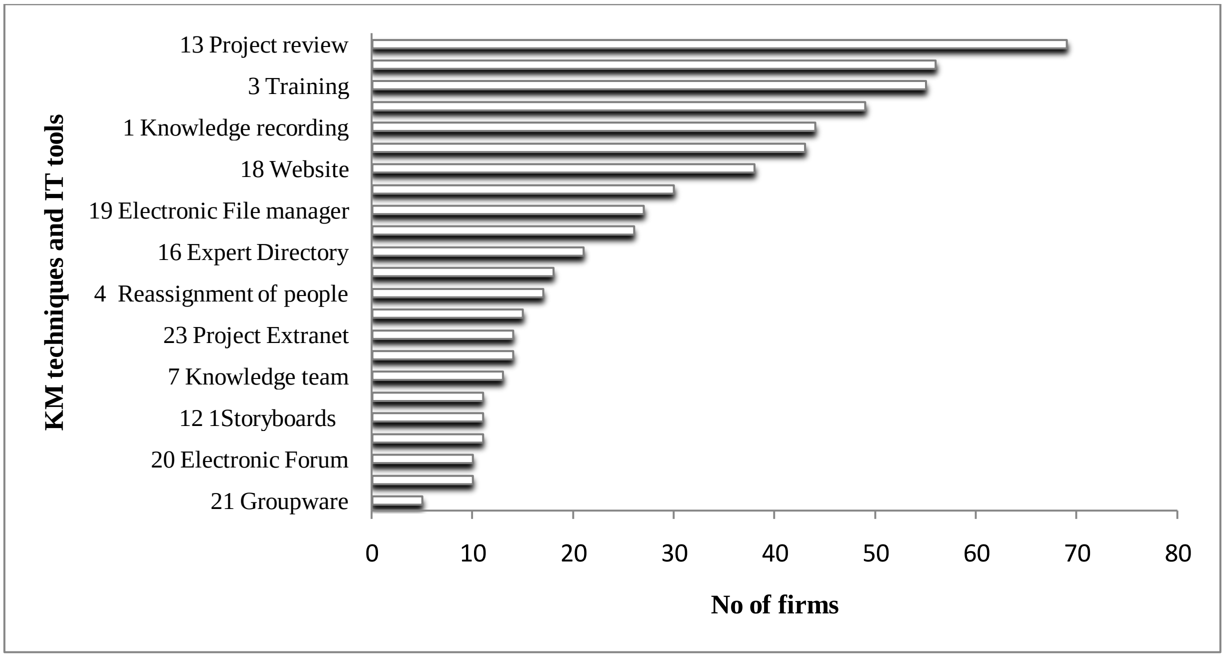
Effectiveness of KM techniques and IT tools – All participated companies



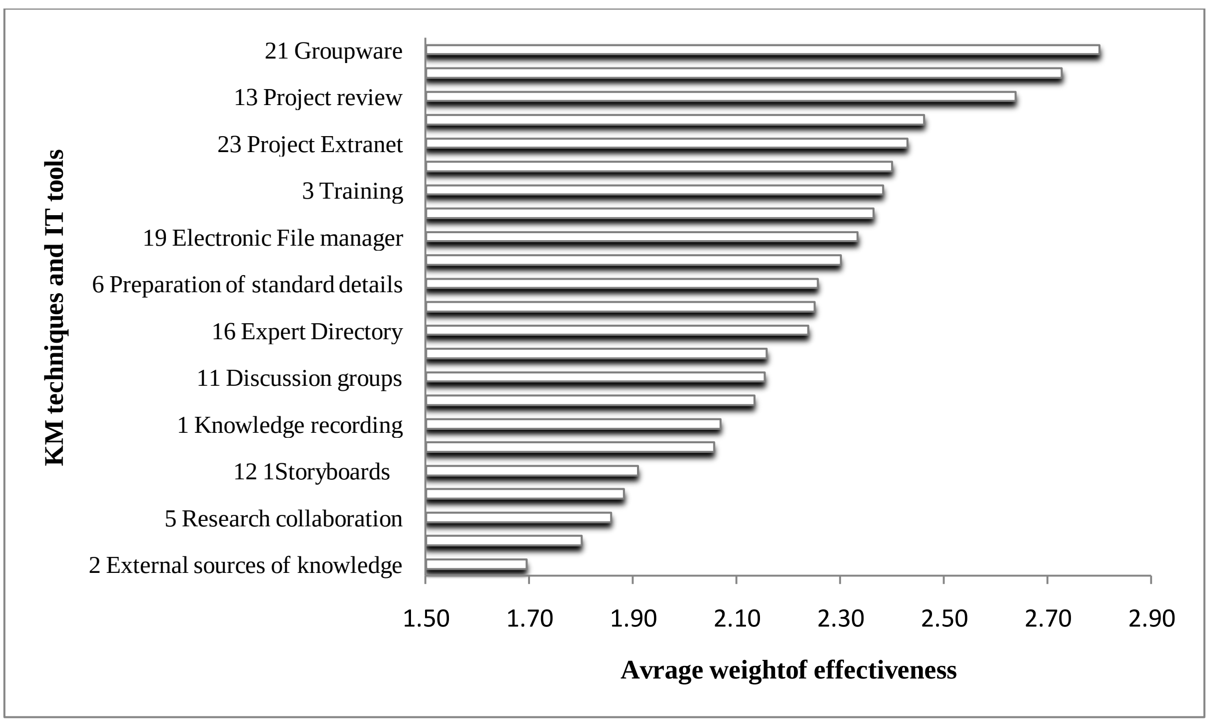
Popularity of KM techniques and IT tool in top companies



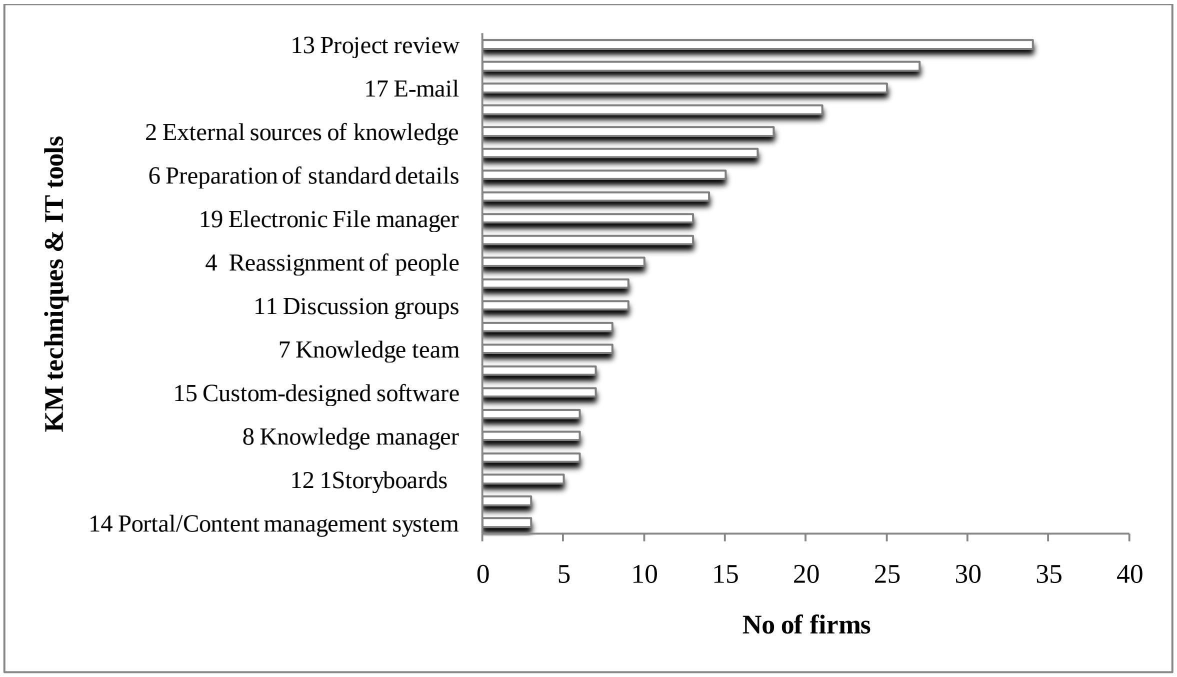
Effectiveness of KM techniques and IT tools in top companies



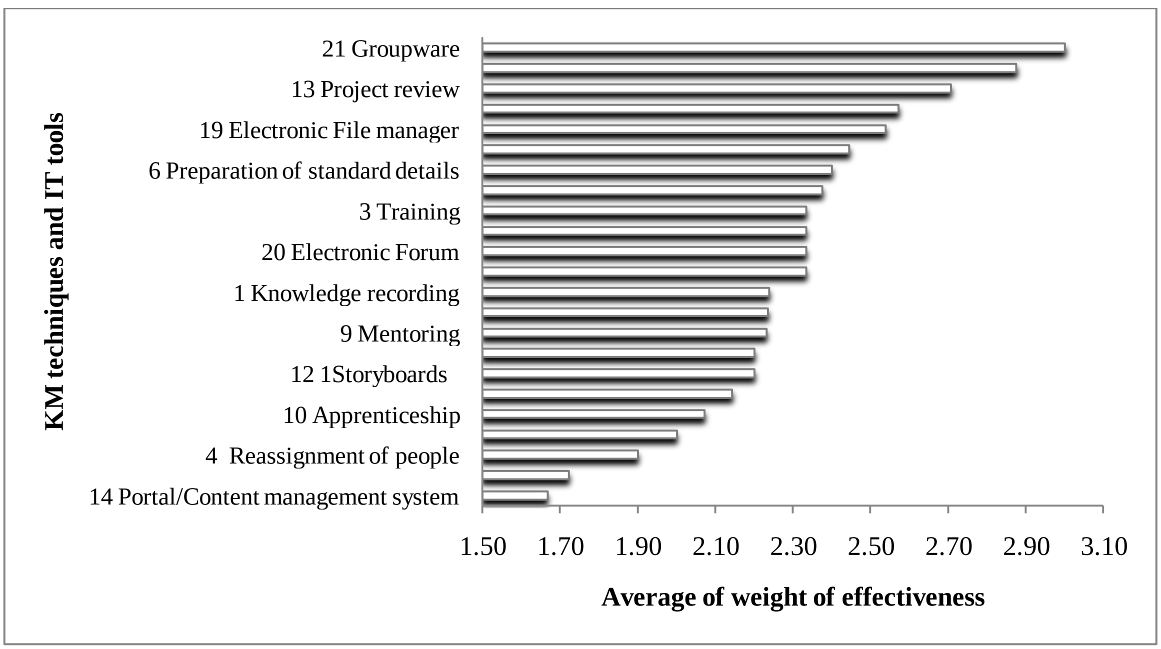
Popularity of KM techniques and IT tools in industry companies



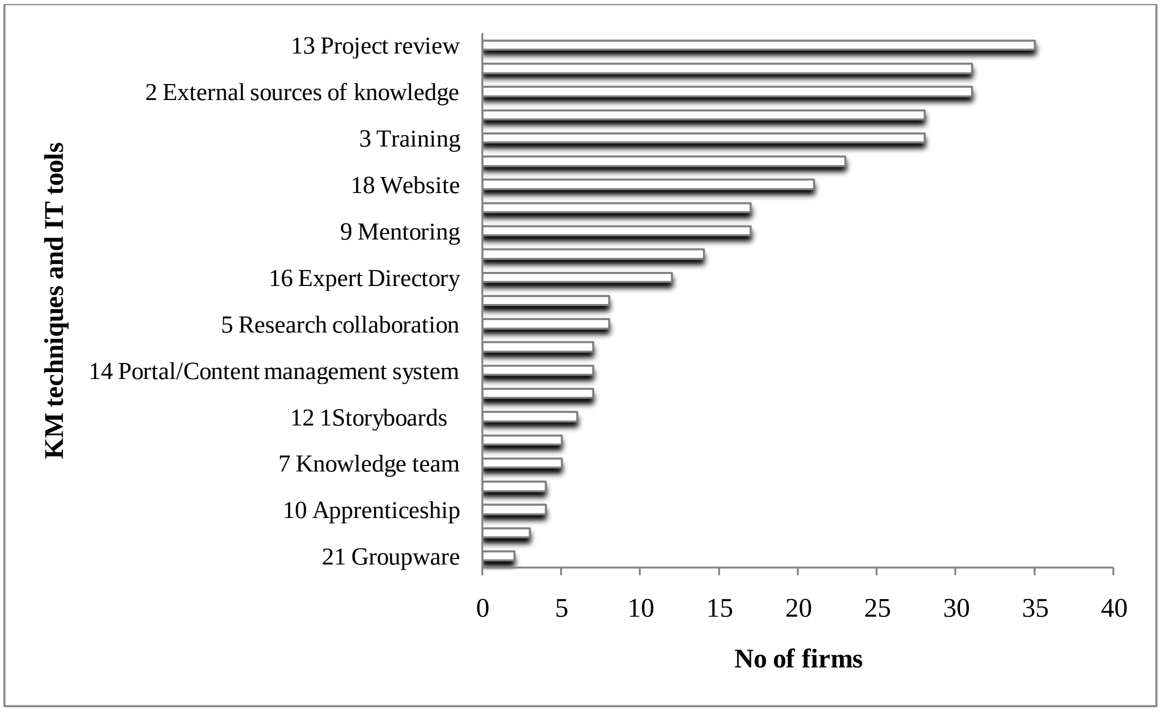
Effectiveness of KM techniques and IT tools in industry companies



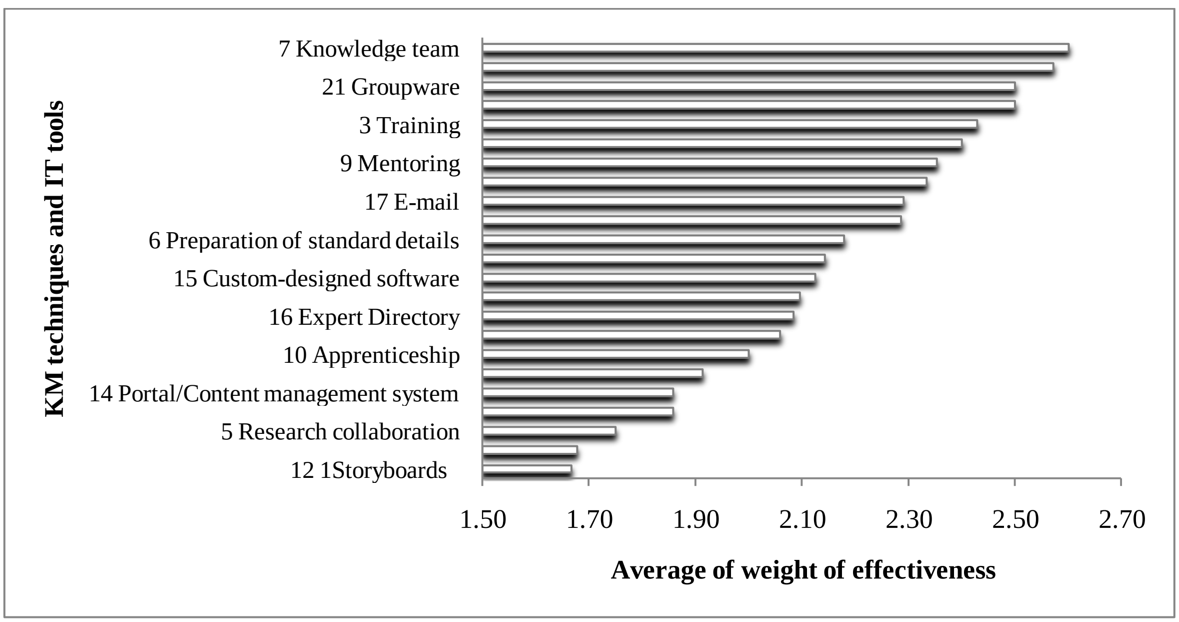
Popularity of KM techniques and IT tools in industry contractors



Effectiveness of KM techniques and IT tools in industry contractors

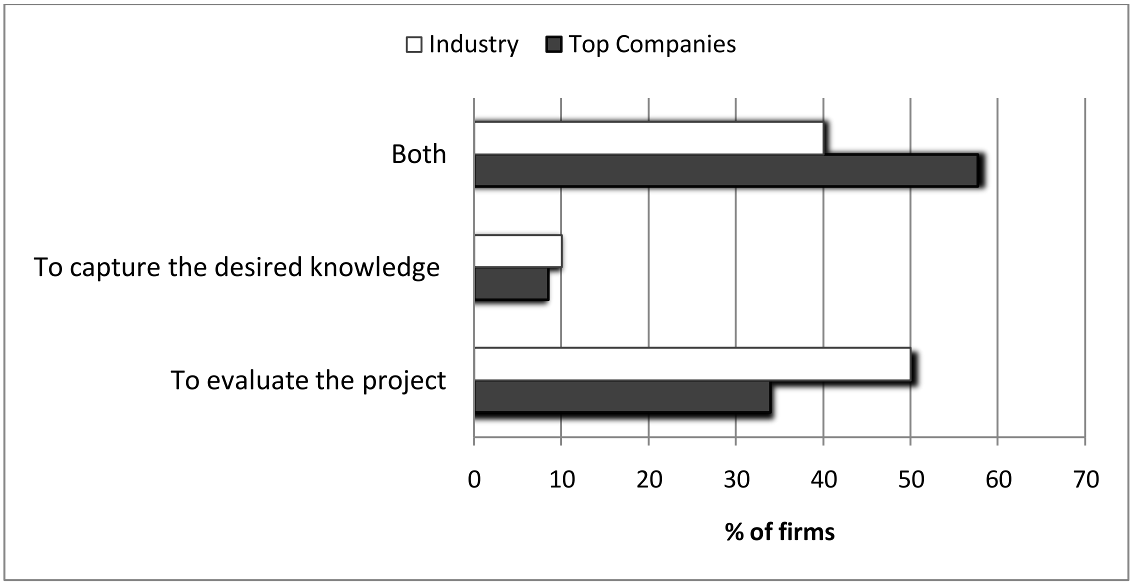


Popularity of KM techniques and IT tools in industry consultants



Effectiveness of KM techniques and IT tools in industry consultants

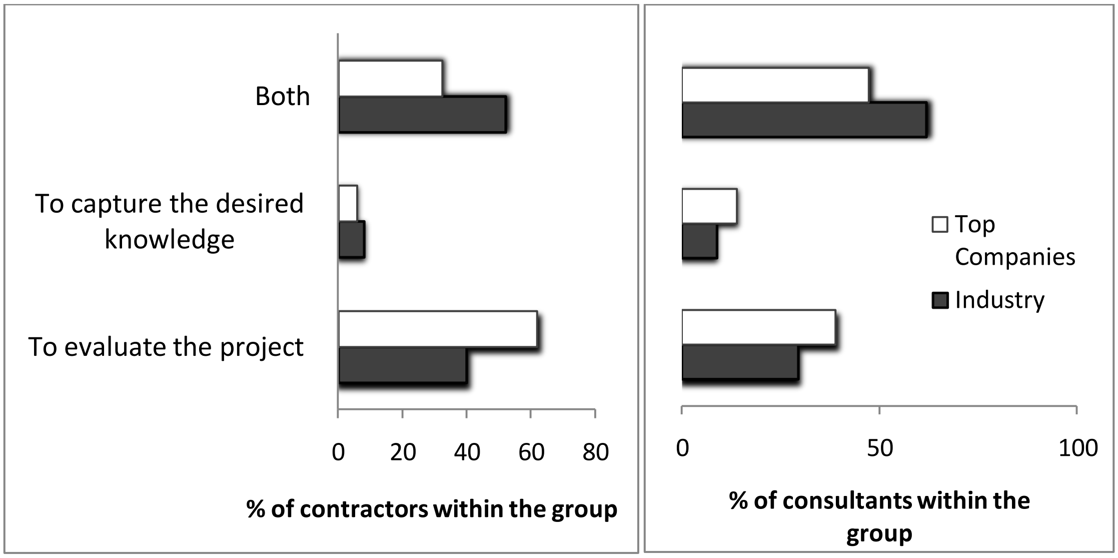
Purpose of conducting project review



Purpose of PR: a comparison between industry companies and top companies - percentages

Purpose of PR - business groups

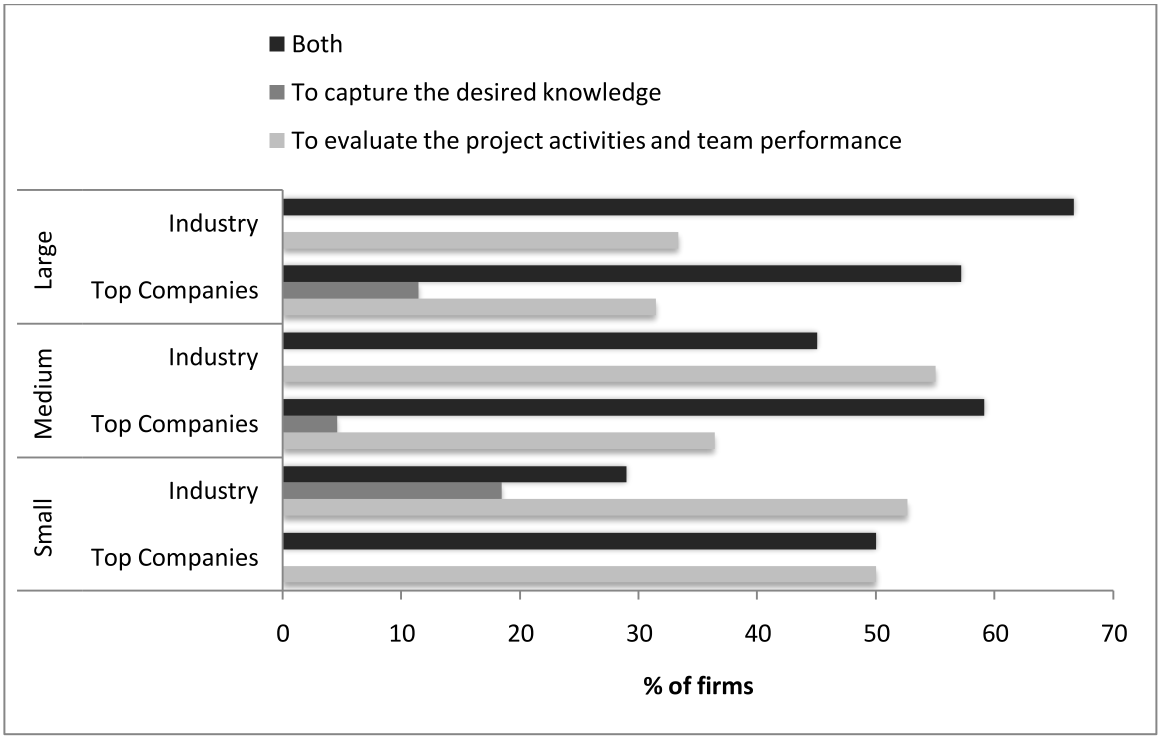
		Business					
		Contractor			Consultant		
		Group		Total	Group		Total
		Top Companies	Industry		Top Companies	Industry	
To evaluate the project activities and team performance	Count	10	21	31	10	14	24
	% within Group	40.0%	61.8%	52.5%	29.4%	38.9%	34.3%
To capture the desired knowledge and use it in the future stages/projects	Count	2	2	4	3	5	8
	% within Group	8.0%	5.9%	6.8%	8.8%	13.9%	11.4%
Both	Count	13	11	24	21	17	38
	% within Group	52.0%	32.4%	40.7%	61.8%	47.2%	54.3%
Total	Count	25	34	59	34	36	70
	% within Group	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%



Purpose of PR by business groups

Purpose of PR by size of companies

		Size of organisation								
		Small			Medium			Large		
		Group		Total	Group		Total	Group		Total
		Top Companies	Industry		Top Companies	Industry		Top Companies	Industry	
To evaluate the project activities and team performance	Count	1	20	21	8	11	19	11	4	15
	% within Group	50.0	52.6	52.5	36.4	55.0	45.2	31.4	33.3	31.9
To capture the desired knowledge and use it in the future stages/projects	Count	0	7	7	1	0	1	4	0	4
	% within Group	0	18.4	17.5	4.5	0	2.4	11.4	.0	8.5
Both	Count	1	11	12	13	9	22	20	8	28
	% within Group	50.0	28.9	30.0	59.1	45.0	52.4	57.1	66.7	59.6
Total	Count	2	38	40	22	20	42	35	12	47
	% within Group	100	100	100	100	100	100	100	100	100

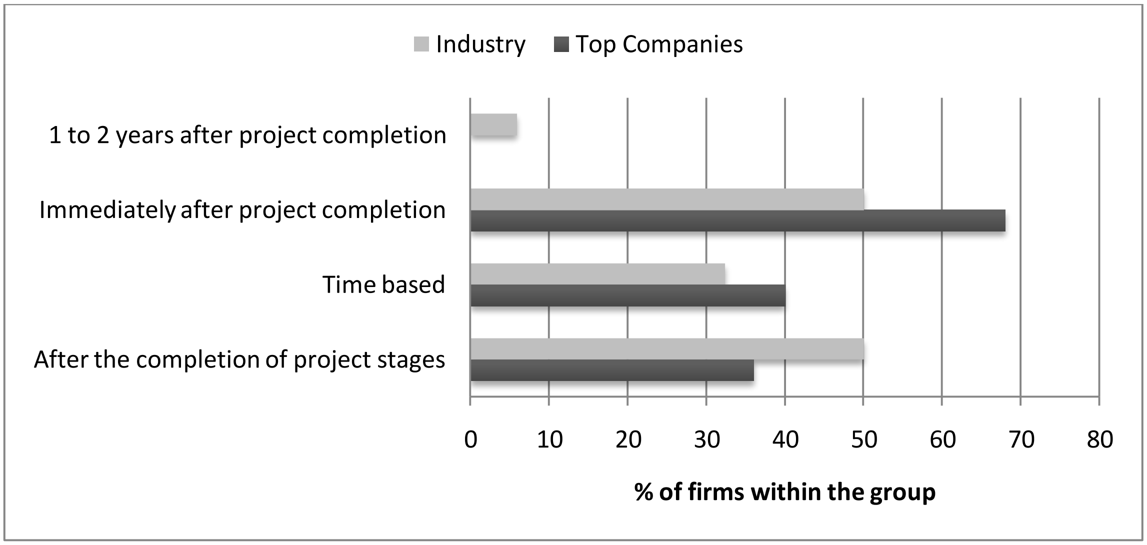


Purpose of PR by size of companies

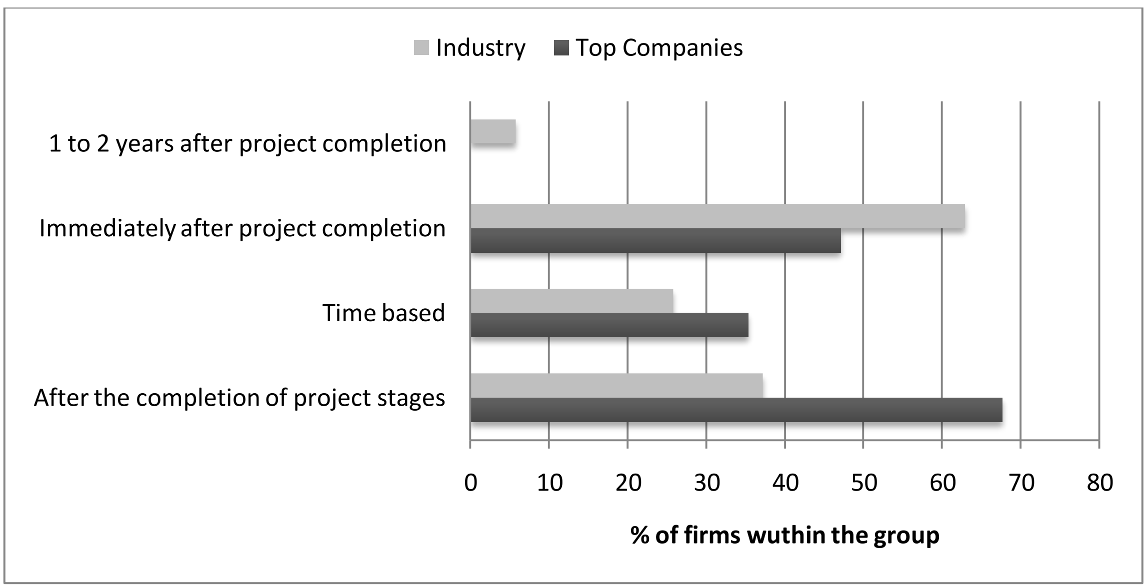
Timing Approaches of PR

Timing approaches of PR within contractors and consultants groups

Valid 128		Contractor			Consultant		
Missing 11							
Conduction time of project review		Top Companies	Industry	Total	Top Companies	Industry	Total
After the completion of project stages	Count	9	17	26	23	13	36
	% within Group	36.0%	50.0%		67.6%	37.1%	
Time based (e.g. weekly, monthly)	Count	10	11	21	12	9	21
	% within Group	40.0%	32.4%		35.3%	25.7%	
Immediately after project completion	Count	17	17	34	16	22	38
	% within Group	68.0%	50.0%		47.1%	62.9%	
1 to 2 years after project completion	Count	0	2	2	0	2	2
	% within Group	.0%	5.9%		.0%	5.7%	
Total	Count	25	34	59	34	35	69



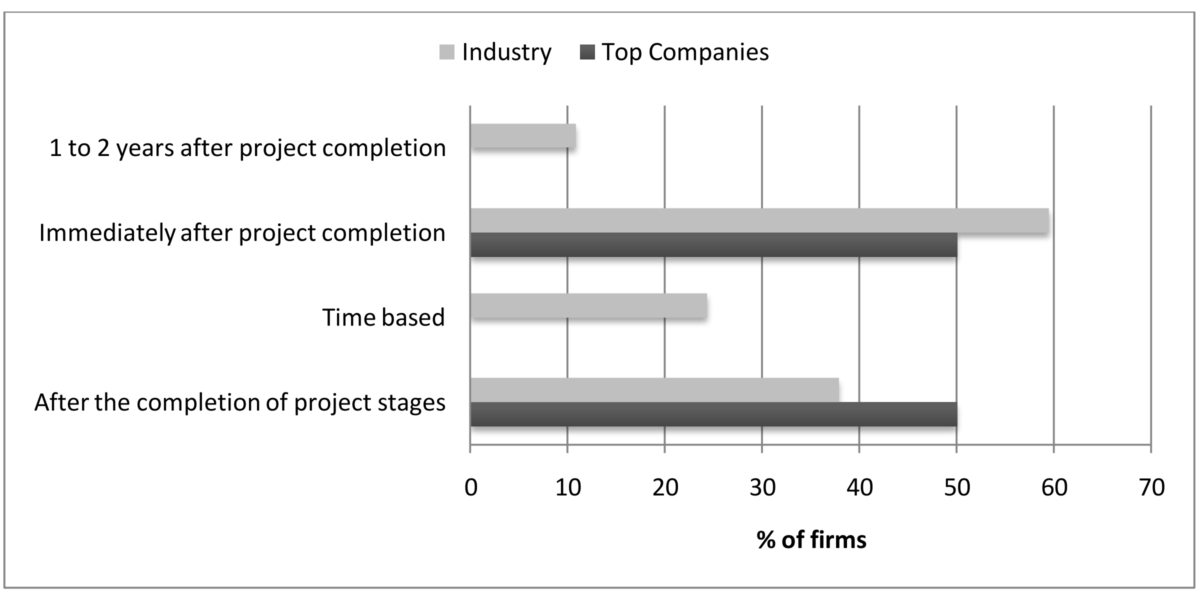
Timing approaches of PR within contractors group



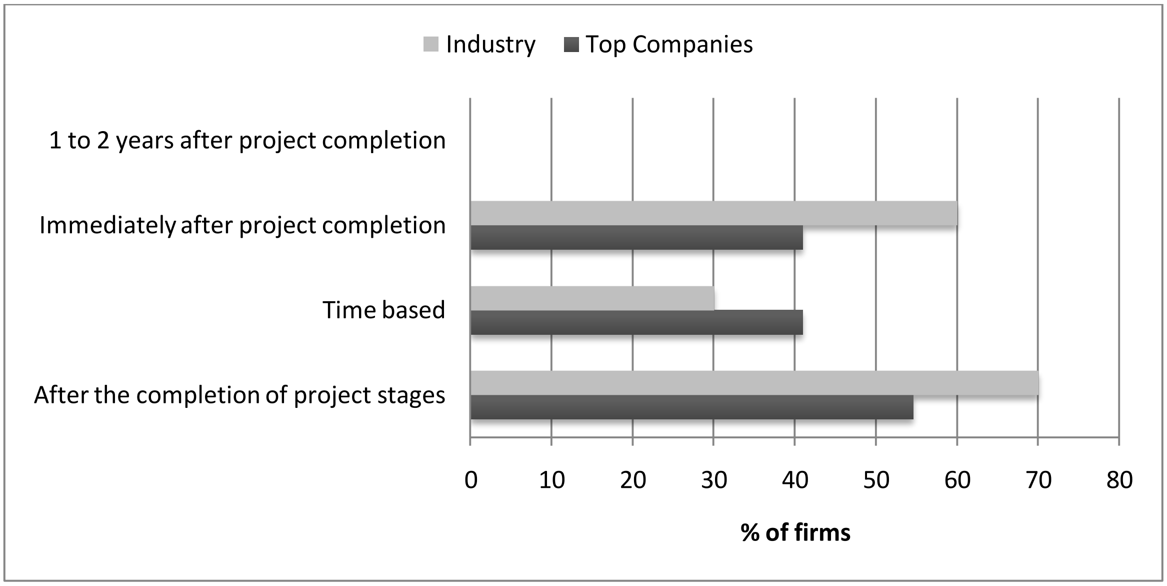
Timing approaches of PR within consultants group

Timing approaches of PR within organisation size group

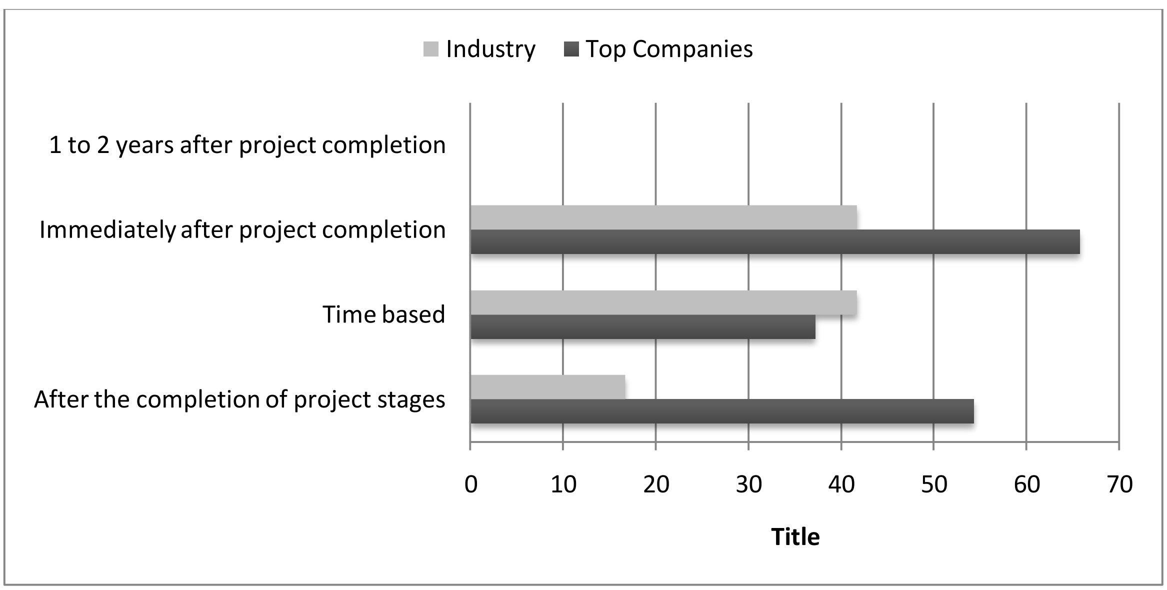
			Size of organisation								
Valid	128			Small			Medium			Large	
Missing	11			Group		Total	Group		Total	Group		Total
Conduction time of project review				Top Companies	Industry		Top Companies	Industry		Top Companies	Industry	
After the completion of project stages			Count	1	14	15	12	14	26	19	2	21
			% within Group	50	37.8		54.5	70.		54.3	16.7	
Time based			Count	0	9	9	9	6	15	13	5	18
			% within Group	0	24.3		40.9	30		37.1	41.7	
Immediately after project completion			Count	1	22	23	9	12	21	23	5	28
			% within Group	50	59.5		40.9	60		65.7	41.7	
1 to 2 years after project completion			Count	0	4	4						
			% within Group	0	10.8							
Total			Count	2	37	39	22	20	42	35	12	47



Timing approaches of PR in small sized companies



Timing approaches of PR in medium sized companies

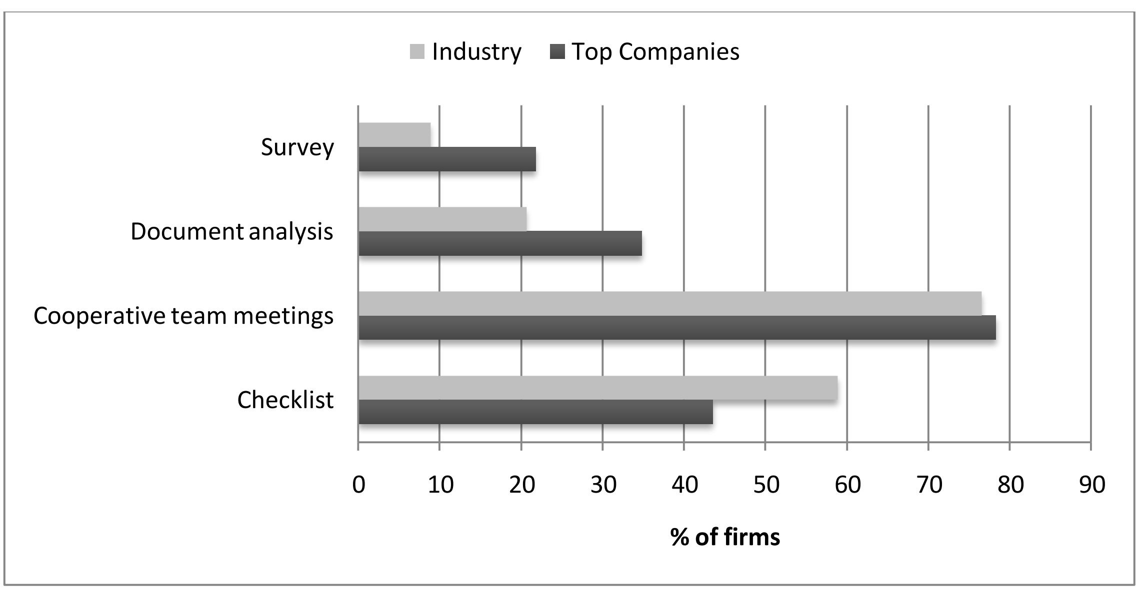


Timing approaches of PR in large sized companies

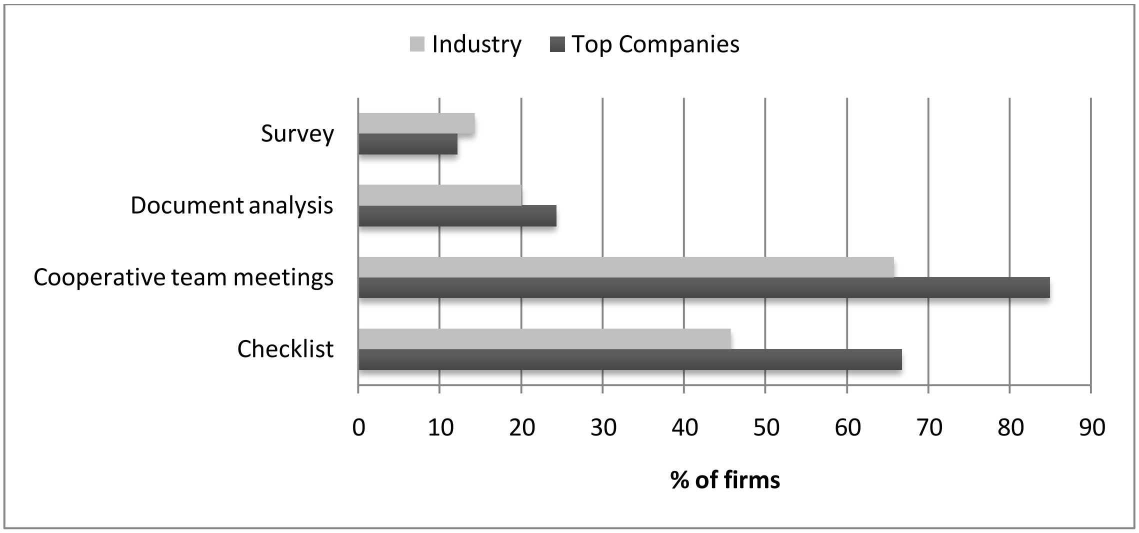
Methods of Project Review

PR methods in the contractors and consultants groups

Valid	125		Contractor			Consultant		
Missing	14		Group		Total	Group		Total
Project review method			Top Companies	Industry		Top Companies	Industry	
Checklist		Count	10	20	30	22	16	38
		% within Group	43.5%	58.8%		66.7%	45.7%	
Cooperative team meetings		Count	18	26	44	28	23	51
		% within Group	78.3%	76.5%		84.8%	65.7%	
Document analysis		Count	8	7	15	8	7	15
		% within Group	34.8%	20.6%		24.2%	20.0%	
Survey		Count	5	3	8	4	5	9
		% within Group	21.7%	8.8%		12.1%	14.3%	
Total		Count	23	34	57	33	35	68



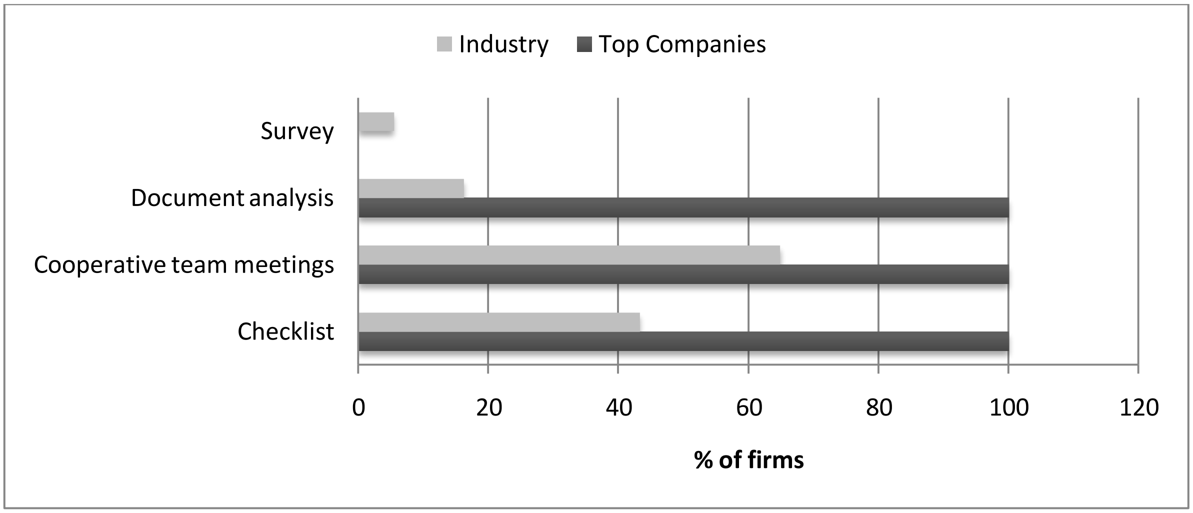
PR methods in the contractor groups



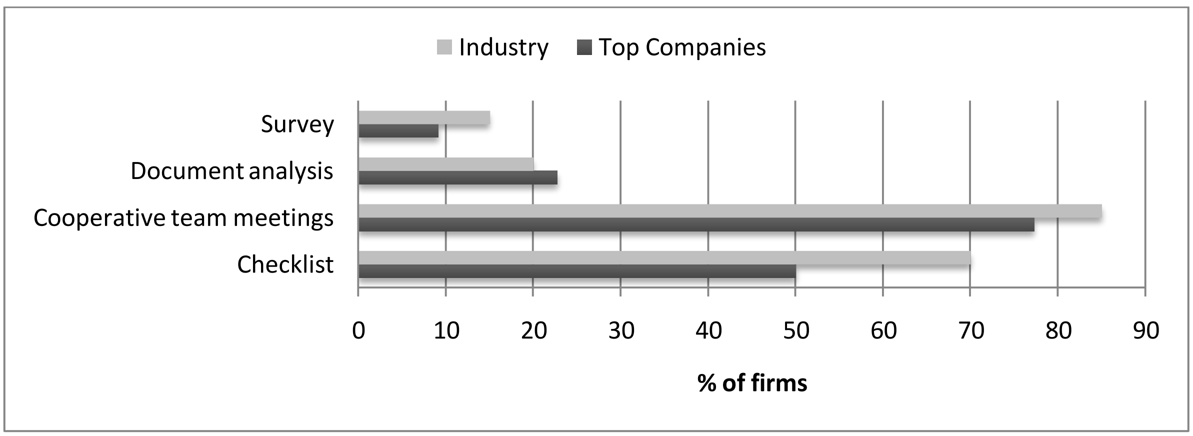
PR methods in the consultants groups

PR methods with the large, medium, and small sized organisation groups

				Size of organisation								
Valid	125			Small			Medium			Large		
Missing	14			Group		Total	Group		Total	Group		Total
Project review method				Top Companies	Industry		Top Companies	Industry		Top Companies	Industry	
Checklist			Count	1	16	17	11	14	25	20	6	26
			% within Group	100	43.2		50	70		60.6	50	
Cooperative team meetings			Count	1	24	25	17	17	34	28	8	36
			% within Group	100	64.9		77.3	85		84.8	66.7	
Document analysis			Count	1	6	7	5	4	9	10	4	14
			% within Group	100	16.2		22.7	20		30.3	33.3	
Survey			Count	0	2	2	2	3	5	7	3	10
			% within Group	0	5.4		9.1	15		21.2	25	
Total			Count	1	37	38	22	20	42	33	12	45



PR methods in the small sized organizations



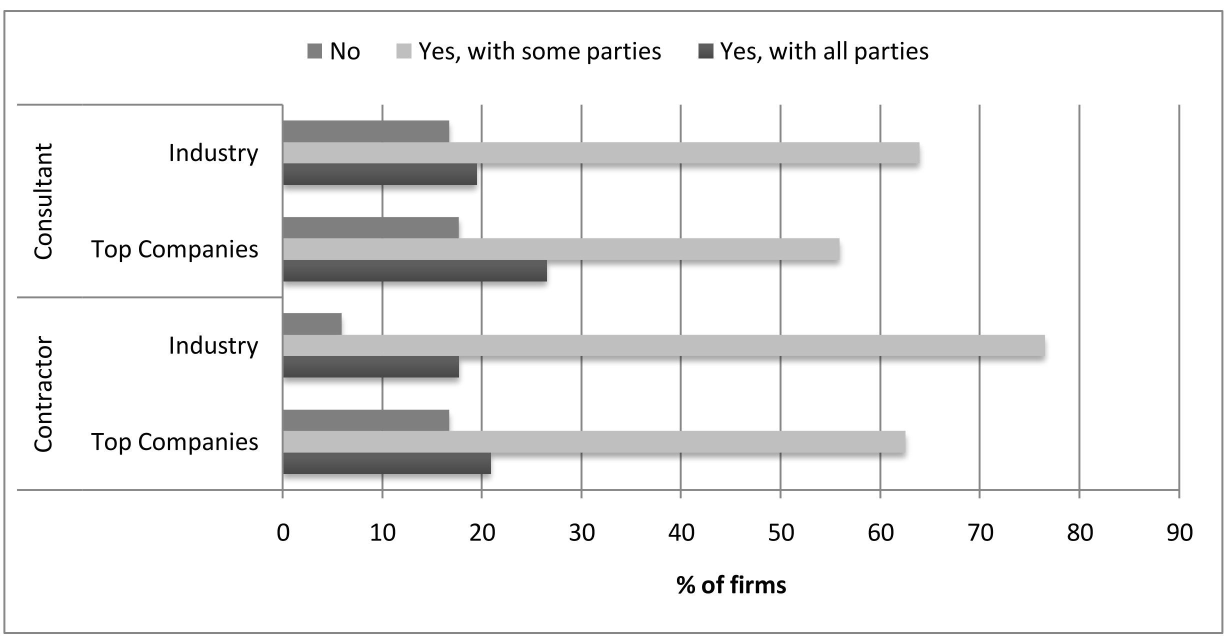
PR methods in the medium sized organizations

PR methods in the large sized organisations

Coordination with project parties

PR and coordination with project parties: contractors and consultants groups

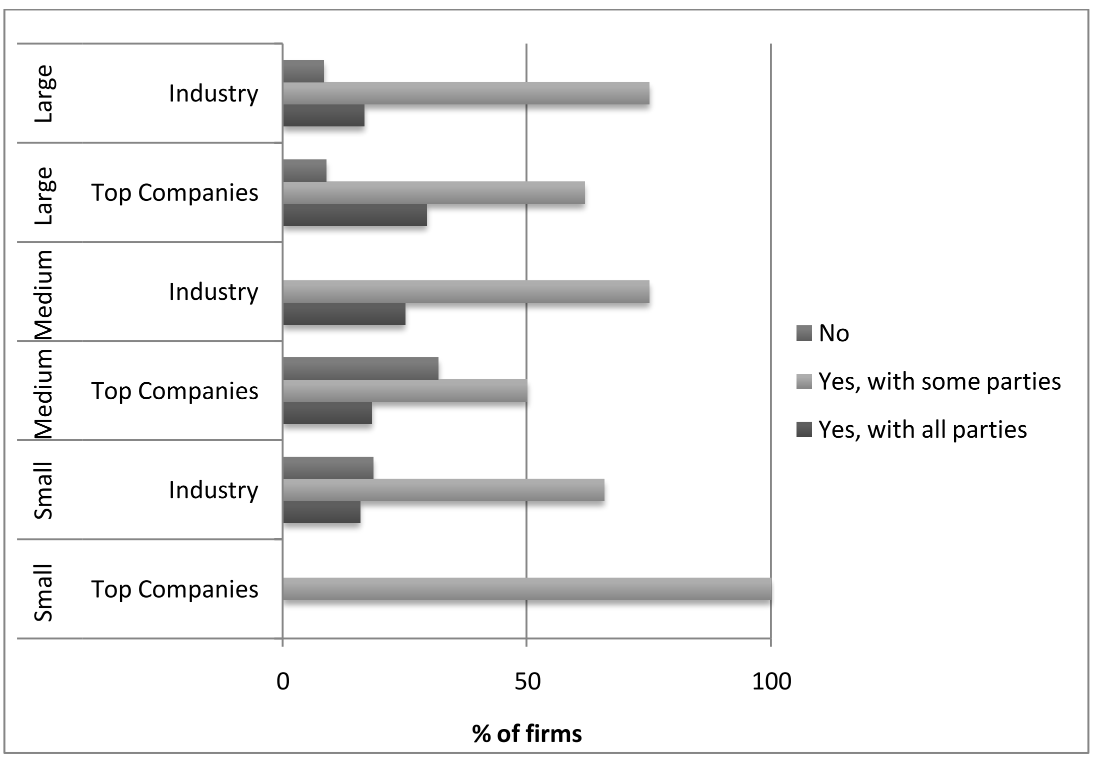
Valid	128			Contractor			Consultant		
Missing	11			Group		Total	Group		Total
				Top Companies	Industry		Top Companies	Industry	
Coordination with project parties	Yes, with all parties		Count	5	6	11	9	7	16
			% within Group	20.8%	17.6%	19.0%	26.5%	19.4%	22.9%
	Yes, with some parties		Count	15	26	41	19	23	42
			% within Group	62.5%	76.5%	70.7%	55.9%	63.9%	60.0%
	No		Count	4	2	6	6	6	12
			% within Group	16.7%	5.9%	10.3%	17.6%	16.7%	17.1%
Total			Count	24	34	58	34	36	70
			% within Group	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%



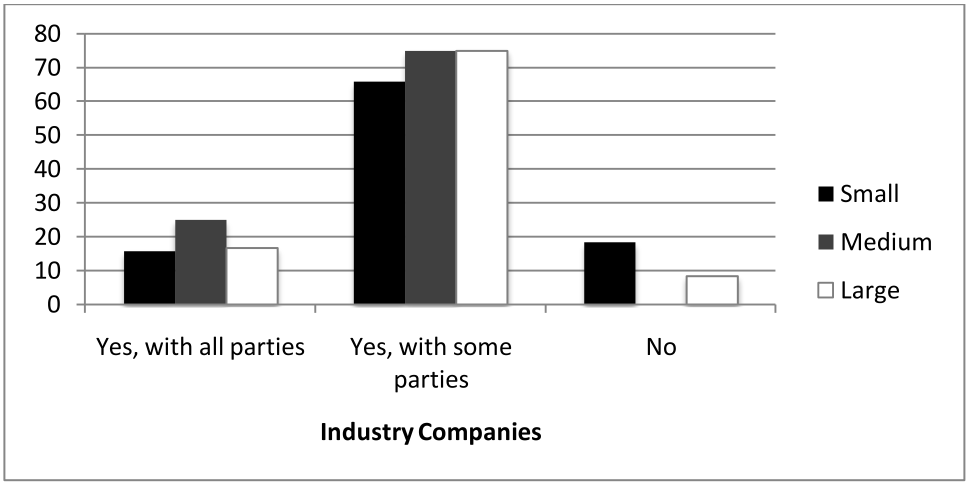
PR and coordination with project parties: contractors and consultants groups

PR and coordination with project parties: Small, medium, and large sizes groups

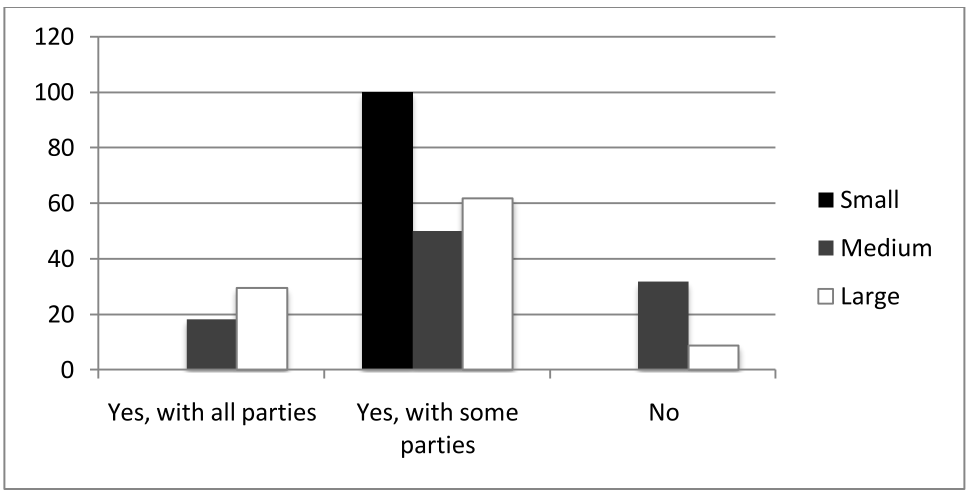
		Size of organisation								
Valid	128	Small			Medium			Large		
Missing	11	Group			Group			Group		
		Top Companies	Industry	Total	Top Companies	Industry	Total	Top Companies	Industry	Total
Yes, with all parties	Count	0	6	6	4	5	9	10	2	12
	% within Group	0	15.8	15	18.2	25	21.4	29.4	16.7	26.1
Yes, with some parties	Count	2	25	27	11	15	26	21	9	30
	% within Group	100	65.8	67.5	50	75	61.9	61.8	75	65.2
No	Count	0	7	7	7	0	7	3	1	4
	% within Group	0	18.4	17.5	31.8	0	16.7	8.8	8.3	8.7
Total	Count	2	38	40	22	20	42	34	12	46
	% within Group	100	100	100	100	100	100	100	100	100



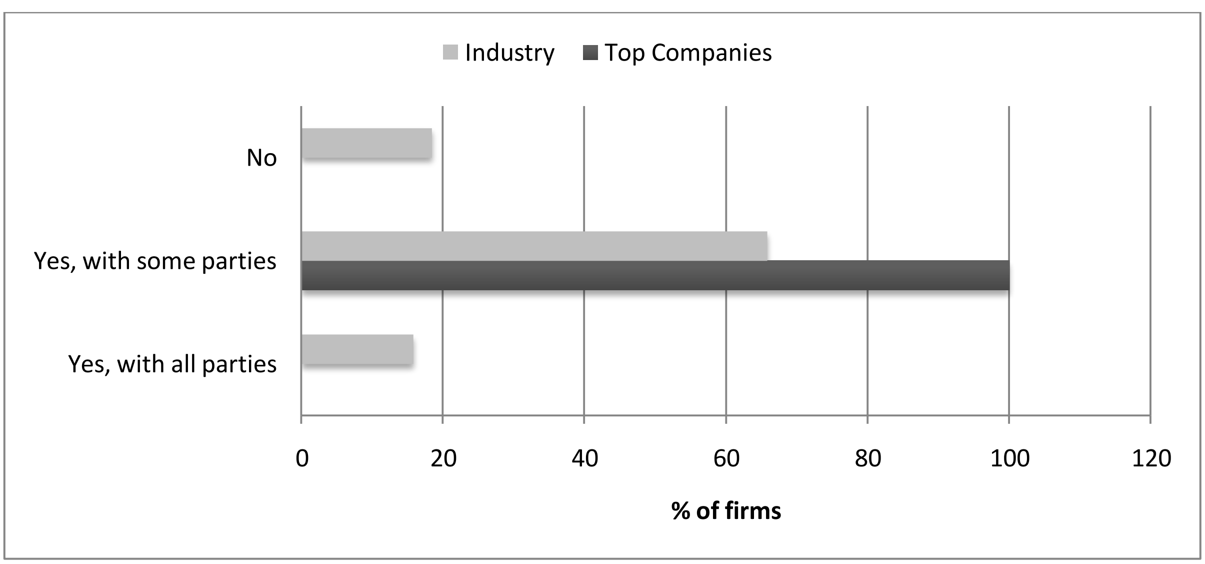
PR and coordination with project parties: Small, medium, and large groups



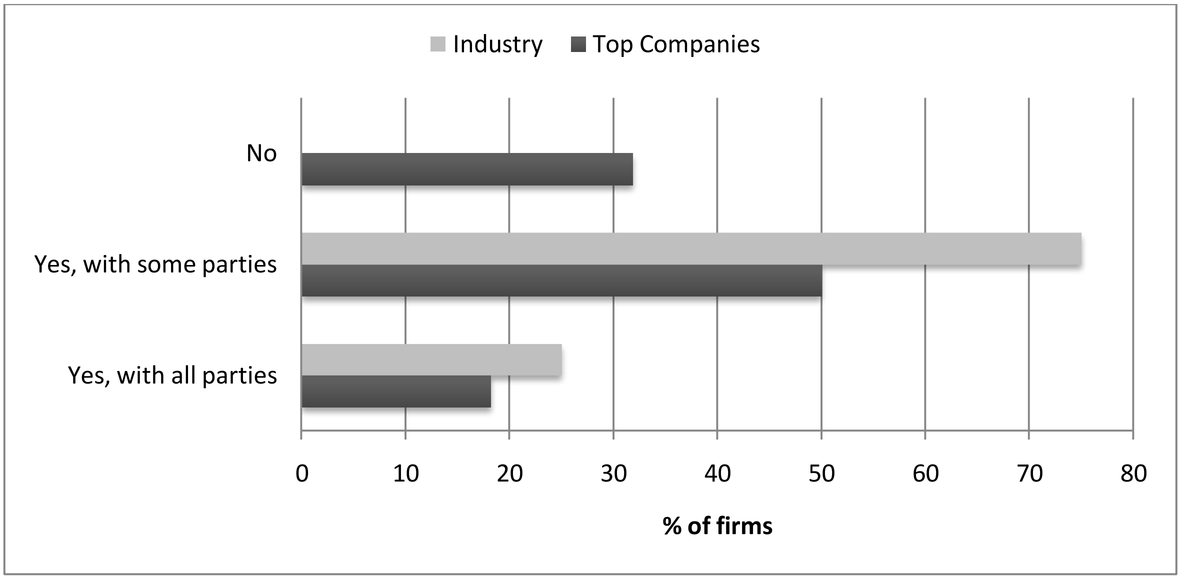
PR and coordination with project parties: size groups of industry companies



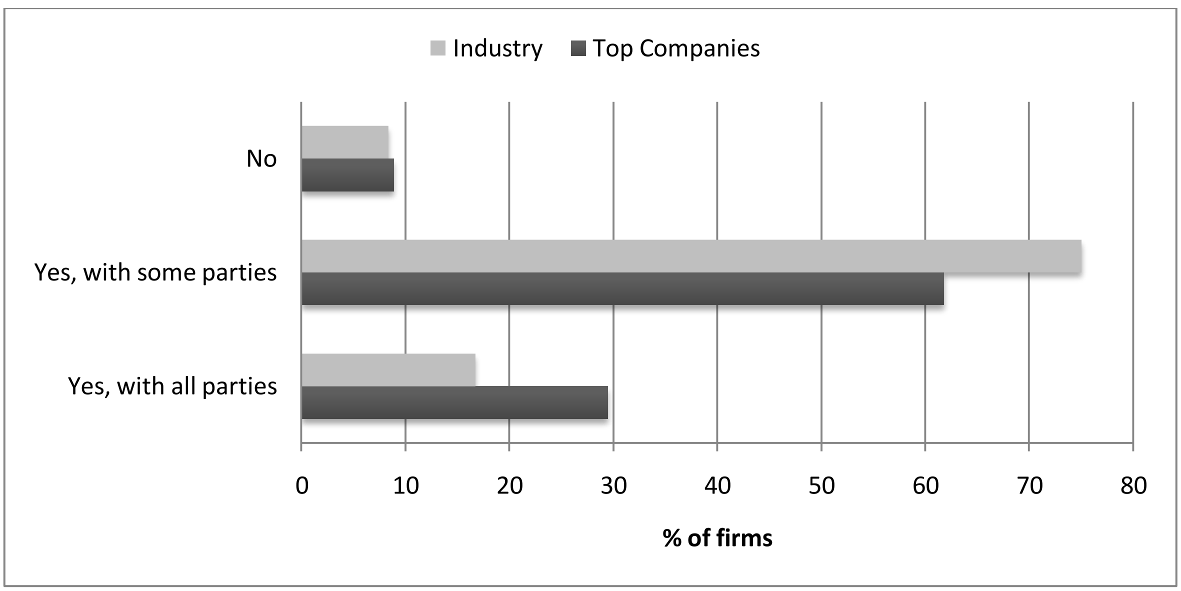
PR and coordination with project parties: size groups of top companies



PR and coordination with project parties: Small sized groups



PR and coordination with project parties: medium sized groups



PR and coordination with project parties: large sized groups