

# **Tacit Knowledge Integration within the Traditional Construction Procurement System**

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## Declaration

I hereby declare that this thesis is presented as an original contribution based on Doctorate of Philosophy research at the University of Salford and the material has not been submitted previously for a degree at any other university.

Name: .....

Signature: .....

Date: .....

## Abbreviations

A&E – Accident and Emergency

AARs – After Action Reviews

BIM – Building Information Modelling

BKM – Building Knowledge Modelling

CIOB – Chartered Institute of Building

COBie – Construction Operations Building Information Exchange

CoP – Communities of Practice

CS1 – Case Study 1

CS2 – Case Study 2

CSDP – Case Studies Design Protocol

CSFs – Critical Success Factors

DIKW – Data, Information, Knowledge, Wisdom

E2E – Existence to Enlightenment

GDP – Gross Domestic Product

HO – Haematology and Oncology

ICT – Information and Communication Technologies

IFC – Industry Foundation Class

ISM – Interpretive Structural Modelling

IT – Information Technology

KI – Knowledge Integration

KM – Knowledge Management

MICMAC – Matrice d'Impacts Croises-Multiplication Applique An Classment

POE – Post-Occupancy Evaluations

PPR – Post Project Reviews

SECI – Socialisation, Externalisation, Combination, Internalisation

SMEs – Small and Medium-sized Enterprises

SSIM – Structural Self-Interaction Matrix

TKI – Tacit Knowledge Integration

TPS – Traditional Procurement System

TQM – Total Quality Management

## Abstract

Knowledge management is a broad concept that has been investigated in many disciplines. Tacit knowledge management is more important in construction industry where common issues exist between the design and construction phase. However, most knowledge is embedded in the minds of professions and based on experiences they achieved from project. The successful completion of a project requires a rigorous understanding of each stage of project lifecycle that can be enhanced through integrating knowledge between project members, in terms of capturing and sharing knowledge between project members, and transferring it to the next project. Due to the temporary nature of construction projects, people who work on these project tend to disperse after completion of the project. This means the knowledge and experiences they achieved through project will be wasted, if it is not captured and shared structurally across project. Within this context, the failure to integrate knowledge will result in increasing the possibility of 'reinventing the wheel', which means spending more time and cost. The rationale that led to this study came as a result of increasing interest in the need for tacit knowledge integration, in terms of capturing, sharing and transferring knowledge, especially within construction project undertaken through the traditional procurement system, because this system is based on the separation of the design and construction phase.

The aim of this research is to develop a framework on how to integrate tacit knowledge in terms of capturing, sharing and transferring, within a construction project undertaken through the traditional procurement system. This is done through conducting documentary survey, experts' survey and case studies sample within the UK construction industry. The documentary survey was used to form researcher's background information and develop a conceptual framework which would be then taken to real life situation to investigate, gather relevant information and understand the perceptions and values of stakeholders in using knowledge integration within construction projects. Furthermore, an experts' survey (expert's interviews) was used to collect qualitative data through interviews with four experts. These experts were from both academia and industry, and they were selected based on their experiences and engagement in the traditional-based construction projects. Multiple-case holistic design was selected for conducting this research, in order to provide credibility to the research outcome. There is only one unit of analysis that is needed to study in order to explore

the approaches and techniques that were used by construction organisations for tackling challenges in the process of tacit knowledge integration. Two case studies were selected to reflect the building sector within construction industry. The projects were complex, large and costs over £5m. The selected case studies differ in that one of them is completed project and the other is an ongoing project at construction phase. As most of the problems and errors occurred in project lifecycle are related to designing phase, the cases were selected from same organisation involved at designing phase in order to analyse and compare the process of knowledge integration. Furthermore, an online open-end questionnaire was conducted to collect experts' opinion on the developed framework. The questionnaire was distributed among 180 experts. In this research the target population was professionals who were involved and experienced in the traditional-based construction project in the UK construction industry.

Research findings highlighted three main challenges for integrating tacit knowledge within the traditional construction project which are Organisational Culture, Contractual Boundaries and Knowledge management system (strategies and policies). The Critical Success Factors (CSFs) for tackling these challenges and required techniques for structurally implementing the process of tacit knowledge integration are identified. Furthermore, it is concluded that BIM technology can be used and enhanced the process of tacit knowledge integration, if the two-stage process traditional procurement is adopted. This means construction contractors should be involved in project before the completion of designing phase.

Building on the research findings, this research offers a framework, with a guideline, on how to integrate tacit knowledge, in terms of capturing, sharing and transferring, within the traditional construction project.

# Chapter 1 – Introduction

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## **1.1 Introduction**

This research explores Tacit Knowledge Integration (TKI) in terms of capturing, sharing, and transferring within the construction project undertaken through Traditional Procurement System (TPS) in the UK. Specifically, the research investigates the challenges (barriers), tools and Critical Success Factors (CSFs) of integrating tacit knowledge within the traditional-based construction project.

This chapter introduces the research work and provides a detailed overview of the research. It presents the background to the research, research problem/justification, aim, objectives, questions, follows with the scope of the research and outlines the structure of this thesis.

## **1.2 Background to the Research**

Knowledge is considered to be the most valuable asset that should be effectively managed in order to create added wealth to the organisation (Shokri-Ghasabeh & Chileshe, 2014). The effective use of knowledge assets enables organisations to be innovative and respond to the customers' requirements in a short time. In general, knowledge is either tacit or explicit; the concept of explicit and tacit knowledge was introduced by Polanyi (1966). The explicit knowledge is articulated, codified, stored, and distributed in certain media, whilst the tacit knowledge is hard to be captured and distributed because it is associated with experiences and skills of individuals (Easterby-Smith & Prieto, 2008).

Managing knowledge is considered in all industries but its importance is more recognised in construction industry, as it is critical for construction organisations to gain a competitive edge (Lindner & Wald, 2011; Bigliardi et al., 2014). This is mainly due to the unique characteristics of construction projects which are complicated, heavily relied on experience, limited to budget, tight schedule, and involved temporary team members.

According to Construction 2025 report (2013), the construction industry accounts for nearly 7% of UK's GDP (£92.4 billion gross value added), which is equivalent to about 10% of total UK employment. The industry is dominated by small and medium enterprises (SMEs), approximately over 90% of all organisations, with a small number of large organisations. The industry increasingly shares many characteristics of the knowledge economy. The term 'Knowledge Management' (KM) and the way in which to achieve it are a new category and

essential in knowledge-based industries like construction (Carrillo et al., 2000; Hari et al., 2005). KM has a vital role in improving the efficiency of project delivery and competitiveness of the construction organisation (Egbu, 2001; Egbu & Robinson, 2005; Sheehan et al., 2005; Fong, 2005; Orange et al., 2005). Many research have been done on KM-related issues within construction industry, including knowledge accumulation, capturing, sharing, translating and so on, but less attention has been paid on the best ways of managing knowledge and its process (Carlucci, 2012).

The construction activities are highly knowledge-intensive and characterised by a high degree of tacit knowledge and require effective management (Hari et al., 2005). The tacit knowledge is of more significance in knowledge-based industries like construction where common issues, in terms of KM challenges, exists between the design and construction phase. However, most design errors identified during construction phase are due to problems within design documentation that are mainly caused by lack of experiences and tacit knowledge of design team in construction practices (Love et al., 2013). Accordingly, KM is more significant in construction project undertaken through the TPS due to the nature of this type of procurement which is based on the separation of the designing and construction team. This means the design of the project is largely completed, by separate organisation, before construction work commences on site. Design team (architects, engineers and quantity surveys) mainly rely on their tacit knowledge (Heylighen & Neuckermans, 2000) which is achieved through their involvement in unique architectural and construction projects (Heylighen et al., 2005; Panuwatwanich et al., 2012). This knowledge is experience-based and ranges from technical to the specialist knowledge within the design and construction process (Bashouri & Duncan, 2014).

One of the main factors that causes the unnecessary construction rework cost is the design mistakes that are mostly caused by lack of training, experience and knowledge (Love et al., 2011). Researchers (Doctors, 2004; Heylighen et al., 2007) indicate that the design team, specifically designers, are highly secretive, not keen to share their knowledge and use KM techniques (Panuwatwanich et al., 2012). In other words, the social network between project members at design phase needs to be developed and improved in order to capture and share innovative knowledge that is created through designing process in construction projects (Bashouri & Duncan, 2014).



The effective KM will enhance project members and organisations to respond rapidly to problems and facilitate processes, specifically in the designing phase. Each construction project is unique and has its own problems, and therefore, it is the responsibility of the members of the project team to use their previous experience and knowledge to resolve them. Moreover, each project will add new experience and knowledge to the project team. Salter and Gann (2003) suggest that the project knowledge held by project team, plays a key role in solving problems. The competitive advantage of organisation and successful completion of a project lie in the ability of effectively managing knowledge (Hari et al., 2005). Therefore, KM plays a significant role in improving performance of organisations in terms of quality, time, reliability and reducing costs, specifically in project-based industries like construction.

### **1.3 Research Problem/ Justification**

KM is a broad concept that has been investigated in many disciplines. It becomes more important in terms of managing tacit knowledge in construction industry because most knowledge is embedded in the minds of professions and based on the experiences they achieved from projects (Pathirage et al., 2007). The rationale that led to this study came as a result of the increased interest in the need for KI, in terms of capturing, sharing, and transferring knowledge, especially within a project undertaken through the TPS in the UK construction industry. It is apparent that the need to tackle the challenges (barriers) of KI and proposing a methodology will create room for improvement in the TPS in the UK construction industry (Quantis, 2005; Winch, 2010; Gustavsson & Gohary, 2012).

The tacit knowledge and experiences that professionals achieved from projects are extremely important to organisations (Pathirage et al., 2007). Researchers (Kazi & Koivuniemi, 2006; Shokri-Ghasabeh & Chileshe, 2014) believe that project knowledge mostly remains in the minds of involved individuals on the project team and is not captured and transferred across the project in order to be used in future projects, specifically in the construction industry. In other words, knowledge is not structurally managed, integrated, between project team members. As the nature of construction projects and its teams are temporary, the continuity of using the same project team members in the future projects will decrease, which leads to project knowledge loss (Shokri-Ghasabeh & Chileshe, 2014). Therefore, one of the key factors

in improving construction project performance is how to structurally integrate knowledge and its utilisation in projects (Lee & Egbu, 2005; Dainty et al., 2006; Winch, 2010; Forman et al., 2011). Jallow et al., (2011) mention that there are multiple factors that lead to project knowledge loss;

- Fragmented nature of the construction industry
- Lack of KM initiative and practices within organisations
- Lack of business process integration or shared activities between project phases
- Difficulties in finding the relevant knowledge even if it exists
- Knowledge from design phase is not readily available at the construction phase
- Lack of capture, documentation and maintenance of knowledge from the previous phase
- Difficulties in understanding and interpreting previously captured knowledge

Ignorance of the above factors not only leads to project knowledge loss, but also affects the project performance and lead the organisations to lose their competitiveness in the industry. In general, for being competitive and improving project performance, it is necessary to integrate knowledge that is held by project team members and achieved from previous projects. This knowledge is usually not transferred and shared across projects and organisations for reusing in future projects (Egbu & Botterill, 2002; Lee and Egbu, 2005; Kazi & Koivuniemi, 2006; Tan et al., 2010; Zhu et al., 2014). This means much knowledge that is gained by project members will be lost and dispersed.

The successful completion of a project requires a rigorous understanding of each stage that can be enhanced through integrating knowledge between all individuals involved in a project. Due to the temporary nature of construction projects, people who worked on these projects, both in the design and construction team, tend to disperse after the project ends. This means their experiences and the knowledge they have achieved through the project will be wasted and not be used in future projects, if it is not captured structurally (Kasvi et al., 2003). In other words, the construction industry suffers from lack of KM between its phases (Pryke, 2005; Kamara et al., 2002; Harty & Schweber, 2010; Love et al., 2011; Zhu et al., 2014).

This issue is more apparent in the traditional-based construction projects as their nature is based on the separation of design and construction process. This separation means that KM issues in terms of capturing, sharing, and transferring knowledge exist between the design and construction phases. According to CIOB report (2010) people involved in the designing team have less experience on construction practices. Furthermore, this report indicates that lack of communication, design team problems, and design faults are the most significant problems that arise within the traditional procurement approach. Ding and Ng (2010) mention that the literature of how designing team share their knowledge in the project environment is limited and needs more research in this context. These issues are in line with the Construction 2025 report (2013) that specified two main weaknesses of the industry;

- *Sector integration*: “Lack of integration often leads to fracture between design and construction management and a fracture between the management of construction and its execution leading to lost opportunities to innovate”
- *Lack of collaboration and limited knowledge sharing*: “learning points from projects are often team-based and lost when the team breaks up and project ends. Low technology transfer”

Within this context, the failure to integrate the knowledge will result in increasing the possibility of “reinvent the wheel”, which means spending more time, cost, and losing competitive advantage with the industry. Many researchers state that organisations are not only unaware of the influence and benefits of capturing knowledge on the performance but also are not prioritising it (Huysman, 2000; Von Zedtwitz, 2002; Williams, 2004; Kotnour & Vergopia, 2005; Chan et al., 2005; Newell et al., 2006; Udeaja et al., 2006; Anbari et al., 2008; Oakes, 2008; Carrillo et al., 2012). Researchers (Kanapeckiene et al, 2010; Shokri-Ghasabeh & Chileshe, 2014) also believe that the construction industry will lose its skilled and knowledgeable workforce, if there is no efficient strategy by which knowledge can be integrated across project and between team members.

Thus, it is important for construction companies not only to capture, share and transfer the knowledge that creates and exists in project team members, but also to create a mechanism to facilitate the KI process both prior to commencing and during the new project (Tan et al., 2010). This will lead to reducing the repetition of similar mistakes and to avoiding projects

overrunning in terms of cost and time, which are significant in projects undertaken through the TPS. It was also discovered through the literature review that few studies have been done in the subject area relating to KI, specifically as related to the construction industry (Ruan et al., 2012). Most of these studies not only investigated the impact of each sub-process of KM separately but also considered the technological aspect rather than the tacit aspect of KI in the TPS in the UK. However, the scope of this research is to integrate the knowledge in terms of capturing, sharing and transferring, which lies in the traditional method rather than other types of procurement methods like 'Design and Build'. The main factor that distinguish the traditional approach from other types of procurement systems is the separation of organisations that are responsible for the implementation process of the main elements of the project like designing and construction. This separation directly impact the process of KI during project lifecycle. However, one organisation takes the responsibility of designing and construction of a project within other types of procurement methods like 'Design and Build', 'Develop and Construct', 'Package deal', and 'Turnkey'. Therefore, the traditional method is more appropriate and has the greatest scope in terms of doing this research, because of the way it is structured and KI is not happening adequately in this system. This discovery is one of the motivating factors that have led to the need for this study to have a holistic view and establish a process to improve the performance of construction projects undertaken through the TPS.

## **1.4 Research Aim and Objectives**

The aim of this research is to develop a framework on how to integrate tacit knowledge, in terms of capturing, sharing, and transferring within a construction project context, undertaken through the TPS, in the UK. It is expected that this framework would help to improve the awareness and understanding of individuals and organisational level about KI and its impact on project performance. The research will focus on construction projects undertaken through the TPS. In order to achieve the aim of this research, the following objectives are presented:

- To establish and document the specific areas of tacit knowledge integration within construction project context
- To investigate different approaches and techniques that are currently used in construction projects with respect to knowledge integration

- To explore key challenges of knowledge integration process within construction project context, undertaken through the traditional procurement system
- To critically analyse the success factors for tacit knowledge integration within construction project context, undertaken through the traditional procurement system
- To develop and validate a framework on how to integrate tacit knowledge within a construction project undertaken through the traditional procurement system

## **1.5 Research Questions**

According to Mason (2002), the research question is used to address and design the research. In fact, the essence of enquiry should be expressed by research questions. In other words, the research questions are used to inform and answer the aim and objectives of research. The research problem (described in section 1.3) requires focusing on literature from the fields of KM, specifically KI. The research questions become:

- What are the processes of KI within construction project context?
- What are the approaches and techniques for each sub-process of tacit KI within construction projects?
- How do individuals involved in projects become aware of the importance of TKI on performance?
- What are the challenges for each sub-process of TKI within the traditional construction project?
- What are the requirements of tacit KI within the traditional construction project?

## **1.6 Scope of the Research**

This research focuses on tacit KI within construction projects in the UK construction industry. Specifically, the research focuses on construction projects undertaken through the TPS. By its nature, the TPS is based on the separation of the design and construction process, which means some issues related to knowledge loss exist between these phases. However, these can be eradicated through a well-defined process of KI in terms of capturing, sharing and transferring (refer to sections 2.7 and 2.7.4). Although it is argued that separation of tacit and explicit knowledge is difficult, the main focus of this research will be on tacit knowledge, which is considered to be the most important and valuable aspect of knowledge. This research seeks

to develop a framework on how to integrate tacit knowledge for capturing, sharing and transferring, within construction projects, undertaken through the TPS in the UK. Although the data collection is limited to the UK construction industry and projects, but as long as the parameters of tacit knowledge, TKI and the traditional-based construction project are the same, the concepts and results of this research can be replicated elsewhere.

## **1.7 Structure of the Thesis**

This research is structured in seven chapters outlined as follows:

**Chapter 1** highlighted the background of the research, research problem and research aim and objectives. The chapter also outlined an overview of the scope of this research and outlined the structure of this thesis.

**Chapter 2** presents an overview of literature considerations for this research that includes the general areas of KM and KI, specifically used within construction industry. The chapter also outlines the approaches, techniques, challenges of KI within a construction project.

**Chapter 3** gives an outline for the methodology adopted to achieve the aim and objectives of this research and also meet the requirements of the research questions. The research philosophies, approach, and strategy of this research are highlighted. Further, the data collection and analysis method with the rationale of selecting research methods for conducting this research are presented.

The research approach of this study is an abductive approach, and the multimethod qualitative research design was adopted to achieve the stated aim and objectives of this research. The case study and survey were selected as the research strategy for conducting this research. The data collection method adopted for conducting this research was semi-structured interviews through the experts' survey and case studies. The experts' survey includes four experts, from both academia and industry. Two case studies, one completed and one on-going, were selected including eight semi-structured interviews with project members at both the design and construction phases. Furthermore, an online open-end questionnaire is conducted to collect experts' opinion in order to validate the developed framework.

**Chapter 4** presents findings from the experts' survey through semi-structured interviews with four experts from both academia and industry. The findings are analysed contently, with the aid of computer NVivo software, in order to find the challenges, approaches and techniques of TKI within the TPS. Further, the ISM approach is used to identify and summarise relationships between the identified challenges.

**Chapter 5** highlights the findings of case studies and synthesis them in order to identify the challenges, techniques, and CSFs of TKI. These findings are further discussed in chapter 6 in the form of comparing the findings from document and the experts' survey. The ISM approach is used to identify and summarise relationships between the identified challenges.

**Chapter 6** presents the discussion on findings from the document survey, the expert's survey and case studies. The final challenges of TKI are identified and presented with the CSFs. The development process of TKI framework is presented. The final framework consists of three main sections which are KI Challenges, KI Means and KI Process. These sections are thoroughly conducted. Further, the framework validation process is discussed. The validation of TKI framework is through an expert's survey by an online open-ended questionnaire. The feedback from the experts' survey leads to the development of a guideline framework.

**Chapter 7** revisits the findings in accordance with the aim and objectives of the research. It also includes the contribution to knowledge, limitations for this research, recommendations, and suggestions for future research.

## **1.8 Summary and Way Forward**

This chapter of the thesis highlighted the background of the research, research problem, and research aim and objectives. The chapter also outlined an overview of the scope of this research, followed by the overall structure of the report. It was argued that the construction industry suffers from lack of KI between its phases, especially in the TPS that has been criticised for several issues: failure to form effective teams, separate approach to project delivery, lack of communication and coordination, time delay. Furthermore, most of the construction projects undertaken through the TPS are overran in terms of costs and time which are due to the lack of communication and knowledge loss between project members,

and designing problems that arise during the project life cycle. In this regard, failure to integrate knowledge will result in increasing the possibility of reinventing the wheel.

The next chapter presents a comprehensive literature review on the KM and KI including their approaches, techniques, and challenges within a construction project undertaken through the TPS, as in line with the objectives of this research.



## Chapter 2 – Literature Review

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## 2.1 Introduction

This chapter presents an overview of the literature for this research that includes the general areas of KM and KI, specifically within the construction industry. In this regard, the characteristics and typologies of knowledge are presented. Furthermore, the main process of KM, knowledge capturing, sharing, and transferring are discussed. The chapter also outlines the approaches, techniques, and challenges of KI within a construction project.

## 2.2 Knowledge

Many researchers state that the definition of ‘knowledge’ is controversial and challengeable (Bhatt, 2000; Carrillo et al., 2003). In other words, it is a never ending task. Plat (427-347 B.C.) defines knowledge as a “justified true belief”. According to this theory, knowledge cannot be acquired by just believing something even if that belief turns out to be true. In other words, one must not only have a strong reason for doing something but must also know the relevant true proposition. For instance, a lawyer can employ true evidence to convince a judge into a belief that turns out to be true; this belief is sufficiently qualified to constitute knowledge (White, 1976). Figure 2.1, illustrates the philosophical view of knowledge.

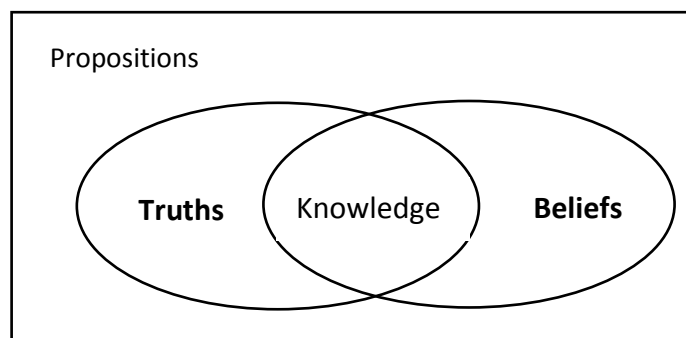


Figure 2.1 – A Philosophical View of Knowledge

Knowledge is generally defined as “content + structure of the individual’s cognitive system” (Propp, 1999). The content of knowledge is unprocessed, disorganised, and meaningless information and it is the cognitive system of an individual that brings meaning to the information and makes it to become knowledge (Sun & Scott, 2005). According to Marakas, knowledge is defined as “meaning made by the mind” (Marakas, 1999). Pillania (2008) defines knowledge as a combination of experiences, insights, and reasoning which are related to processes, technology, customers, products, etc. that enable effective actions.

Since there are few consensuses about the definition of knowledge, the different definitions from Hicks et al. (2007) and other scholars are classified in Table 2.1.

Table 2.1 – Definitions of Knowledge

Knowledge	Reference
Justified true belief	Plato (427-347 B.C)
“information that has been authenticated and thought to be true”	Vance (1997)
A framework for evaluating and incorporating new experiences and information	Davenport & Prusak (1998)
Content + Structure of individual’s cognitive system	Propp (1999)
“justified personal belief that increases and individual’s capacity to take effective action”	Alavi & Leidner (1999)
“information made actionable in a way that adds value to the enterprise”	Vail (1999)
Meaning made by the mind	Marakas (1999)
“integrated information I context”	Galup et al., (2002)
What we know + mental structure used in learning, understanding and comprehension	Wilson (2002)

Distinguishing knowledge from ‘data’ and ‘information’ leads to having a better understanding of the nature and the purpose of knowledge. Regarding this issue, the DIKW model, also known as DIKW Hierarchy, represents the structural relationship between data, information, knowledge and wisdom. This model was, initially, detailed by Ackoff in the 1988 address to the International Society for General Systems Research.

Data are raw materials like signs or symbols in the world that can be sensed. Ackoff (1989) introduces data as any objective facts or observations that have no values until they are transformed into a relevant and usable form. In other words, data will turn into information when they are assigned meaning. According to Choo et al. (2000), data are simple messages, facts, and figures that are not organised and do not have any meaning; whilst information is defined as processed data that has values and meanings. During the data processing to produce information, some irrelevant data minimises. In other words, information is the result of inference from relevant data. It could be concluded that the distinction between ‘data’ and ‘information’ is functional rather than structural.

Knowledge, what we know, is construed as what we build from our understanding of the world in our mind, which includes our expectations and beliefs. It originates and is applied by analysing and synthesising expectations, beliefs, values, and information. Davenport and Prusak (1998) say that when new information is compared and connected with existing information, it becomes knowledge. In addition, it is also a requirement that new information is evaluated by humans in order to find out its consequences on future actions and decisions. On the other hand, wisdom is the ability to make a decision and use judgement by employing integrated knowledge and information, apparently without thought (Wallace, 2007; Gamble & Blackwell, 2002). This ability is used to increase effectiveness and add values, which are unique and personal for each individual.

### 2.2.1 Definitions of Knowledge and Related Concepts

In order to have a better understanding of knowledge and its related concepts, it is better to review and group different sets of definitions that have been introduced by scholars. Based on this theory, Zins (2007) conducts a Critical Delphi study to collect views of different scholars on their understanding about concepts of data, information, and knowledge. He asked 45 Information Science scholars from 16 countries to participate in his research. The summary of his research and set of definitions by other scientists are shown in Table 2.2.

Table 2.2– Definitions of Data, Information and Knowledge

Data	Information	Knowledge	Information Scientist
“are facts that are the result of observation or measurement (Landry <i>et al.</i> , 1970)”	“is meaningful data or data arranged or interpreted in a way to provide meaning”	“is internalized or understood information that can be used to make decisions”	Carol Tenopir (Tenopir <i>et al.</i> 2011)
“are raw material of information, typically numeric”	“is data which is collected together with commentary, context and analysis so as to be meaningful to others”	“is a combination of information and a person’s experience, intuition and expertise”	Charles Oppenheim (cited in Boyd, <i>et al.</i> , 2007)
“are facts and statistics that can be quantified, measured, counted, and stored”	“is data that has been categorized, counted, and thus given meaning, relevance, or purpose”	“is information that has been given meaning and taken to a higher level. Knowledge emerges from analysis, reflection upon, and synthesis of information. It is used to make a difference in an enterprise, learn a lesson, or solve a problem”	Donald Hawkins (Hawkins <i>et al.</i> , 1988)
“are atomic facts, basic elements of “truth,” without interpretation or	“is a set of facts with processing capability added, such as context,	“is information with more context and understanding, perhaps with the addition	Donald Kraft (cited in Zins, 2007)

greater context. It is related to things we sense”	relationships to other facts about the same or related objects, implying and increased usefulness. Information provides meaning to data”	of rules to extend definitions and allow inference”	
“are dynamic objects of cultural experience having the aspect of being meaning-neutral and a dual nature of description and instruction”	“is dynamic objects of cultural experience having the aspect of being belief-neutral and a dual nature of content and medium”	“is dynamic objects of cultural experience having the aspect of being action-neutral and a dual nature of abstracting to and from the world”	Ken Herold (2001)
“are representations of facts about the world”	“is data organised according to an ontology that defines the relationships between some set of topics. Information can be communicated”	“is a set of conceptual structures held in human brains and only imperfectly represented by information that can be communicated. Knowledge cannot be communicated by speech or any form of writing, but can only be hinted at”	H.M. Gladney (2008)
“is one or more kinds of energy waves or particles (light, heat, sound, force, electromagnetic) selected by a conscious organism or intelligent agent on the basis of a pre-existing frame or inferential mechanism in the organism or agent”	“is an organism’s or an agent’s active or latent inferential frame that guides the selection of data for its own further development or construction”	“is one or more sets of relatively stable information”	Glynn Harmon (2001)
“are sets of characters, symbols, numbers, and audio/visual bits that are represented and/or encountered in raw forms”	“is facts, figures, and other forms of meaningful representations that when encountered by or presented to a human being are used to enhance his/her understanding of a subject or related topics”	“is a reservoir of information that is stored in the human mind. It essentially constitutes the information that can be “retrieved” from the human mind without the need to consult external information sources”	Haidar Moukdad (cited in Zins, 2007)
“are unprocessed, unrelated raw facts or artifacts”	“is data or knowledge processed into relations (between data and recipient)”	“is information scripted into relations with recipient experiences”	Joanne Twining (1999)
“are a set of symbols representing a perception of raw facts”	“is organized data (answering the following basic questions; What? Who? When? Where?)”	“is understood information (answering following basic questions; why?, how?, for which purpose?)”	Nicolae Dragulanesu (2013)
“are a string of symbols”	“is data that is communicated, has	“is a personal/cognitive framework that makes it	Raya Fidel (cited in Zins, 2007)

	meaning, has an effect, has a goal”	possible for humans to use information”	
“are raw evidence, unprocessed, eligible to be processed to produce knowledge”	“is the process of becoming informed; it is dependent on knowledge, which is processed data”	“perceived, becomes information. Knowledge is what is known, more than data, but not yet information. Recorded knowledge may be accessed in formal ways. Unrecorded knowledge is accessible in only chaotic ways”	Richard Smiraglia (2014)
“is a quantifiable fact that can be repeatedly measured”	“is an organized collection of disparate datum”	“is the summation of information into independent concepts and rules that can explain relationships or predict outcomes”	Scott Seaman (cited in Zins, 2007)
“are sensory stimuli that we perceive through our senses”	“is data that has been processed into a form that is meaningful to the recipient (Davis & Olson, 1985)”	“is what has understood and evaluated by the knower”	Shifra Baruchson-Arbib (Bar-Ilan et al., 2006)
“are the raw observations about the world collected by scientists and others, with a minimum of contextual interpretation”	“is the aggregation of data to make coherent observations about the world”	“is the rules and organizing principles gleaned from data to aggregate it into information”	William Hersh (cited in Zins, 2007)
“are artifacts that reflect a phenomenon in natural or social world in the form of figures, facts, etc.”	“is anything communicated among living things. It is one of the three mainstays supporting the survival and evolution of life, along with energy and materials”	“is a human construct, which categorize things, record significant events, and find causal relations among things and/or events, etc. in a systematic way”	Yishan Wu (cited in Zins, 2007)

It can be inferred that there is a clear relation between knowledge and its related concepts which are data, information. These views show that ‘knowledge’ is a processed ‘information’ which itself is a processed form of ‘data’. This relation will enable the researcher to have a better understanding DIKW model (Figure 2.2).

## 2.3 Knowledge Frameworks

### 2.3.1 DIKW Model

The DIKW hierarchy represents the chain from ‘Know-Nothing’ (data) to ‘Know-What’ (information) to ‘Know-How’ (knowledge) to ‘Know-Best’ (wisdom). This model was offered by Ackoff (1989) and has been the most cited model in the literature of information science.

He also includes another concept between ‘knowledge’ and ‘wisdom’ which is called ‘Know-Why’ (understanding). As a whole scholars have little consensus on describing the process of transforming the lower elements of DIKW hierarchy into those above them. Rowley (2007) represents a model (Figure 2.2) that describes the transitions from the lowest element ‘data’ to the highest element ‘wisdom’. This model is called ‘The understanding hierarchy model of DIKW’.

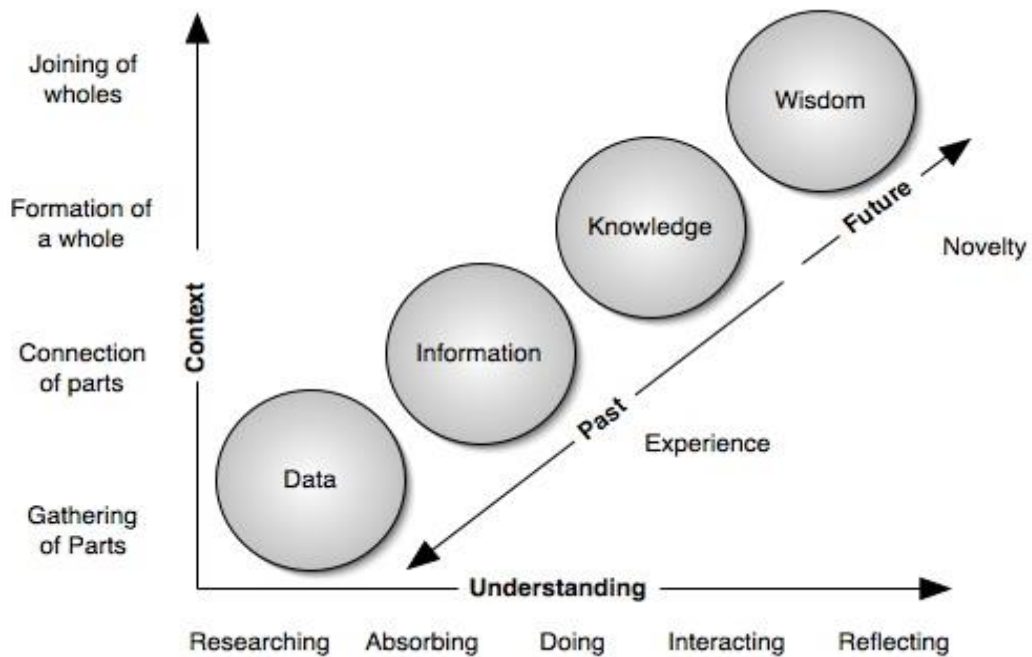


Figure 2.2 – The Understanding Model of DIKW, (Rowley, 2007)

This model illustrates a better understanding of transforming data to wisdom. Data is formed by doing research and gathering parts. Information is formed by both connecting the different parts of data and understanding relations between them. Then the gathering of appropriate information and understanding the patterns between them will lead to form knowledge. Wisdom, know-best, is formed by joining integrated knowledge and understanding the principles which will result in increasing the ability of making decisions and using judgement. The model also describes data, information, and knowledge as based on experience and past-oriented; whilst wisdom is future-oriented and used to create ideas. Furthermore, this model represents a way of understanding that is started by researching data, absorbing data and information, followed by acquiring information and knowledge, interacting knowledge and finished by reflecting wisdom.

The DIKW model was developed by many researchers like Nonaka (1991) and Rowley (2007). Fricke (2009) criticised by arguing that the hierarchy model (DIKW) is methodologically undesirable and unsound and has a theoretical and intellectual gap between the interrelationship and nature of its components. He adds value to information science by representing positive theories about the nature of the components of the DIKW model. He introduces data as “anything recordable in a semantically and pragmatically sound way”, both information and knowledge as “weak knowledge”, and wisdom as “the possession and use, if required, of wide practical knowledge, by an agent who appreciates the fallible nature of that knowledge”.

### **2.3.2 E2E Model**

Faucher et al. (2008) adopt a complex-based perspective to analyse and extend the DIKW model. They proposed a new model by adding two new components, ‘Existence’ and ‘Enlightenment’, called the E2E model. Furthermore, they argue that the relationship is non-pyramidal and non-linear among six components (Existence, Data, Information, Knowledge, Wisdom and Enlightenment), which means that each component can occur without any specific order. Faucher et al. (2008) sit an example of a new receptionist having the wisdom for managing customer relationships without having any data about customers. The required wisdom could be achieved during his/her formative years. The DIKW model lies in between existence and enlightenment that provide the boundaries for the cognitive system of knowledge. In other words, the DIKW is the abstraction of the existence and the enlightenment is the highest level of abstraction which leads to understanding.

According to Faucher et al. (2008), the elements of the DIKW model are based upon the abstraction of existence and could be either tacit or explicit. The level of understanding of these elements is the basis of both differentiating them and the conversion process among them. Figure 2.3 illustrates the E2E model based on Faucher et al. (2008).



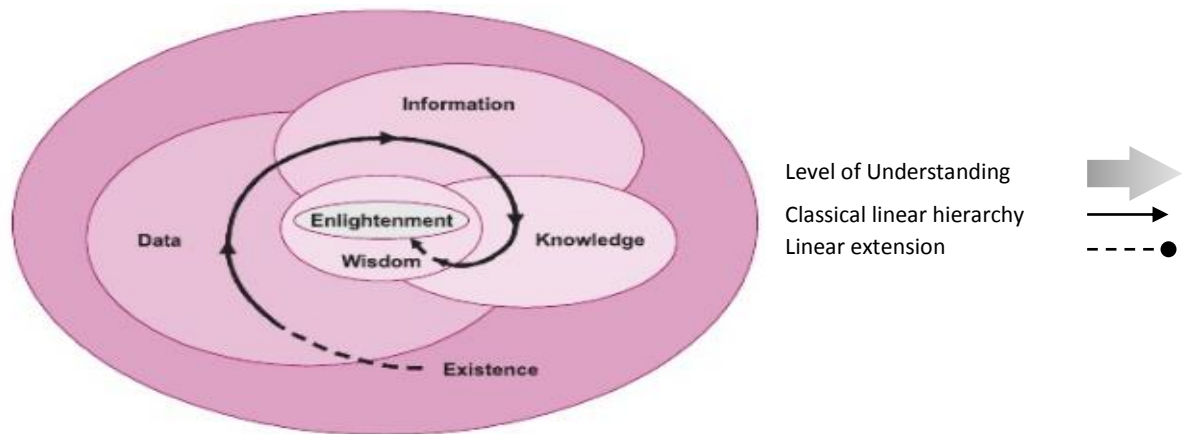


Figure 2.3 – Knowledge System (Faucher et al., 2008)

Based on foregoing the discussion on knowledge and its related concepts, Faucher et al. (2008) also reviewed the literature on the components of the knowledge system. It should be mentioned that few authors have defined wisdom. Their definitions and findings are presented in Table 2.3.

Table 2.3 – Definition of Data, Information, Knowledge and Wisdom (Faucher et al., 2008)

Data	Information	Knowledge	Wisdom	Information Scientist
is “symbols”	is “data that are processed to be useful”	is “ability to answer “How” questions”	defined “as an evaluated understanding”	<b>Ackoff (1989)</b>
is “static, unorganised and unprocessed facts. Set of discrete facts about events”	“facts based on reformatted or processed data. Aggregation of data that makes decision making easier and has a meaning, purpose and relevance”	“higher level of abstraction that resides in people’s minds. Includes perception, skills, training, common sense, ad experiences”	“as the highest level of abstraction, with vision, foresight, and the ability to see beyond the horizon”	<b>Awad &amp; Ghaziri (2004)</b>
“is a basic interpretation of existence”	“is viewed as a meaningful interpretation of existence, one that has a purpose”	“is a meaningful and procedural abstraction of existence”	“is understood as a meaningful, procedural, and justified abstraction of existence based on experience”	<b>Faucher et al., (2008)</b>
			defined “as the critical ability to use knowledge in a constructive way and to discern ways in which new ideas can be created”	<b>Matthews (1998)</b>
	“structured data useful for analysis and decision making”	“obtained from experts based on experience”	defined “as the ability to judge soundly over time”	<b>Thierauf &amp; Hctor (2006)</b>

After providing a range of definitions, it is concluded that there is no universal accepted definition. Eysenck (1979) suggests that when there is no consensus on an accepted definition, it is better to share the personal understanding applicable in the context. Regarding this issue, similarities and differences of presented definitions are discussed in the following section. This will lead to the generation of the operational definitions.

## **2.4 Discussion of Elements of E2E Model**

### **2.4.1 Existence**

Faucher et al. (2008) found a gap in the literature in that scholars paid less attention to the definition of data. Data is defined as observations of reality, but Faucher et al. (2008) claimed that data are level of understanding of existence and defined it as “whole environment that humans can grasp and create data about”. Hence, the authors extended the hierarchy frameworks of knowledge system, DIKW model, by including existence as the basic element of data, information, knowledge, and wisdom. They referred to Jean-Paul Sartre, a French philosopher who said “existence precedes essence” (Sartre, 1956). Therefore, the knowledge system is built upon existence. Faucher et al. (2008) present an operational definition for existence;

*“Existence describes the whole environment that humans can grasp and create data about.”*  
(Faucher et al., 2008)

### **2.4.2 Data**

After reviewing the above mentioned definitions of data, it can be concluded that all of them have four relationships and concepts in common. First, data is defined as one or more kinds of facts, statistics, symbols, stimuli, energy waves, numbers, and characters. Secondly, data is result of observation, which is used to interact with the environment. In other words, it is perceived and sensed through our seven senses. Thirdly, individuals select sensed and perceived data which is done through a pre-existing frame in the organism. In other words, not all symbols and perceived data are selected for processing by an individual human. Finally, the process of selecting data is framed or based on an inferential mechanism in the agent or organism, which means that individuals select data according to their cultural experience.

*Data is stimuli or facts that could be sensed and selected by human based on their pre-existing cultural experience and frame of mind.*

### **2.4.3 Information**

In reviewing the above mentioned definitions of information, some concepts and relationships become apparent. Initially, information is an organised, processed, aggregated, constructed, developed, analysed, and interpreted data. In other words, information is a transformed data. Secondly, the process of transforming data depends on cultural experience of individuals and a dual nature of content and medium which are used to process data. Thirdly, information is an aggregated data which means it is collection of organised data. Finally, information is facts and ideas that must be communicable, meaningful, relevant, and useful to others.

*Information is an aggregated form of organised, collected and culturally influenced data. Information is meaningful, relevant, useful and communicable between sender and recipient.*

### **2.4.4 Knowledge**

Similar to the previous elements, some concepts and relations emerge after reviewing the definitions of knowledge. First, knowledge is transformed information that is analysed, evaluated, synthesised, summarised, reflected upon, relatively stabled, understood, abstracted, and converted into concepts and rules that are independent. Secondly, experiences, intuitions and cognitive frameworks influence the transformation process of information to knowledge. Thirdly, knowledge can be used to predict outcomes, solve problems, create rules, learn a lesson, explain relationships, and organise principles. Finally, knowledge can only be represented and communicated imperfectly. The operational definition of knowledge is

*Knowledge is meaningful, reflection and abstraction of information that is influenced by cognitive frameworks, experiences and intuition during the process of transformation from information. It can create rules, learn a lesson, predict outcomes, organise principles and explain relationships. Knowledge can only be communicated imperfectly.*

### **2.4.5 Wisdom**

According to Table 2.3, it is inferred that wisdom is a justified and procedural abstraction of existence, an evaluated understanding, and is the ability of individuals to have vision and foresight. Wisdom is a critical ability of using knowledge by individuals in a way that new ideas emerge. The definition by Faucher et al., (2008) will be adopted.

*“Wisdom is understood as a meaningful, procedural, and justified abstraction of existence based on experience.”*

### **2.4.6 Enlightenment**

As existence is the lower boundary of the knowledge system; enlightenment is the higher boundary. The elements of the knowledge system can be achieved inside the boundary, but like existence, enlightenment “is not something to have; it is a state of being” (Faucher et al, 2008). Budahists also define enlightenment as “the awakening of beings”. (Faucher et al, 2008). Since this is in line with Faucher et al. (2008) definition, the definition of enlightenment will be

*“Enlightenment is the highest form of understanding and state of being.”*

Having the operational definition on the elements of E2E model, specifically the data, information, and knowledge will enable the researcher to have a better understanding of the research topic while conducting the research.

## **2.5 Typologies of Knowledge**

Generally, there are two common dichotomies of knowledge types that used are by researchers. First the tacit and explicit knowledge. Second the individual and collective or group knowledge (Hislop, 2013).

### **2.5.1 Tacit and Explicit Knowledge**

Despite various classifications of knowledge, most scholars have consensus on using two types of knowledge, tacit and explicit, in their research (Gourlay, 2006; Nonaka & Takeuchi, 1995). This dichotomy is generally used for analysing organisational knowledge. According to Nonaka (1994), tacit knowledge is the kind of knowledge that can only be experienced and achieved in a relevant context but cannot be easily articulated. In other words, it consists of an

individual's values, beliefs, and mental models ingrained in their minds, and skills. Nonaka et al. (2000) define tacit knowledge as knowledge, based on the past experiences of individuals in the form of attitudes, commitment, evaluation, points of view, and motivation. In contrast, explicit knowledge is the knowledge that can be articulated, codified, and stored in certain media. It can easily be understood and transferred to another person by verbalising it without knowing the subject. However, transferring tacit knowledge requires full potential of personal interaction in order to build trust and share understandings between the knowledge holder and recipient (Nonaka & Takeuchi, 1995). According to Cook and Brown (1999), Nonaka and Takeuchi (1995), and Alavi and Leidner (2001), there are three main areas in which tacit knowledge differs from explicit knowledge:

1. Codifying and methods of transferring knowledge
2. Methods of accumulation and acquisition of knowledge
3. Modes of appropriation and aggregation of knowledge

From the characteristic viewpoint:

- Tacit knowledge is inexpressible in a codifiable form, subjective, personal, context-specific and difficult to share
- Explicit knowledge is codifiable, objective, impersonal, context independent and easy to share

Nonaka (1994) divides tacit dimension of knowledge into two elements; cognitive and technical. The former element is comprised of mental maps, viewpoints, beliefs, and paradigms. In other words, it refers to an individual's mental model that helps them to interpret their world, their conception of reality. The latter element is based on practice that applies to a specific context. It consists of the concrete know-how, crafts and skills (Alavi & Leidner, 2001); in short, it encompasses information related to the know-how (Pathirag et al., 2008). An example of tacit knowledge is the experience and skills of managers in the construction industry, who have the ability to provide thoughts and advice that relies on prior experience both internal and external to company. The technical element of the tacit knowledge dimension is also known as 'Implicit Knowledge'. Most of the studies have been about the differences between tacit and explicit knowledge and less has been dedicated the

importance of implicit knowledge, which can be called the ‘shade of grey’ between the two. Implicit knowledge is about the process of doing something and it is sometimes used interchangeably with the term ‘tacit knowledge’. Based on the Alavi and Leidner (2001) discussion on the tacit dimension of knowledge, Figure 2.4 represents the dimension diagrammatically.

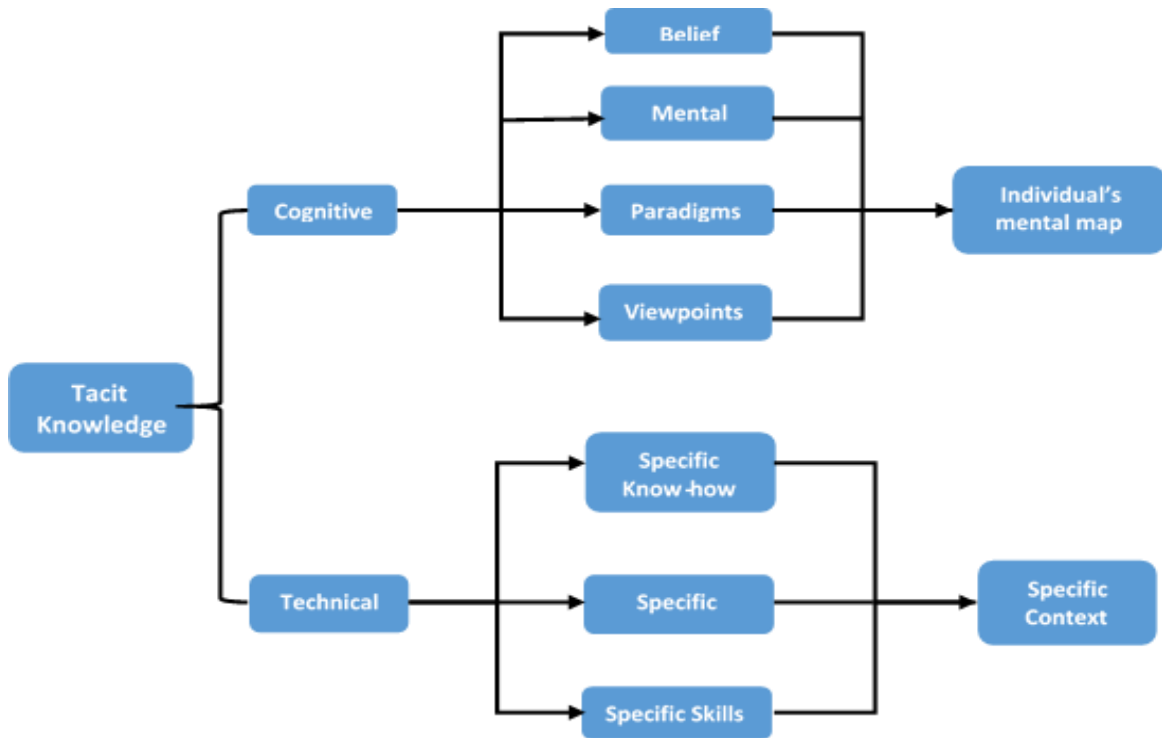


Figure 2.4 – Dimension of Tacit Knowledge (Alavi & Leidner, 2001)

## 2.5.2 Individual-group Knowledge

Some researchers would say that knowledge resides not only in individuals but also in social groups. Knowledge can be found in different form of shared assumptions or perspectives and within shared work practices and routines in social groups (Hislop, 2013)

Spender (1996) uses the tacit and explicit dichotomy and individual-group dichotomy together in order to produce generic types of knowledge. This model, Table 2.4, consists of two-by-two matrix with four types of knowledge which are; *Conscious*, *Objectified*, *Automatic* and *Collective*. Objectified and Collective types are more important because they exist in social groups. For example, formalised organisational routines or documented rules are objectified knowledge which are explicit and reside in the social group. An example of collective knowledge on the other hand is informal organisational routines and ways of accomplishing

task and working. This type of knowledge is the most important one because it not only exists in social groups but also it is a form of tacit knowledge that cannot be codified.

Collective knowledge is not limited to a specific type, size, or characteristics of a community. It exists and develops in different types of communities from the small-scale level, like teams or communities, to the large-scale level like departments, business units, sites, and organisations.

Table 2.4 – Generic Knowledge Types (Adopted from Hislop 2013)

	Individual	Social
Explicit	Conscious	Objectified
Tacit	Automatic	Collective

Hecker (2012) did a deep analysis and distinguished three types of collective knowledge which is worth being highlighted. According to his analysis, collective knowledge consists of *Shared Knowledge*, *Complementary Knowledge* and *Artefact-Embedded Knowledge*. The first type is located within the individuals. For example, the way of managing customer interactions within a sales team is a type of shared knowledge. The complementary knowledge focuses on the importance of the distribution of expertise within a group or the community. Group members could benefit from this type of knowledge to effectively coordinate their work activities because the sum of individual (expertise) knowledge and their collective effort is greater than a single individual’s effort and knowledge. The last type of collective knowledge is about knowledge embedded in artefacts which are used by group members like a shared presentation or database, or collectively developed products; an example is technological artefacts. Table 2.5 represents different types of collective knowledge.

Table 2.5 – Hecker’s (2012) Three Types of Collective Knowledge

Collective Knowledge Types	Definition	Locus	Relationship to Individual Knowledge	Origin
<b>Shared Knowledge</b>	Knowledge held by individuals in a group	Individuals	Overlapping, common knowledge	Shared experiences
<b>Complementary Knowledge</b>	Knowledge regarding the division of expertise within a group	Interdependencies between individual knowledge		Specialized division of knowledge within group
<b>Artifact-Embedded Knowledge</b>	Knowledge embedded in collective, group artefacts	Artefact	Combinations of individual knowledge in an articulated form	Codification and articulation of knowledge

## 2.6 Different perspectives on Knowledge

The importance of reviewing different perspectives of knowledge relies on having a better understanding of the different views on knowledge because each view indicates a different strategy for managing knowledge. Regarding this issue, Alavi and Leidner (2001) carried out studies reviewing perspectives of the concept of knowledge. Table 2.6 represents the main views of knowledge that were studied by Alavi and Leidner (2001).

Table 2.6 – Different Perspectives on Knowledge (Alavi and Leidner, 2001)

Perspectives	Implication for Knowledge	Implication for Knowledge Management (KM)	References
<b>Processed Information</b>	Knowledge is authenticated and personalised information	KM focuses on introducing useful information to individuals and facilitating assimilation of information in decision support	<b>Dretske (1981); Machlup (1983); Vance (1997)</b>
<b>State of Mind</b>	Knowledge is ‘a state or fact of knowing and understanding’	KM focus is on enhancing the ability of individuals in learning and understanding by providing information	<b>Schubert et al. (1998)</b>
<b>Object</b>	Knowledge is a thing that can be stored and manipulated	KM involves in ‘building and managing knowledge stocks’	<b>Carlsson et al. (1996); McQueen (1998); Zack (1998a)</b>
<b>Process</b>	Knowledge is ‘a process of applying expertise’ – process of simultaneously knowing and acting	Key KM issue is knowledge flows – ‘the process of creating, sharing and distributing knowledge’	<b>Zack (1998a)</b>
<b>Access to Information</b>	Knowledge is a condition of access to information – extension view of knowledge as an object	KM focuses on ‘organising access to knowledge objects and retrieval of content’	<b>McQueen (1998)</b>
<b>Capability</b>	Knowledge is the capacity and potential to influence action	KM involves in ‘building core competencies and understanding strategic know-how’	<b>Carlson et al. (1996)</b>



Comparing these perspectives, three main points emerges:

- Much focus is on understanding and differentiating data, information and knowledge
- Knowledge is personalised. In order to be useful and interpretable by the receivers, it should be accurately captured, shared and transferred
- Only that information which is processed in an individual's mind is valuable and useful. This process consists of reflection, enlightenment or learning

Having description on typologies of knowledge and its perspectives allows the reader to have a better understanding when discussing KM in next section.

## **2.7 Knowledge Management**

As knowledge is a critical resource, KM is a fundamental and mandatory issue that brings success to organisation (Binney, 2001). What is KM? Is it rebranding of the term information management? Some researchers (Alvesson & Kärreman, 2001; Scarbrough & Swan, 2001; Ellis et al., 2004) argue that the meaning of the term KM is based on flawed and incongruous version of information management; we can only manage what has been captured and represented in physical artefacts through information. This means that the only thing that is managed is information. According to Wilson (2002a, b), KM is not only about managing knowledge but it also covers a wide variety of practices. There are two pre-existing fields, management of information and management of people, which are covered by an umbrella called KM. According to Vasconcelos (2008), managing people will lead to maximising the advantage of using knowledge in an organisation. This idea opens different dimensions with a wider scope to the classic processes of managing information. Information is meaningful and an aggregated form of organised facts; whilst knowledge is an abstraction form of information which is influenced and shaped by cognitive frameworks and experience. In this sense, KM is different from information management. The former relates to managing the knowledge of people; whereas the latter relates to managing facts and data.

In order to have a better understanding of KM, it is better to outline a different set of definitions which were introduced by different scholars in Table 2.7.

Table 2.7 – Definition of Knowledge Management

Definition of KM	Information Scientist
“is the process of capturing, distributing and effectively using knowledge”	<b>Davenport (1994)</b>
“is the process of critically managing knowledge to meet existing needs, to identify and exploit existing and acquired knowledge assets and to develop new opportunities”	<b>Quintas et al. ( 1997)</b>
“is the activity which is concerned with strategy and tactics to manage human centred assets ”	<b>Brooking (1997)</b>
“is to understand, focus on, and manage systematic, explicit, and deliberate knowledge building, renewal, and application--that is, manage effective knowledge processes”	<b>Wiig (1997)</b>
“promotes an integrated approach to identifying, capturing, retrieving, sharing, transferring and evaluating an enterprise’s information assets. These information assets may include databases, documents, policies and procedures, as well as the un-captured tacit expertise and experience stored in individual worker’s heads”	<b>Gartner Group (1999)</b>
“refers to a systemic and organizationally specified process for acquiring, organizing and communicating both tacit and explicit knowledge of employees so that other employees may make use of it to be more effective and productive in their work”	<b>Alavi &amp; Leidner (1999)</b>
“is creating, securing, capturing, coordinating, combining, retrieving, and distributing knowledge”	<b>Tserng &amp; Lin (2005)</b>
“includes all the activities that utilize knowledge to accomplish the organizational objectives in order to face the environmental challenges and stay competitive in the market place”	<b>Greiner et al. (2007)</b>
“any process or practice of creating, acquiring, capturing, sharing, and using knowledge, wherever it resides, to enhance learning and performance in organisations”	<b>Armstrong, (2009)</b>
“is defined as a systematic process of gathering, organizing, sharing, and analyzing knowledge in terms of resources, documents, and people skills within and across an organization”	<b>Ma &amp; Yu (2010)</b>

The above definitions effectively draw conclusions. Initially, KM is a systematic process. Secondly, it involves critical activities such as identifying, capturing, organising, sharing, transferring and evaluating knowledge. Thirdly, it involves tactics and strategies to manage both information and human assets (e.g. databases and an individual’s skills). Fourthly, it involves all activities for developing new opportunities, increasing productivity and efficiency, and achieving an organisation’s objectives. Finally, one important factor that is not mentioned in the definitions is the importance and effect of information technology in KM. In this sense, the operational definition of KM would be:

*Knowledge management should be seen as an explicit and systematic process of learning issues in terms of creating, capturing, organising, retrieving, sharing, transferring and evaluating information assets and intellectual capital of individuals by*

*predicating on information technology and social interaction in order to increase efficiency, productivity and achieving objectives of organisation*

The concept of explicit and tacit knowledge was introduced by Polanyi (1966). Explicit knowledge could be articulated, codified, stored, and distributed in certain media; whilst the tacit knowledge is hard to capture and distribute because it is associated with experiences and skills of individuals (Easterby-Smith & Prieto, 2008). Because knowledge is a critical resource, KM is a fundamental and mandatory issue that brings success to an organisation (Binney, 2001). According to Wilson (2002, 2003), KM is not only about managing knowledge but it also covers a wide variety of practices. The aim of KM is to capture and distribute knowledge within a project's and organisations environment before it is forgotten or lost in order to improve effectiveness of all primary activities. In other words, effective KM will be a main source of the competitive advantage of an organisation by reducing time and cost of a project, and improving the project's quality and performance (Kivrak et al., 2008). KM is a wide concept that consists of various processes such as creating, securing, capturing, coordinating, combining, retrieving, and distributing knowledge (Kivrak et al., 2008). Some of these processes are briefly described.

### **2.7.1 Knowledge Capture**

Hari et al. (2005) state that capturing knowledge is the process of turning personal knowledge into corporate knowledge in order to be shared among involved individuals in projects. Therefore, identifying the critical knowledge sources in a project is a prerequisite for capturing knowledge. Egbu et al., (2003) considered the involved individuals in projects to be the most important knowledge source. Kivrak et al. (2008) state some knowledge sources of companies that could facilitate the knowledge capturing process which are listed according to their importance: colleagues, company's experience, personal experience, company documentation, current project documentation, project team meetings, intranet, personal library, clients, internet, knowledge brokers external to the firm, and external events (conferences, seminars). However, the operational definition of knowledge capture adopted in this research is:

*An iterative process of identifying the source of tacit or explicit knowledge and using appropriate techniques and technologies to retain it*

### **2.7.1.1 Knowledge Repository**

As knowledge is a key asset for individuals and organisations, it should be captured and saved in repositories in order to be reused in future projects. The benefits of using knowledge repositories includes saving costs and time and increasing efficiency (Meyers & Zack, 1996; Bukowitz & Williams, 2000). In other words, knowledge repositories would prevent the phenomenon of reinventing the wheel, a notable problem in project organisations, by providing captured knowledge from previous projects and transferring it to project members. This captured knowledge includes solutions that were created and developed by project members during the lifecycle of previous projects. Therefore, project members in new project would not need to spend more time to create and develop solutions that are already existed. Although, the objective of the knowledge repository is to transfer knowledge from previous projects into new project and make it available for immediate action in practice. Therefore, if any problems occur with the new project, the information from previous projects would be readily available for the current project managers.

March (1991) and Gray (2001) define knowledge repositories as collections of documents that could be used to transfer organisations' codified knowledge resources. In other words, knowledge repository acts as a bridge that connects knowledge capture and knowledge use (Meyers & Zack, 1996). Therefore, once knowledge is captured, its content should be standardised in a generic format or 'refined' within the repository (Bukowitz & Williams, 2000) in order to be efficiently useful for transferring. Moreover, the operational definition of knowledge repository in this research is:

*Collections of tacit and explicit knowledge of individuals which are systematically organised and categorised*

### **2.7.2 Knowledge Sharing**

Knowledge sharing is one of the important aspects of KM (Riege, 2005). There have been various definitions of knowledge sharing by researchers. Hickins (2000) describes knowledge sharing as the process of capturing tacit knowledge of individuals and transforming it into a shareable form. It is also defined as "activities of transferring or disseminating knowledge from one person, group or organisation to another" (Lee, 2001). Cummings (2004) has defined

knowledge sharing as “the provision of receipt of task information, know-how, and feedback regarding a product or procedure”. According to Berggren et al. (2011), knowledge sharing is “the process of developing trans-specialist understanding through creation of overlapping knowledge fields”. The important factor that was ignored by researchers is the difference of knowledge sharing and knowledge transfer which is the unidirectional flow of knowledge from one group, department or a project to another. Therefore, the operational definition adopted for knowledge sharing in this research is:

*The process of capturing tacit or explicit knowledge and using appropriate techniques and technologies to transform it into shareable form, and share it between individuals in a group or organisation involved in a project*

The nature of knowledge (tacit or explicit) plays a significant role in the process of knowledge sharing in the organisation and projects (Aziz et al., 2012). Sharing tacit knowledge is difficult because it is an unarticulated knowledge that is stored in an individuals’ mind and requires the full potential of personal interaction in order to build trust and share understanding between the knowledge holder and recipient. Therefore, the knowledge sharing process leads to provide more knowledge for both the project’s members and organisation (Aziz et al., 2012).

### **2.7.3 Knowledge Transfer**

Knowledge transfer is a critical process in KM that enables knowledge to transfer (Cranfield & Yoong, 2007). It is the process of moving knowledge, skills and experience from one knowledge entity like an individual, group, or organisation to another in order to assimilate, accumulate, and develop new knowledge, ideas, processes, and practices in the receiving unit (Szulanski, 2000; Carlilo & Rebentisch, 2003). Studies about practitioner and project learning have pointed out that there is a need to transfer knowledge within and between projects (Baccarini, 1999; Schindler & Eppler, 2003; Walker, 2004; Bower & Walker, 2007). Regarding the aim of this research, the operational definition of knowledge transfer will be:

*The process of moving knowledge, experience, and skills of individuals and groups from a completed project to a new project in order to share and reuse captured knowledge that would lead to development of new ideas, processes, and practices*

As project knowledge and experiences can be used in other projects, it would be essential to share the captured knowledge across projects in order to avoid unnecessary rework (Love et al., 2004; Carrillo, 2005). Knowledge transfer plays a significant role in project-based organisations. Most project-based organisations tend to embark on rework thereby repeating the same mistakes due to the lack of awareness of the importance of knowledge transfer and its impact on project performance (Desouza & Evaristo, 2006; Landaeta, 2008). In fact, the lack of effective knowledge transfer would lead to the captured knowledge from a previous project not being efficiently reused in other relevant projects and would cause time loss, errors, and unnecessary rework. Ekambaram et al. (2014), state three main issues in the disregarding of knowledge transfer in a project:

- *Inadequate decision making*: project members cannot make effective decision because the existing knowledge is not considered
- *Reinventing the wheel*: project members will spend more time to create and develop solutions that already exist
- *Lack of work process planning*: not utilising existing knowledge will lead to have no standard and detailed work process planning

According to Kwawu et al. (2010), different mechanisms have been used to transfer both types of knowledge, tacit and explicit, from individuals, group or organisation to another; including training programme, observation, implementation, project reviews, communities of practice, discussion forum, technology transfer seminars/conferences, face-to-face meetings, etc. However, these mechanisms are highly dependent on the project manager. In fact, it is the responsibility of the project manager, as the centre of project network, to develop and continuously maintain a communication chain between project members that requires social communication and explicit information channels such as project documents. The crucial issue in successful and effective transfer of knowledge between different projects is the way in which knowledge is captured and codified for reuse. Udeaja et al. (2008) state that the process of knowledge transfer should seek to do the following:

- Provide knowledge that can be utilised at the operational and maintenance stage of the asset's lifecycle

- Facilitate the reuse of the collective learning on a project by individual firms and teams involved in its delivery

#### 2.7.4 Knowledge Integration

The processes of knowledge development depend on specific contexts and settings that have different mechanisms and structures. These processes affect the way in which knowledge is transferred, shared, and used in other contexts like integration. According to Gherardi (2000), knowledge development is a ‘continuous’ process where there is a link between ‘doing’ and ‘knowing’. From this point of view, KI is understood when it occurs in the activities performed.

There have been various definitions of KI by researchers. Carlilo (2004) indicates that KI is the process of transferring, translating and transforming knowledge between individuals involved within the same organisation. It is also defined as “a dynamic process which relies on the team’s ability to iterate between a variety of specific KI mechanisms, some of which are based on face-to-face interaction and communication and some of which are not” (Enberg, 2007). Haddad and Bozdogan (2009) have defined KI as “the process of transferring knowledge, both tacit and explicit, across organizational boundaries, sharing it with individuals and teams at the recipient site, and applying the resultant knowledge to solve problems”. Table 2.8 represents different definitions of KI and Table 2.9 presents an overview of the most cited literature related to KI.

Table 2.8 – Definition of Knowledge Integration

Reference	Knowledge integration
<b>McElroy (1999)</b>	"The process by which an organization introduces new knowledge claims to its operating environment and retires old ones".
<b>Enberg (2007)</b>	"a dynamic process which relies on the team’s ability to iterate between a variety of specific knowledge integration mechanisms, some of which are based on face-to-face interaction and communication and some of which are not".
<b>Haddad &amp; Bozdogan (2009)</b>	"Knowledge integration is bringing diverse knowledge from multiple sources to bear on a complex problem or task" " the process of transferring knowledge, both tacit and explicit, across organizational boundaries, sharing it with individuals and teams at the recipient site, and applying the resultant knowledge to solve problems"

KI plays an important role in KM which has been addressed by different scholars (Carlilo, 2004; Enberg, 2007, Haddad & Bozdogan, 2009; Baiden & Price, 2010; Ruan et al., 2011). It has a

direct impact on project performance and project delivery team effectiveness (Baiden *et al.*, 2006).

Analysing the definitions of KI presented in Table 2.8 and 2.9 shows that none of the mentioned definitions is complete and in line with the topic of this research. In other words, most of the definitions only considered knowledge transfer and proposed collaboration as a solution for integrating knowledge. Only definitions that are proposed by Carlilo (2004), Haddad and Bozdogan (2009) are close to the research topic but do not cover all sub-process of KI. For instance, the Haddad and Bozdogan (2009) definition on KI does not support the process of capturing knowledge. Therefore, the following operational definition of KI is proposed for this research:

*Knowledge integration is the process of capturing, sharing, and transferring knowledge, both tacit and explicit, within and across project in order to improve the project performance*



Table 2.9 – Overview of literature on Knowledge Integration

Researcher	Focus	Results	Method
<b>Ancona &amp; Caldwell, 1992</b>	External team interactions with the environment	Vertical negotiation and horizontal task coordination as well as scouting for technical knowledge increase team performance	Conceptual & Hypothesis-test
<b>Nonaka &amp; Takeuchi, 1995</b>	Creating new knowledge through a cycle of articulating, sharing, combining, absorbing	Knowledge must spiral up from individuals to groups and across organisational boundaries in order to realise its value	Conceptual
<b>Szulanski, 1996</b>	Impediments to knowledge transfer inside the organisation	Knowledge ambiguity, lack of trust and arm's length relationships impede the transfer of knowledge inside the organisation	Conceptual & Empirical
<b>Grant, 1996 (a)</b>	Knowledge integration as the basis for the knowledge-based theory of the firm	Efficient knowledge integration by using multiple informal and formal mechanism, tacit and explicit, flexibly and simultaneously	Conceptual
<b>Grant, 1996 (b)</b>	Knowledge integration as the means for evolving organisational capability	Tacit knowledge is integrated by routine tasks and activities, explicit knowledge by codified directives, procedures, technology	Conceptual
<b>De Boer et al., 1999</b>	Knowledge integration as a function of organisational forms and capabilities	Integration design and architectural knowledge relies on the firm's socialisation, coordination and information systems capabilities	Conceptual & Case-study
<b>Hoopes &amp; Postrel, 1999</b>	Product development performance as a function of intra-firm knowledge integration	Increasing product complexity requires increased knowledge sharing across boundaries and early specs development	conceptual & Case-study
<b>Dyer &amp; Nobeoka, 2000</b>	knowledge integration through collective learning routines across organisations	Network-wide communities, people rotation, dedicated resources and free assistance to members increase network learning	Conceptual & Empirical
<b>Aoshima, 2002</b>	Knowledge transfer across product generations	Transfer system knowledge by rotating engineers; transfer component knowledge by documents and information systems	Hypothesis-test
<b>Edmondson &amp; Sole, 2002</b>	Knowledge integration to bridge gaps across geographically dispersed IPT's	IPT members compensate for knowledge gaps by drawing on broader and deeper expertise and skills in communities of practice	Conceptual & Case-study
<b>Hansen, 2002</b>	Knowledge integration across team boundaries in an organisational network	Direct inter-team connections are beneficial for transferring tacit knowledge, but inefficient for transferring codified knowledge	Conceptual & Hypothesis-test
<b>Okhuysen &amp; Eisenhardt, 2002</b>	Formal interventions for improving group flexibility and knowledge integration	Questioning others enables knowledge integration in groups, while information sharing internally has little to no impact	Hypothesis-test
<b>Carlil, 2004</b>	Knowledge integration across syntactic, semantic and pragmatic boundaries	IT systems, liaison individuals and negotiators or modellers to transfer, translate and transform knowledge respectively	Conceptual & Empirical

## 2.8 Knowledge Management in Construction

The UK construction industry has in excess of 1.5 million employees and constitutes approximately 20 percent of total enterprises in UK. This industry plays a significant role in the gross domestic product (GDP) of the UK which contributes around 8 per cent (Construction 2025, 2013). Furthermore, 99 percent of organisations are SMEs in this industry and construction activities are highly knowledge-intensive which require effective management (Hari et al., 2005).

According to Latham (1994) and Egan (1998) report, the UK construction industry has suffered from performance problems and has been in transition to overcome this issue. In order to improve overall performance of construction industry, two core factors, knowledge and learning, should be considered more (CRISP, 1995; OST, 1995). The term 'knowledge management' and the way in which to achieve it are a new category and essential in knowledge-based industries like construction (Carrillo et al., 2000; Hari et al., 2005). KM has a vital role in improving the efficiency of project delivery and competitiveness of organisations (Egbu, 2005; Sheehan et al., 2005; Fong, 2005). Therefore, the implementing KM in construction organisations is confronted with challenges such as capturing, sharing, and transferring information and knowledge across projects, due to the fact that construction projects are likely to be short-term, project-based or task-oriented. Furthermore, Egbu and Botterill (2002) claim that the rate of developing and generating new ideas and knowledge are very low because the technical knowledge that was achieved from one project is usually lost or will not be used in the next project (Figure 2.5). In essence, for being competitive and improving project performance it is necessary to capture, share, and transfer knowledge and experiences that are achieved from previous projects (Lee & Egbu, 2005).

Reviewing relevant literature suggest that KM needs to be studied and explored more in the construction industry; specifically more empirical research in project-based environments (Egbu, 2001; Chan et al., 2006).

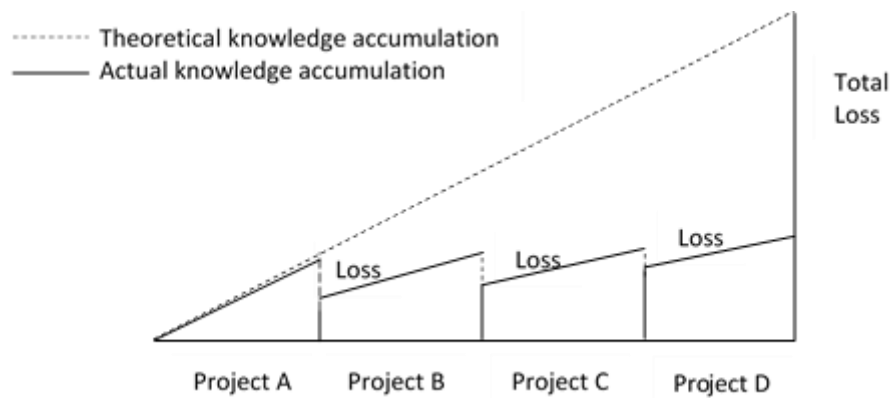


Figure 2.5 – Knowledge Accumulation and Loss Across Projects

The KM research in the construction industry investigated over the last decade is presented in Table 2.10. A significant amount of research has focused on the appropriate taxonomies and ontologies of KM and the importance of knowledge retrieval for the organisation (Rezgui, 2006; El-Gohary & El-Diraby, 2010; El-Gohary & El-Diraby, 2011; Wang et al., 2011; El-Diraby, 2013). Furthermore, researchers have also focused on different aspects of KM within construction projects; people, state of the practice, and implementation (Javernick-Will, 2012; El-Diraby, 2013; Zhang & Tan, 2013; An et al., 2014). Researchers developed theoretical frameworks to bridge and overcome difficulties and challenges that exist in the implementation of KM in the construction industry. These challenges and frameworks are briefly discussed in next section.

Table 2.10 – Knowledge Management Research in Construction

Reference	Research
<b>Carrillo et al., (2003)</b>	Proposing 'IMPaKT' framework, focusing on business impact of KM strategies in AEC organisations
<b>Cheng et al., (2003)</b>	Proposing 'CLEVER_KM' tool for developing KM strategy for AEC organisations
<b>Tsreng &amp; Lin (2004)</b>	Proposing an activity based KM system for capturing knowledge generated in construction phase
<b>Lin et al., (2005)</b>	Developing a knowledge map framework for capturing and reusing knowledge construction projects
<b>Tan et al., (2007)</b>	'Capri.net' – a web based KM system for live capture and reuse of project knowledge in the same construction project as well as future projects

## 2.8.1 Knowledge Management Approach in Construction Project

Generally, KM approaches are classified into two categories: process and object approach (Alavi & Leidner, 2001). The former views knowledge as a process of applying expertise and focuses on the tacit aspect; whilst the latter views knowledge as an object or product that can be stored and manipulated (explicit aspect). However, the researcher considers the SECI model, introduced by Nonaka and Takeuchi (1995), as an approach in this research.

The actions of individuals, construction organisations, and project teams along with the interaction of different types of knowledge (tacit and explicit) between the design phase and construction phase will lead to create construction project knowledge. Nonaka and Takeuchi (1995) introduced four modes of interaction that result in the creation of knowledge. This theory of knowledge creation is known as SECI model (Figure 2.6).

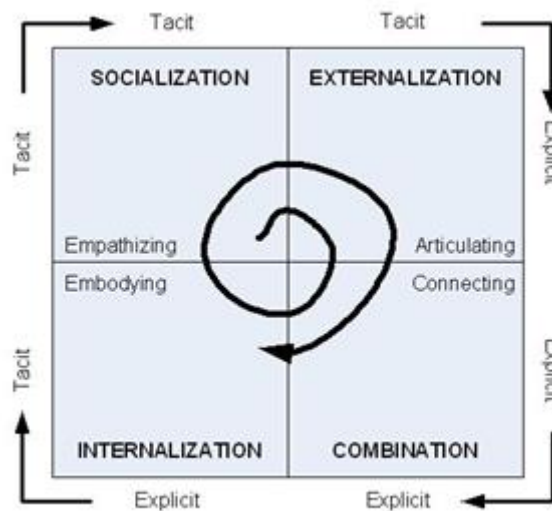


Figure 2.6 – Knowledge Creation Theory (Nonaka and Takeuchi, 1995)

*Socialisation* is the process of tacit to tacit knowledge interaction that involves capturing, transferring, and sharing tacit knowledge through social interaction like face-to-face or experiences. In the construction context, an example of this type of interaction is when an architect gives an explanation of a design concept to a client or other project members during a meeting. However, this continual interaction leads to reinforce and develop experiential knowledge through sharing experiences. *Externalisation* is the process where tacit knowledge is transformed to explicit. For example, architects provide a written instruction or translate a design concept into sketches to explain to engineers and quantity surveyors. *Internalisation* is the reverse process where explicit knowledge is transformed to tacit by individuals through

recognising patterns, connection and making sense between fields, concepts, and ideas. In the construction context, an architect could interpret explicit documents (books or manuals on design standards) to create a mental model of a unique design. *Combination* is the process of explicit to explicit knowledge interaction through the process of gathering, integrating, transferring, diffusing, and editing knowledge. For example, explicit knowledge in the form of project documents (design brief, engineering documents, contracts, performance specification) is integrated and processed by technologies like databases, emails, and CAD systems in order to convert and create explicit knowledge.

This approach mostly covers all processes of KM in construction projects and is in line with the operational definition of KI (section 2.7.4). Therefore, the SECI model approach is suggested for this research; mainly focusing on socialisation, externalisation, and internalisation modes of interaction.

### **2.8.2 Knowledge Management Challenges in Construction**

From the project perspective, Egbu (2001) considers KM in all the ways in which projects can benefit from knowledge of individuals and knowledge that has been created from previous projects. Regarding this perspective, KM challenges are classified into two categories. The first is to identify existing challenges in project environment that affects KM. The second is to identify the means of implementing, exploiting, and sharing knowledge of individuals and projects in order to enhance project success and increase the benefits of a project's clients.

Carrillo et al. (2000) consider four main challenges that confront KM in the construction industry. They are:

- Ignorance of the value of the employee
- Tacit dimension of project knowledge
- Hierarchical organisational structures
- Multi-disciplinary teams in project process

Carrillo et al. (2000) support these challenges by presenting ten challenges that affect successful implementation of KM in construction enterprise. These include: Lack of Time, Trying to solve large problems, Converting Knowledge, Large number of SMEs, Multi-

Disciplinary Teams, Lack of Learning, Lengthy Time Period, Loss of faith and IT support. Furthermore, they developed a theoretical framework (Figure 2.7).

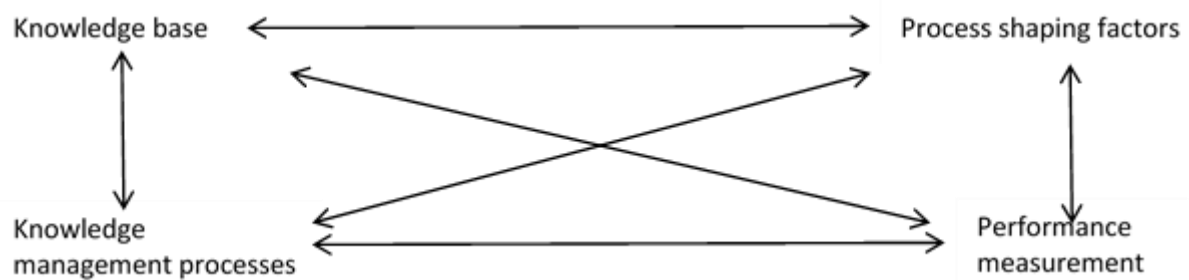


Figure 2.7 – Conceptual framework for Knowledge Management (Carrillo et al., 2000)

This framework illustrates four categories which are internally connected to each other and involved in managing knowledge. The ‘knowledge base’ consists of data, information, and project knowledge that need to be identified and managed. The ‘KM processes’ includes activities, tasks, processes and tools that are required to capture, share, reuse, and manage knowledge. The ‘Process shaping factors’ include issues that clarify the need for knowledge and the way in which it is applied within the organisational structure (the context of use). The last factor, performance measurement, deals with the measurement and assessment of implemented and used knowledge in an organisation and the way in which this knowledge improves business performance.

Some issues do overlap when considering this framework with the challenges of managing knowledge in construction industry, which are identified by Carrillo et al. (2000). In other words, this framework could be useful in managing knowledge in the construction industry. However, the fact that should be considered is that the three categories, KM processes, process shaping factors and knowledge base, are integrated, interrelated to each other, and should not be considered separately in the implementation process of KM. Although Carrillo et al. (2000) presents this framework with the interrelationships between the four categories, it is not possible to clarify and describe the way in which these categories interact in the organisational dynamic context, specifically the usage of KM in construction industry. Furthermore, challenges that were identified by Carrillo et al. (2000) from the construction project context cannot be bridged and overcome by implementing this framework.

According to Wetherill et al. (2002), knowledge is classified into three categories in the construction industry; *Domain knowledge, Organisational knowledge* and *Project knowledge*.

- Domain knowledge refers to the knowledge that is available to all companies like: technical rules, administrative information, product databases, etc. In other words, this type of knowledge forms the overall information context and could partly be stored in electronic databases
- Organisational knowledge, also called intellectual capital, refers to the specific type of knowledge, either tacit or explicit, that belongs to a specific company. This type of knowledge could be stored both formally in organisation's documents and informally through the skilled processes of organisation. In other words, it includes knowledge that is achieved by employees from project experience, personal skills, and cross-organisational knowledge that is collected from business relationships with clients, engineering companies, architects, contractors, and with other partners
- Project knowledge is the source of the two types of knowledge that are identified above. It refers to both the knowledge that is created and achieved from communications and interactions between companies and the knowledge that each company has about the project. This type of knowledge cannot be capitalised on for creating knowledge by companies and partnerships because it does not have a form to be reused (e.g. solutions to technical problems or avoiding repeated mistakes). Wetherill et al. (2002) mention this type of knowledge which includes "both project records and the, recorded and unrecorded, memory of processes, problems and solutions"

Wetherill et al. (2002) identify seven limitations and challenges in managing the above knowledge in the construction industry. First, individuals who are working within the domain hold much of construction knowledge. Secondly, decisions are made without recording and documenting the reasons and intent that exists behind them. Thirdly, sometimes individuals may not be aware of the importance of collecting and recording a project's data and information for other actors who are involved in the project and might use the information. Fourthly, the collected and archived data at the end of the construction stage may not always be managed properly. Sometimes, the knowledge that involved individuals gained during the project is not captured when the project is finished. Fifthly, "Lessons learned are not organised well, and buried in details. It is difficult to compile and disseminate useful knowledge to other projects" (Wetherill et al, 2002). Sixthly, usually the historical reports of projects that are held

by companies do not include a rich representation of data context and the individuals who prepared the reports are the only ones who can understand the hidden meanings. As people move from one company to another, it is difficult to reach the author of the original report. Finally, managing knowledge between and within firms and companies presents new approaches and challenges. Wetherill et al. (2002) mention that these new approaches “imply major changes in individual roles and organisational processes. While the potential gains are desired, the necessary changes are resisted.”

Implementing IT technology for managing knowledge has become popular in the construction industry. Researchers believe that IT technology could be used for capturing, storing, indexing and retrieving project information and knowledge which will enhance and develop KM in the construction industry. Some of these technologies are; Collaborative Construction Information - CCIN (Sun et al., 1999), e-Cognos infrastructure (Wetherill et al., 2002), Cross Organisational Learning Approach - COLA (Orange et al., 2005), Dynamic Knowledge Map (Woo et al., 2004), Event Database – Audio Diary (Lee & Egbu, 2005). In fact, most of these frameworks focus on IT support within KM.

Having said that the existing frameworks highly based on IT support within KM, they did not consider the tacit and social dimension of knowledge as two critical issues and elements within the application context in managing knowledge in the construction industry. The lack of considering these issues will lead to failure of managing knowledge properly. In other words, the existing frameworks fail to address the way in which knowledge should be retrieved from information. Knowledge can be captured and stored as information by an IT infrastructure and then knowledge can be retrieved and used in working practice only when individuals can understand it. These frameworks presume that once individuals get information then they can get knowledge. In fact, two concepts of ‘information’ and ‘knowledge’ are mixed in the statements of frameworks. In reality, for transferring and transforming information to knowledge individuals need assistance. As IT tools alone cannot efficiently perform the conversion process of knowledge, other conditions are required to be in place. McDermott (1999) points out these conditions: face-to-face contact, common language, trust, and time to interact between participants. According to Kogut and Zander (1992), the degree of codification and complexity are two important factors that affect transferability of knowledge



between organisations. It would be better to mention that these factors affect the transferability process of knowledge both between organisations and projects.

According to Sveiby (1997), social interaction plays an important role in knowledge creation, due to the fact that knowledge is embedded in people. Furthermore, Egbu et al. (2005) point out that all existing models mentioned above ignored the impact of social interaction, human-to-human, on the process of transferring and sharing knowledge. The existing models emphasise information technology (IT) and less about people (Scaborough, 1999). It can be concluded that there are more proper and efficient means of solution. Therefore, Egbu (2001) and Cross et al. (2006) suggests different methods and activities for transferring and sharing tacit knowledge such as coaching, quality circles, networking, mentoring, communities of practices (CoPs), and storytelling. In fact all of these methods and activities are social networking activities.

Many researchers (Hari et al., 2005; Bessick & Naicker, 2013; Ekambaram et al., 2014) have investigated the major drivers and challenges of KM in the construction industry. Kamara et al. (2002) and Carrillo et al. (2004) state that the need to improve performance and the need to share valuable tacit knowledge are the main drivers in the UK construction industry. Therefore, implementing KM in construction organisations presents challenges such as capturing, sharing and transferring information and knowledge across projects, due to the nature of construction projects which are unique, short-term, project-based, or task-oriented. People who work on these projects, both in design and construction teams tend to disperse after the project ends. This means their acquired experiences and knowledge obtained from the project will be wasted and not be used in future projects (Kasvi et al., 2003). This issue is seen more common in the traditional-based construction projects because they are based on the separation of design and construction process. Aziz et al. (2014), state that the traditional construction process approach has been criticised for several issues:

- *Failure to form effective teams*
- *Separated approach to project delivery*
- *Time delay*
- *Lack of communication and coordination*
- *Rising costs*

- *Rework and Wastages*

However, it is necessary to put in place the structure that facilitates participation and interaction of involved people in the design and construction process to integrate knowledge, in terms of capturing, sharing, and transferring across the traditional-based construction project in order to improve project performance. Therefore, project manager needs to consider challenges that are involved in these processes.

### 2.8.3 Summary of Knowledge Management Challenges

A brief summary of the KM challenges (two main categories with their sub-categories) which have been discussed in the previous section are provided below (Table 2.11). However, it should be mentioned that the lack of considering tacit and social dimension of knowledge are two critical issues in managing knowledge in the construction industry.

Table 2.11 – Knowledge Management Challenges Classification

Knowledge Management Challenges		
<b>Main Categories</b> (Egbu, 2001)	Identifying existing challenges in project environment that affects KM	Identifying the means of implementing, exploiting and sharing knowledge of individuals and projects
<b>Sub-categories</b> (Carrillo <i>et al.</i> ,(2000)	<ul style="list-style-type: none"> <li>• Ignorance of employees' value</li> <li>• Hierarchical organisational structures</li> </ul>	<ul style="list-style-type: none"> <li>• Tacit dimension of project knowledge</li> <li>• Multi-disciplinary teams in project process</li> </ul>

## 2.9 Knowledge Integration in Construction

The KI procedure is critical to project performance (Nonaka & Takeuchi, 1995), especially in a project-based industry like construction. Several studies have been conducted on KM in construction projects, but only few of them focused on KI between different construction projects (Adenfelt & Maaninen-Olsson, 2007; El-Gohary & El-Diraby, 2010). From the working perspective, KI is defined as the process that leads to a practical solution by contributing the expertise and knowledge of all involved parties. According to Mitchell (2006), KI is the ability to integrate internal and external knowledge to respond to environmental change. In other words, the KI process should enhance the dynamic capacity of organisations in a way to

prevent environmental changes affecting the project performance. KI in this study is the process of capturing, sharing, and transferring knowledge within a project environment.

The importance of KI has attracted discussions in both academia and industry. Having a better understanding of KI between projects and their organisational context is vital, due to the importance of knowledge in organisations and projects (Koskinen et al., 2003). There are three most common characteristics within projects. First, projects are temporarily organisational units which mean they only exist until the original assignments and goals of projects are completed and achieved. Secondly, projects are unit of individuals who are located in different places and sometimes in different organisations. Thirdly, projects may be unique in design, implementation and independent of its organisational context (Adenfelt & Maaninen-Olsson, 2007).

According to Ochieng and Price (2009), temporary organised teams, unpredictable working schemes and unique project designs are characteristics of construction projects which present challenges and have direct impacts on KM applications in the construction industry. This issue is more common in a construction project undertaken through the TPS because the nature of this system is based on the separation of design and construction process (Aziz et al, 2014). The focus of scholars and researchers about implementing KM applications in the construction industry has been changed from how to manage knowledge within particular projects to how to manage knowledge across projects (Egbu, 2000; Egbu & Botterill, 2002). Furthermore, this change highlights the challenges that confront managing knowledge across projects.

As knowledge is the most value-added input and output of projects, then the study of KI between teamwork within project and across projects will provide a meaningful insight for stakeholders and academics that enable them to improve further the performance and competitiveness of industry. Baiden et al. (2006) state that gathering individuals with different skills and knowledge from different organisations in the form of an integrated project team can be efficient and effective for an organisation. In other words, such an integrated project team has the potential to create new skills and knowledge. This viewpoint is also in line with the study of Briscoe and Dainty (2005) that explored the importance of effective communication and information management as tools for combining the knowledge of different involved individuals in projects. These assets will lead to effective KI. Furthermore,

El-Gohary and El-Diraby (2010) carried out the research which is in line with the above viewpoint and argued that not only simple exchange and integration of data but also KI of different work processes are highly encouraged for the construction industry. However, Carrillo (2004) indicates that the more effectively the knowledge is managed, the better project performance will be. The research focus of Carrillo (2004) is within individual organisations, whilst knowledge of experts, who are involved in different organisations; is required in most project activities in the construction industry.

On the other hand, many researchers have argued the involvement and the effect of project change in KM in academic research, because this issue involves a range of organisations. According to Egbu et al. (2003), project change is like an effective vehicle that can be used to enable knowledge production in construction projects. Furthermore, Sexton and Senaratne (2008) explored this issue and advocated that a project change can be used as a problem-solving process in construction projects, because it requires both knowledge and information processing from individuals that involved in project team. However, the fact that is not discussed and explored by researchers is the importance of KI across projects and organisational borders. Researchers suggest that knowledge sharing is a complex and essential social process in construction projects. In addition, KM is highly dependent on social capital and informal networks in the construction industry. However, a traditional economic theory, which is focused on transaction rather than network attributes, is used for analysing the process of a construction project (Styhre & Gluch, 2010).

The construction industry has suffered from low efficiency of project delivery due to its failure both to form effective teams and to implement a united approach to project delivery (Egbu et al., 1998). In other words, poor performance affects the efficiency of project delivery because it is caused by lack of integrated teams where project participants are unable to work together effectively. As cost and time overruns are ordinary, many resources are used to rectify the defects. Latham's (1994) and Egan's (1998, 2002) reports have challenged the construction industry and suggested the implementation and use of integrated and collaborative approaches rather than the traditional *modus operandi*. In addition, process and team integration are suggested as a key factor of change that is required to improve the performance within the construction industry and make it become more successful. The definition of success is varied and usually defined as the achievements in terms of individual

organisational metrics rather than the collective project outcomes (Cornick & Mather, 1999). Therefore, the construction industry has not fully benefited from teamwork or from achievements that can be result of KI within or across projects. A construction project encompasses a collaborative process which comprises the involvement of different organisations that constitute ‘the construction project team’.

Adenfelt and Maaninen-Olsson (2007), investigated the way in which project performance is positively influenced by integrating knowledge between projects. According to their studies, three main factors were identified:

- KI depends on interaction between the projects and the organisational context of the projects
- KI depends on concerned actors’ “time for reflection”, “the nature of the activities in the project”, and “interest and motivation of the involved actors”
- The role of KM for integrating knowledge

Despite the positive influence of these factors on project performance, they should be investigated in terms of challenges that exist in KI sub-processes.

## **2.10 Knowledge Integration Approach and Techniques in Construction**

KI across different construction projects should be considered within an overall strategy of construction organisations. According to Kamara et al., (2002) (mentioned in Anumba *et al.*, 2005), the KI in construction organisations should include the following factors:

- The capture of lessons learned and best practice in operational procedures, design guidelines, etc., which serve as a repository of process and technical knowledge. Post-Project Reviews(PPR) are usually the means for capturing lessons learned from projects
- The use of formal and informal feedback between providers and users of knowledge as a means of to transfer learning/best practice, as well as to validate knowledge (for example, site visits by office-based staff to obtain feedback on work progress)

- A strong reliance on the knowledge accumulated by individuals, but without a formal way of capturing and reusing much of this knowledge
- A strong reliance on informal networks and collaboration and “know-who” to locate the repository of knowledge
- The involvement (transfer) of people in different activities as the primary means by which knowledge is transferred and/or acquired
- Within firms with hierarchical organisational structures, there was a reliance on departmental/divisional heads to disseminate knowledge shared at their level, to people within their sections

All of the mentioned factors are associated, directly and indirectly, with the management of project knowledge. Therefore, drawing from the operational definition of KI and the SECI model approach adopted in this context, it becomes important to investigate the different techniques associated with the KI sub-processes.

### **2.10.1 Knowledge Capturing Techniques**

Considering knowledge sources will facilitate the knowledge capturer to use a proper technique. The knowledge sources were identified in previous section. According to Shokri-Ghasabeh and Chileshe (2014), different techniques of capturing knowledge from projects have been proposed by researchers. The following studies have been investigated: Von Zedtwitz (2003), Carillo (2005), Williams (2007), Kululanga and Kuotcha (2008), Fuller et al. (2011), and Henderson et al., (2013). An overview of their techniques is presented in Table 2.12. However, all the mentioned studies highlighted the benefits and impacts of capturing knowledge on the performance of organisations involved in construction industry, but it has not being prioritised in the organisational culture.

Table 2.12 – Different Knowledge Capture Approaches

Researchers	Techniques	Drawbacks
<b>Von Zedtwitz (2003)</b>	Post-Project Reviews (PPR)	Limited advice on how to capture knowledge during project process Limited advice on how to store, document and disseminate captured knowledge
<b>Carillo (2005)</b>	12 steps approach	Limited advice on how to store and disseminate captured knowledge
<b>Williams (2007)</b>	Identifying challenges to lesson learned process (knowledge capture)	
<b>Kululanga and Kuotcha (2008)</b>	Measuring project review process	
<b>Fuller et al., (2011)</b>	Event-Based	Required to adopt double-loop learning Restricted to the construction phases only Time-lag between capturing knowledge and reusing it in future project
<b>Henderson et al., (2013)</b>	Double-loop learning (After Action Reviews (AARs) Post-Occupancy Evaluations (POE) )	Time-lag between capturing knowledge and reusing it in future project

### ***Post-Project Reviews (PPR)***

The PPR technique aims to review both failed and successful projects to capture project knowledge by analysing the project, identifying the best practices, and addressing the success and failure factors in a project. This will lead to improvement in both the performance of organisations and their future projects as knowledge can be transferred to subsequent projects. Furthermore, this technique will enable involved individuals in projects to consult and learn from others who have done similar tasks in the past. The only drawback to this technique is that it does not consider how to capture knowledge during a project which is the most important. Furthermore, PPR does not advice on how the captured knowledge should be disseminated and reused in future projects. However, the beneficiaries of this technique are future projects, not the current one, and usually individuals are reluctant to engage in activities that lead to criticism. This technique will be effective, if adequate time is allocated for involved individuals in projects to participate in PPR meetings. However, it is crucial that

this technique takes place immediately after completion of the project as project members may be transferred or moved to other projects. Therefore, there is a need to improve the awareness for individuals of the importance in using this technique.

### ***12 Steps Approach***

Carillo (2005) mentioned a 12 step approach for capturing knowledge which was recommended by Collinson and Parcell (2001). The drawback to this technique is the lack of consideration for how effectively the captured knowledge should be stored and reused. The steps are:

1. Call the meeting
2. Invite the right people
3. Appoint a facilitator
4. Revisit the objectives and deliverables of the project
5. Revisit the project plan
6. Ask 'what went well?'
7. Find out why these aspects went well and express the learning as advice for the future
8. Ask 'what could have gone better?'
9. Find out what the difficulties were
10. Ensure that the participants leave the meeting with their feelings acknowledged
11. Determine 'what next'
12. Record the meeting

This technique will improve performance on future projects, which is desirable for many construction organisations and enable them to readily recall what went well on a project and attempt to recreate those successes. Furthermore, the important factor about this technique is the ability to avoid the repetition of previous mistakes. However, the drawback to this process is time consumption on capturing knowledge during a project and reviewing the captured knowledge when the project members are transferred to a new project (Carillo, 2005).



### ***Identifying Challenges***

Williams (2007) proposed a capturing knowledge technique by identifying and overcoming the challenges to the process of knowledge capturing. These challenges are:

- Lack of employee time
- Lack of management support
- Lack of incentive
- Lack of human resources
- Lack of clear guidelines
- Lack of support from others in organisation
- Our process does not capture useful lessons
- Data repository too hard to search
- Lessons are not transferable
- Wrong people are involved
- We already put in enough effort

Some of the main challenges and their appropriate critical success factors (CSFs) are further discussed in this chapter.

### ***Measuring Project Review Process***

A structured management framework was introduced by Kululanga and Kuotcha (2008) to measure captured knowledge by an organisation in project review process. This technique would be more effective if it is used the PPR technique. This process has nine variables:

- Timing for project reviews
- Project review team
- Systems approach to a project review
- Use of TQM tools in project reviews
- Recording experiences in project review
- Project review depositories for lessons
- Specific lessons learned from project reviews
- Sharing lessons learned from project reviews

- Implementation plan for lessons learned in a project review

This framework has the potential to influence the way construction managers analyse and control project reviews.

### ***Event-based***

The Event-based technique, as well as promotion of benefits measurement, were developed by Fuller et al. (2011) to integrate project knowledge by capturing, codifying, and sharing it. This approach is cyclic and consists of seven main factors:

- Identification of lessons
- Prioritisation
- Selection of best ideas
- Benefits card preparation
- Review/ looking back
- Implement/ looking forward (post-event)
- Personal reflection (pre-work)

This technique uses some facilitators in undertaking some tasks during the process of capturing knowledge as “benefits card preparation”, which is similar to step 3 of the 12 step technique proposed by Carillo (2005).

### ***After Action Reviews (AAR) and Post-Occupancy Evaluations (POE)***

Henderson et al. (2013) suggested that there is a need for adopting double-loop learning to cover the limitations of two knowledge capturing techniques, AARs and POE, for addressing buildability-related issues. The main drawback to AARs is that it is only limited to construction phases. On the other hand, POE is less focused on capturing knowledge from the design phase and more focused on evaluating the final product’s functionality in use (Henderson et al., 2013). Therefore, AARs and POE are complementary and according to Henderson et al. (2013), a ‘double-loop learning’ technique would be an effective technique for capturing knowledge in both the design and construction phase.

Despite the benefits of mentioned techniques, Carillo (2005) highlights the main concerns about these techniques; both the process of capturing project knowledge and process of

transferring and reusing knowledge by project members in new projects take a long time. In other words, the KI process takes a long time, specifically in the construction industry, which is a main concern.

According to Matsumoto et al. (2005), the knowledge-capture report (KCR) could be used as a tool for capturing knowledge generated on projects. This tool has the ability to be used in a construction project and integrated with the design process which will enable the project team members to capture the main decisions, events, and design details. The KCR of each project could be used for sharing knowledge or the re-use of knowledge in a future project.

#### **2.10.1.1 Building Information Modelling (BIM) and Knowledge Repository**

BIM is defined by the National BIM Standard as “a digital representation of physical and functional characteristics of a facility, which is forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition” (BSA, 2012). In other words, BIM represents a three dimensional digital model of a building and provides a platform for project members to get access, share, and exchange information and data concerning the project. However, it should be noted that BIM is not only about technology and exchanging information but also about the process of the project life cycle and the facilitation of the communication of involved individuals in the project during the design and construction phase. In other words, it is a context rich, centralised platform that contains design and some construction information. BIM enables organisations to use the data and information more intelligently. Figure 2.8 illustrates the BIM maturity diagram model which was developed by Mark Bew and Mervyn Richards in 2008 (Richards, 2010). This model has three levels from 0 to 3 which enables the users to understand the processes, tools and techniques to be used in BIM.

According to the Government Construction Strategy, published by the Cabinet office on May 2011, all government construction projects will be using BIM level 2 by 2016. The report indicated that BIM level 3 will be implemented in all construction projects by UK Government and the construction industry by 2025. The level 3, known as ‘iBIM’ or integrated BIM, is an open process and data integrated which enables collaboration between all project members by means of using a single and sharable project model which is held in a centralised repository (Sackey *et al.*, 2013).

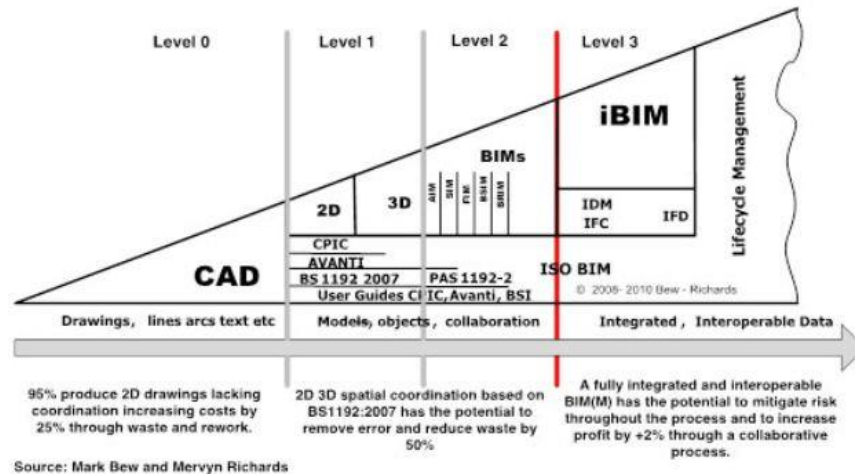


Figure 2.8 – BIM Maturity Diagram

In the UK construction industry, BIM is being viewed as a both technical and valuable process to determine the performance of projects, facilitate the communication, mediate between project members, promote learning, and manage knowledge (Bouazza et al., 2015). BIM applications are information-assisted building modelling technologies and are not mature enough to capture knowledge. It can be improved and integrated with KM approaches in order to capture, share, and transfer knowledge in construction projects. In construction project, one of the criteria for effective KM is having the ability to communicate and preserve knowledge effectively across the design and construction phase of project. In this regard, BIM can be used as a means for learning and managing knowledge effectively through the entire design cycle from pre-designing through the construction phase.

Bouazza et al., (2015) investigate research projects on the potential of using BIM in managing knowledge in construction project delivery. Some of these recent research is:

- Moving from BIM to Building Knowledge Model (BKM) potentially facilitates the collaboration of team members in digital design through using two models which are the Issue-Concept-Form (ICF) and the Schema Emergence in human mind and digital design (Oxman, 2009).
- Developing a building knowledge modelling (BKM) approach that integrates BIM and KM to capture knowledge and reuse it in BIM processes. This approach requires the integration of an intermediate module called 'Knowledge+' which is used to connect BIM with a Knowledge Management System (KMS) (Liu et al., 2013).

- The BIM-based Knowledge Sharing Management (BIMKSM) system is proposed as a visual platform that combines a BIM approach and web technologies. This approach increases the use of BIM approach in sharing knowledge in construction projects (Jan et al., 2013).
- A new method that captures knowledge during the design phase and construction phase utilizing the parametric of BIM models through Industry Foundation Class (IFC) format (Deshpande et al., 2014).

The IFC format can also be used as an approach for extracting data in BIM model. In other words, the BIM model can be exported through the IFC file which can be used for describing, exchanging and sharing information between various software applications used in the construction industry, because it uses an international platform neutral standard specification (ISO 16739). According to the BIM maturity diagram (Figure 2.8), the IFC file is allocated at level 3. However, the Construction Operations Building Information Exchange (COBie), which is mostly used at BIM level 2, is one of the most developed information exchange standard which facilitates the exchange of digital information between the design and construction phase (Sackey *et al.*, 2013). According to the report for the Government Construction Client Group Building Information Modelling (BIM) Working Party Strategy, published on March 2011, COBie is a data format for the publication of a subset of building model information focused on delivering building data, not geometric modelling.

As mentioned in the above section, different techniques could be used for capturing knowledge. The captured knowledge needs to be stored in a knowledge repository (section 2.7.1.1) in order to be shared and transferred among project members and across projects. Regarding to the definition of COBie and IFC files, BIM technology can benefit from them in developing a repository which shares digital building information models (Liu et al., 2013). However, it should be mentioned that the building knowledge repository depends on both using BIM technology and KM in the construction lifecycle processes in order to manage the corporate knowledge and increase the productivity and efficiency.

### **2.10.2 Knowledge Sharing Techniques**

Fong and Chu (2006) conduct a research on knowledge sharing and identified its different techniques in construction organisations in the UK. It was found that the professionals often

use informal chatting and storytelling for sharing knowledge with their colleagues. According to their study, 14 techniques for sharing knowledge in the UK construction industry have been used;

1. Informal chatting and story telling
2. Phone calls and teleconferencing
3. Meetings
4. Project briefing and reviewing sessions
5. E-mail
6. Intranet
7. Memoranda and letters
8. Internal training courses
9. Mentoring and tutoring
10. Talks and seminars
11. Internet
12. Internal newsletters and circulars
13. Newsgroup and web-based discussion
14. Knowledge sharing boards

The above techniques include sharing both tacit and explicit knowledge and are in line with SECI model approach which was adopted in this research. These techniques have been successful nearly 50% of the time in sharing by project members at workplace. This is due to the fact that these techniques are limited to certain practices (Fong & Chu, 2006). Individuals might use different and unique practices and styles for different types of communicative situations based on their role in projects and organisations.

### **2.10.3 Knowledge Transfer Techniques**

According to Kwawu et al., (2010), different techniques have been used to transfer both types of tacit and explicit knowledge from individuals, group or organisation to another. However, Cheng (2009) highlighted some methods for implementing knowledge transfer in construction projects. These techniques are presented in below Table.

Table 2.13 – Knowledge Transfer Techniques

Cheng (2009) – in Construction Project	Kwawu et al., (2010) - General
Written messages	Training programme
Face-to-Face communication	Observation
Project Reviews and Documents	Implementation
Meetings	Project Review
Mentoring	Communities of Practice
Integrating diverse knowledge through knowledge base and live capture methodology	Discussion forum
Building a knowledge-sharing organisational culture	Technology transfer seminars/conferences
adopting new forms of procurement	Face-to-Face meetings

All the techniques listed above are both formal and informal and can be facilitated by Information and Communication Technologies (ICT) like; online chats, multi-media, databases, email, and teleconferencing in order to transfer both tacit and explicit knowledge. However, these techniques are highly dependent on project managers. In fact, it is the responsibility of a project manager, as a centre of project network to develop and continuously maintain a communication chain between project members that requires social communication and explicit information channels like project documents. However, the direct and successful transfer of project knowledge heavily depends on tacit knowledge accumulated by project members.

#### 2.10.4 Summary

The KI sub-processes techniques will reveal that they are in line with the SECI model approach which was adopted in this research. These techniques will cover the socialisation, externalisation, and internalisation mode of interaction, which means knowledge could be transformed from tacit to tacit, tacit to explicit, and explicit to tacit in order to facilitate the KI process.

## 2.11 Knowledge Integration Challenges in Construction

As the positive effects of KI on project performance are mentioned, it would be better to investigate challenges that confront the sub-processes of KI.

### 2.11.1 Knowledge Capture Challenges in Construction

The knowledge capture process, like other sub-processes of KM, is confronted with challenges. After a thorough review of literature, these challenges are mainly categorised from three perspectives; Social issues, Technical issues and Process issues (Hari et al., 2005).

*Social issues* include challenges like; people, communication and networks, culture, motivation and structure.

*People issues:* usually, most of tacit knowledge captured through informal network in project team. Unfortunately, project members usually depend on the professional's help to find the appropriate document. This gives a professional an overwhelming feeling by receiving too many calls which will waste time. This means tacit knowledge of experts has not been captured in order to help team members to find key documents.

*Communication and networks issues:* It is one of the main social challenges in capturing knowledge, specifically in construction projects that are based on the TPS. Separation of project phases (design and construction phase) and separation of sites would affect the process of capturing knowledge. Therefore, establishing a network between people involved in a project and across project's phases will develop a knowledge base for project team members.

*Culture:* It is the main challenge to capture knowledge in the construction industry. Individuals and experts are reluctant to share their knowledge because they consider knowledge a powerful tool. Furthermore, they also do not tend to learn from others' experiences because they have fear of negative impact of admitting mistakes among their team members. However, there is a need for project managers to review with involved experts, both successful and failed projects after their completion in order to uncover what can be learned.



*Motivation issue:* It is the responsibility of project managers to improve the awareness of the team members on the importance of capturing knowledge and its impact on project performance and implementation of work tasks. The project manager should understand the expectations and needs of project members in order to motivate them about their jobs and encourage them to cooperate in knowledge capture process

*Organisational structure issues:* The flexible and decentralised organisational structure will prepare and enable the project environment for project members to easily and freely exchange their knowledge and share good/best practices. However, the certain use of techniques and technology for capturing knowledge depends on the size and structure of the organisation.

*Technical issues:* These are highly focused on explicit knowledge and are all from the IT perspective. In other words, technology is used to capture, transfer, share and reuse knowledge. Hari et al., (2005) identified some technological issues;

- Lack of IT software's and technical support
- Practical difficulties in accessing the intranet and website from site offices
- Lack of standardisation of the system
- The technologies have had to compromise one way or another between simplicity and specificity in capturing and publishing knowledge

*Process issues:* The knowledge capture process should be controlled and customised. The knowledge manager should determine the time for capturing tacit and explicit knowledge, when to transform tacit to explicit knowledge, when to leave knowledge in its native form, and make sure that all involved individuals in project have access to explicit knowledge about procedures and processes.

Furthermore, codification and dissemination of knowledge are also important. Capturing and maintenance of knowledge can be costly and time-consuming; therefore, the knowledge manager should keep track of decisions, rationale, and discussions with of professionals and team members in short-term projects in order to improve project performance.

### **2.11.2 Knowledge Sharing Challenges in Construction**

The knowledge sharing process in the construction industry depends on personal and informal communication (Styhre et al., 2004). Researchers and practitioners have neglected studying the process, challenges and actual practice of knowledge sharing in construction projects (Styhre, 2009; Johansson, 2012). However, researchers investigate other processes of KM in construction industry like; capturing, codifying, and transmitting knowledge (Johansson, 2012).

Researchers have identified three main challenges that affect knowledge sharing process in organisation and project. They are; culture, trust, and motivation (Smith & Bollinger, 2001; Stenmark, 2001; Bartol & Srivastava, 2002; Ipe, 2003; Riege, 2005; Fong & Chu, 2006; Wang & Noe, 2010; Bessick & Naicker, 2013). Organisational culture is highlighted as the most important factor in the knowledge sharing process that creates a link between knowledge sharing and business problems (McDermott & O'Dell, 2001). However, collaboration among involved individuals in projects and mutual trust along with having the culture of support are other initiatives and success factors that will facilitate knowledge sharing process.

Generally, researchers categorised knowledge sharing challenges into three types; lack of supporting culture, lack of mutual trust, and lack of motivation and time for sharing knowledge (Kivrak et al., 2008; Bessick & Naicker, 2013). Existence of supporting culture is highly important in sharing knowledge among individuals in an organisation and project. This is mainly dependent on attitudes of the knowledge manager to encourage and motivate knowledge holders and build reward and recognition systems by using different techniques and technologies. However, the knowledge manager should consider this issue that knowledge holders are reluctant to share their knowledge when they feel their job is insecure. Therefore, mutual trust and the awareness of knowledge holders about the importance of knowledge sharing on project performance should be improved. In addition, McDermott and O'Dell (2001) determined that lack of time will prevent knowledge holders from sharing their knowledge in temporal-based projects, like construction projects, even when the available technology is efficient.

### **2.11.3 Knowledge Transfer Challenges in Construction**

Construction organisations are reluctant to invest in knowledge transfer and required infrastructure support due to their low profit margins and conservative nature (Cheng, 2009). In fact, organisations are not aware of the importance and benefits of knowledge transfer on project performance. In construction projects, the main challenge of transferring knowledge is to transfer designing knowledge, in terms of intentions and rationale to individuals on construction teams. The involvement of multiple organisations in a project means that the transfer of knowledge from one phase to another depends on the kind of contract type or procurement strategy adopted for the project (Kamara et al., 2002). The awareness of construction organisation members has been seen to be relatively low in terms of the importance of tacit knowledge and knowledge transfer. It is necessary to improve this awareness and encourage them to implement knowledge transfer activities through incentives such as salary increases, promotions, personal growth, and acknowledgements. However, it is dependent on the organisational culture and should also be based on trust (Cheng, 2009).

Cheng (2009) identified three main challenges in implementing knowledge transfer in construction projects. They are; Insufficient Time of Members, Organisational Culture Challenge and Lack of Standard Processes. There are several challenges for knowledge transfer between projects. Ekambaram et al. (2014), highlighted five main challenges:

- Lack of incentives to share information and knowledge: it is necessary for project members to be motivated to share their knowledge; otherwise, no/inadequate knowledge will probably be shared
- Attitudes – lack of awareness/willingness to share knowledge: organisations need to consider and prioritise knowledge transfer in their culture and project process
- Low stability or continuity in relations between collaborating organisations: this stability can develop trust between individuals which is important for effective knowledge transfer
- Time pressure: usually project members have no time for sharing and transferring their knowledge because they will be recruited for another project once it is complete or

they become involved in several projects at the same time or within a certain time-period.

- Inadequate information systems: lack of having effective and efficient information systems (like knowledge database, documentations and reports) will have negative impact on the knowledge transfer process

These challenges are interconnected. Comparing these with the previous mentioned challenges will reveal that the culture of organisation is the main challenge for transferring knowledge which is mainly affected by trust. Organisational culture should be prioritised and increase the awareness level of its members on the importance of knowledge transfer. This is highly dependent on having a standard working process and existence of trust between project members. However, organisational culture besides effective standard process will accommodate the time pressure challenge.

### 2.11.4 Summary of Knowledge Integration Challenges

A brief summary of KI challenges which have arisen in previous sections are provided in below Table 2.14.

Table 2.14 – Knowledge Integration Process and Challenges

Knowledge Integration Challenges		
Knowledge Capture	Knowledge Sharing	Knowledge Transfer
<ul style="list-style-type: none"> <li>• Process issues</li> <li>• Technical issues</li> <li>• Social issues               <ul style="list-style-type: none"> <li>– People</li> <li>– Culture</li> <li>– Motivation</li> <li>– Structure</li> <li>– Communication &amp; Network</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Culture</li> <li>• Motivation</li> <li>• Trust</li> <li>• Lack of Awareness to share knowledge</li> </ul>	<ul style="list-style-type: none"> <li>• Lack of incentives to share information and knowledge</li> <li>• Low stability or continuity in relations between collaborating organisations</li> <li>• Lack of awareness to share knowledge</li> <li>• Time Pressure</li> <li>• Inadequate information systems</li> </ul>

## 2.12 Knowledge Integration – Challenges and Critical Success Factors (CSFs)

Most of the studies in the construction industry have focused on identifying challenges associated with capturing knowledge rather than challenges of sharing, transferring and retrieving knowledge (Collinson & Parcel, 2001; Disterer, 2002; Schindler & Eppler, 2003; Julian, 2008; Shokri-Ghasabeh & Chileshe, 2014). However, challenges of capturing knowledge may be different to challenges associated with other processes of KI. Therefore, there is a need to investigate challenges to all processes of KI. It is worthy to note that identifying the challenges should be discussed along with referring to some Critical Success Factors (CSFs) or enablers for implementing the KI process within the construction organisations. The rationale for considering CSFs is that they would act as strategies for overcoming the noted challenges.

### 2.12.1 Knowledge Capture – Challenges and CSFs

The process of capturing knowledge causes challenges that were identified by Williams (2007). These challenges are; *Lack of employee time, Lack of management support, Lack of incentive, Lack of human resources, Lack of clear guidelines, Lack of support from others in organisation, Our process does not capture useful lessons, Data repository too hard to search, Lessons are not transferable, Wrong people are involved, and We already put in enough effort.*

***Lack of employee time:*** Involved individuals in projects are always confronted with this challenge that the lack of time is available to undertake capturing knowledge. According to Carrillo et al. (2004) and Williams (2007), employees involved in construction projects highlighted “not enough time” as the main challenge for capturing knowledge. For instance, it would be difficult for employees to coordinate project debriefings while they are engaged in multiple projects (Egbu et al., 2003; Sexton & Senaratne, 2008; Wiewiora et al., 2009). Furthermore, it is noted by Schindler and Eppler (2003) that time pressure to finish a project under tight project schedules will increase the chance of failure in documenting the captured knowledge from the project and sharing it with others. In other words, involved individuals in project may be willing to share their knowledge, but the lack of time for delivering project on time will affect the knowledge sharing culture. However, project workers are not willing to allocate time for sharing their knowledge and capturing new knowledge, due to the lack of their awareness of the benefits of capturing knowledge (Williams, 2007).

In order to overcome this challenge, Wong (2005) suggested freeing up time for project members to involve them in learning and knowledge capturing activities. Furthermore, Fuller et al., (2011) have suggested new approaches like “project learning processes” to overcome this challenge. This approach will improve the awareness of project members about the importance of capturing knowledge and will enhance the capturing project-based learnings by explaining and implementing “project life cycle” elements.

**Lack of human resources:** Human resources are one of the main factors that facilitate project learning and capturing knowledge. However, researchers have identified that these resources could negatively affect the process of capturing knowledge:

- Inadequate resources (Keegan & Turner, 2001)
- Lack of incentives (Bresnen et al., 2002)
- Lack of attention, personal interest and ability (Von Zedtwitz, 2002)
- Insufficient willingness for learning from mistakes of the person involved (Schindler & Eppler, 2003)
- Employee resistance (Carillo et al., 2004)
- The process is not included in formal job description (Wang & Noe, 2010)
- Inadequate communication (Carillo et al., 2012).

In order to overcome this challenge, Wong (2005) identified “Human Resources Management” (HRM) as a CSF and highlighted that effective recruitment of employees is essential for the organisation in order to benefit from knowledge and experiences of employees. Similarly, Pathirage et al., (2007) also highlighted that organisations should benefit from human and knowledge resources as a prime resources; otherwise, they will be wasted.

**Lack of clear processes/guidelines:** Carillo et al., (2004) identified lack of proper processes or guidelines for capturing knowledge are the most important challenge to KM in the UK construction industry. This challenge was highlighted by researchers (Schindler & Eppler, 2003; Newell et al., 2006; Williams, 2007).

In order to overcome this challenge, Wong (2005) suggested implementing technological networking tools in order to facilitate the knowledge capturing process. However, Wang and Noe (2010) developed a framework of capturing and sharing knowledge. This framework

highlights five areas that need to be considered in order to overcome this challenge. They are as follows:

1. Organisational context
2. Interpersonal and team characteristics
3. Cultural characteristics
4. Individual characteristics
5. Motivational factors

Kululanga and Kuotcha (2008) and Fuller et al. (2011) noted this challenge and highlighted the importance of finding appropriate ways of capturing knowledge from projects.

**Lack of senior management support:** The project members' perception of a knowledge capturing culture and willingness to share knowledge has been shown to be positive in relation with management support (Lin, 2007). Therefore, lack of senior management support may directly lead to knowledge capturing challenges. This has been noted as one of the main challenges to capturing project knowledge by researchers (Crosman, 2002; Pan & Flynn, 2003; Carillo et al., 2004).

In order to overcome this challenge, it has been suggested to increase the awareness of senior managers on the way in which their support can be an enabler or critical element in the creation and implementation of a KM strategy and facilitation of the knowledge capturing process (Martensson, 2000; Pan & Flynn, 2003). Evidence of this CSF for capturing and sharing knowledge is provided by Holsappe and Joshi (2000, cited in Wong, 2005).

**Lack of money:** Lack of money is directly associated with "lack of time" (Zollo & Winter, 2002). Carillo et al. (2004) also noted this issue as another CSF in capturing knowledge when viewed as a "financial resource". Wong (2005) also highlighted that successful KM implementation depends upon financial resources.

**Organisational Culture:** Organisational culture is the root of most of the above-mentioned challenges. According to Glanville (2003), there are some factors embedded in organisational culture or climate that can dramatically affect the process of capturing and sharing project knowledge: "ambition", "threat that the project might be stopped or curtailed", "fear of

failure”, “desire to justify the past rather than manage the future”, and “unwillingness to speak about difficult issues”. Therefore, an organisational culture or organisational climate can be a challenge to capturing and sharing project knowledge (Carrillo et al., 2004; Schepers & Van den Berg, 2007). However, Carrillo et al. (2012) noted that organisations do not recognise the value and importance of capturing project knowledge and its impact on solving problems and improving performance due to the lack of communication, lack of awareness, and unwillingness to admit the existence of a problem.

In order to overcome this challenge, Wong (2005) suggested “collaboration” as a mechanism that would encourage organisations and project members to share their experiences and capture their knowledge. Another CSF is to improve the awareness of project members on the importance of capturing project knowledge. “Open and forgiving corporate culture” was identified by Pan and Flynn (2003) as one of the CSFs for analysis of failed projects.

Based on the mentioned challenges and CSFs, a knowledge manager needs to consider some factors in order to facilitate and have a successful capturing process (Matsumoto et al., 2005).

- Participation: encouraging all project members to participate in the knowledge capture process
- Integration: integrating the knowledge capture process with the overall project processes
- KCR: the KCR is the prerequisite for the knowledge capture process and should remain a high level overview document
- Tailoring: encouraging the project members to adopt the best capture methods that suit their needs

### **2.12.2 Knowledge Sharing – Challenges and CSFs**

Studies in construction databases mostly outlined the desired organisational characteristics that support knowledge sharing instead of highlighting the challenges and process of knowledge sharing (Fong, 2003, 2005a,b; Fong & Cao, 2004; Fong & Lo, 2005; Fong & Wong, 2005; Fong & Chu, 2006). This is also in line with the Johansson (2012) research which states that knowledge sharing is mainly investigated from an intra-organisational perspective in construction industry.



Bessick and Naicker (2013) identified some knowledge sharing challenges that exist in organisations:

1. Differences in education levels
2. Organisational barriers such as the lack of leadership and managerial direction
3. Knowledge retention of highly skilled and experienced staff is not always a high priority; lack of transparent rewards and recognition are both counterproductive
4. Reluctance to use IT systems
5. Lack of demonstration of all advantages of any new systems in preference to the existing ones
6. Individual barriers: age and gender differences
7. Lack of trust and failure to take ownership of intellectual property
8. Integration of KM strategy and the sharing of initiatives of the company's goals
9. Technological barriers: lack of integration and the compatibility of IT systems and processes
10. Lack of technical support and lack of communication

Knowledge sharing challenges in the UK construction industry is categorised into two types by Fong and Chu (2006); personal and organisational. The main personal challenge is identified as limited access to intranets and databases; whilst time constraints on sharing knowledge are identified as the main organisational challenge for sharing knowledge. These challenges are respectively presented in Table 2.15.

The UK construction industry needs to improve the awareness of its stakeholders of the benefits of sharing knowledge. This is highlighted by Fong and Chu (2006) as the number one critical factor for effective knowledge sharing. The critical success factors along with attitudes and reasons for sharing knowledge and experience in the UK construction industry are presented in Table 2.16 according to their rank in Fong and Chu (2006) research.

Table 2.15 – Knowledge Sharing Challenges

	Personal	Organisational
1	Limited access to intranets and databases	Time constraints on sharing, as a result of heavy work load and busy nature of work
2	Difficulties in generalising knowledge from one project for use in another	Lack of proactive management strategies, for example, internal staff rotation
3	Lack of understanding of the benefits of knowledge sharing	Lack of ICT infrastructure
4	Poor communication skills	Lack of defined responsibilities and budget for knowledge sharing
5	“Not my business” attitudes	Competitive working environment
6	Lack of respect from others due to the presence of departmental hierarchy	No reward, either monetary or nonmonetary, from the company
7	Individuals do not share best practice so as to be competitive	No unified vision of knowledge sharing
8	Individuals are selfish and unwilling to share	Lack of sharing spaces
9	Lack of trust and poor relationship among colleagues	Lack of top management support and participation
10	Lack of commitment to the company	No knowledge sharing culture within the department
11	Lack of common language	Lack of experienced colleagues

Table 2.16 – Critical Success Factors and Attitudes and Reasons for Sharing Knowledge

	Critical Success Factors	Attitudes and Reasons
1	Understanding the benefits of knowledge sharing	Increasing levels of expertise and knowledge sharing
2	Colleagues’ participation and cooperation	Encouraging colleagues to share knowledge
3	Time	Learning colleagues’ unique knowledge
4	Experienced colleagues	Improving quality of work
5	Colleagues’ awareness and attitudes	Improving working morale and motivation
6	Top management support and commitment	Promoting innovation and creativity
7	Trust building between colleagues	Enhancing organisational competitiveness
8	Knowledge management policies and strategies	Encouraging a continuous improvement process
9	Common language	Improving operational efficiency
10	Company’s culture	Improving internal communications
11	Technical support	Assisting in decision making
12	Practices or channels for sharing	Utilizing company’s intellectual assets
13	Sharing spaces	Minimising company’s knowledge erosion
14	Incentives and rewards	Enhancing effectiveness in problem solving
15	Funding	Enhancing personal capability and organisational learning

### 2.12.3 Knowledge Transfer – Challenges and CSFs

Knowledge transfer is context-based and one of the key factors for the better performance in construction projects. Therefore, it is necessary to understand and consider its challenges and critical success factors to improve the performance of transfer process (Harada, 2003; Cheng, 2009). Cheng (2009) identified three main challenges in implementing knowledge transfer in construction projects:

- Insufficient time of members
- Organisational culture challenge
- Lack of standard processes

Projects are usually time-constrained. This means project members have insufficient time to capture and share their knowledge and experiences, because of being busy with complex loads of project tasks. Furthermore, after a project is completed, project members may be recruited by project manager to work on a new project. Therefore, project members have no time for reviewing the completed project to sum up their experiences and knowledge that they captured. Therefore, project knowledge is rarely documented and transferred in order to be reused in future projects and will be wasted when the project is completed. Lack of social communication between projects prevents valuable captured knowledge to transfer across projects. This is more often in construction projects due to their geographical dispersion and time limitation (Wiewiora et al., 2009). Knowledge transfer process highly depends on communication among individuals from various cultural contexts rather than technological oversights. Therefore, organisational cultural factors play significant role in this process. Technology can be used to cross challenges and streamline the transferring of explicit knowledge.

Improving the knowledge transfer process represents challenges to involved individuals in projects due to the complexity of knowledge capturing and sharing process. According to (Kwawu et al., 2010), critical success factors have been used as a management measure in several fields including construction management. They have identified four top critical factors that affect the process of project knowledge transfer; *Supportive leadership, Trust, Organisational Culture* and *Communication*. The organisational culture should be supportive in terms of awareness, knowledge sharing and willingness to embrace new ideas and

technology. However, the complex nature of construction projects, which are mostly temporal, brings serious challenges; project members tend to 'reinvent the wheel' in each new project instead of utilising knowledge from previous projects. In other words, lack of effective knowledge transfer will lead knowledge not to be shared and reused properly. In fact, rework and lack of using knowledge transfer will lead to poor performance, productivity, and waste of time in construction industry.

As mentioned above, the key factor in the successful knowledge transfer process in the organisational culture is trust. Trust is prerequisite for transferring knowledge among individuals through communication. The period of a project is usually limited which means project members often will not have enough time to develop this feature. Furthermore, project managers should adopt a high standard and consider the knowledge transfer process in order to have a clear plan of the work processes.

## **2.13 Construction Project Environment**

### **2.13.1 Procurement and Project**

A procurement system is the organisational structure for the implementation of a construction project (Masterman, 2002). As the building of procurement systems is so wide, it requires categorisation in order to assist clients in the selection of the most suitable procurement system. Therefore, Masterman (2002) categorised the building procurement systems into four main categories: *Separated*, *Integrated*, *Management-oriented* and *Discretionary* procurement systems.

- *Separated procurement systems*: This category contains the *Traditional* or *Conventional* system where separate organisations (quantity surveyor, design consultants, contractor) are responsible for the implementation process of the main elements of the project like designing and construction
- *Integrated procurement systems*: In this system the client only deals with one organisation that takes responsibility of designing and construction of a project. This category contains main systems, *Design and build*, *Novated design and build*, *Develop and construct*, *Package deal*, and *Turnkey* approach.

- *Management-oriented procurement systems*: In this category, an organisation is responsible for management of the project through working with the designer and other consultants in order to produce design and manage physical operations which are carried out by contractors, package, or works. There are three main systems in this category: *Management contracting*, *Construction management* and *Design and manage*.
- *Discretionary systems*: “where the client lays down a framework for the overall administration of the project within which he/she has the discretion to use the most appropriate of all the procurement systems contained within the other three categories”. This category includes two main frameworks: *Partnering* and *British Property Federation system*.

The suggested procurement systems categorisation by Masterman (2002) for the management of the design and construction of the building projects is illustrated in Figure 2.9.

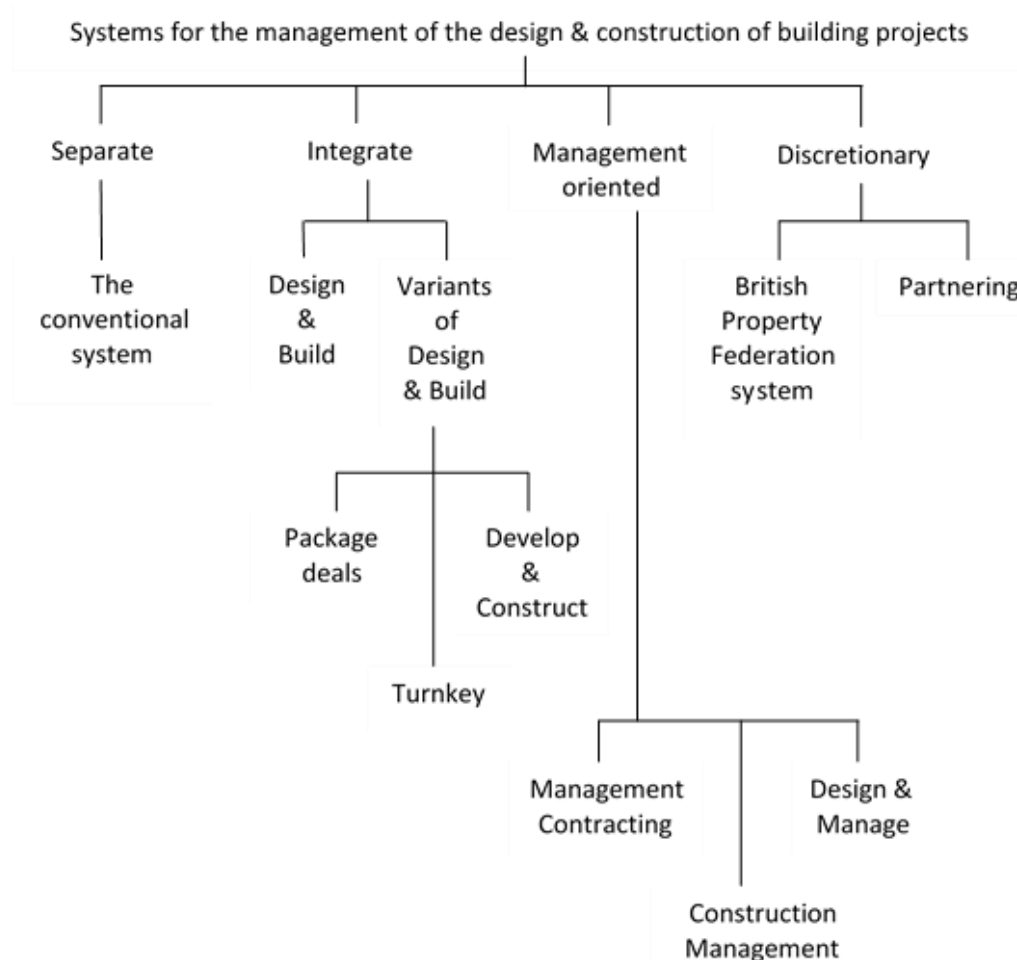


Figure 2.9 – Categorisation of Building Procurement Systems (Masterman, 2000)

The general categories of procurement are briefly discussed. Regarding to the scope of this research (Section 1.6), the research focuses on construction projects undertaken through the TPS. The TPS is structured on the separation of the design and construction processes which means some issues related to knowledge loss exist between these phases. Therefore, the TPS challenges and KM challenges within construction projects undertaken through the TPS are discussed in the next sections.

### **2.13.2 Traditional Procurement and Its Challenges**

As mentioned previously, separate organisations (quantity surveyor, design consultants, contractor) are responsible for the implementation process of the main elements of the project like designing and construction in this type of procurement system. In other words, the designing and supervision process are being carried out by an architect assisted by other specialist consultants. Figure 2.10 shows that the phases of the TPS are very much separated with little overlap. However, the design phase is much separated from construction phase. The uniqueness of the TPS is the separation of the responsibility of the designing and construction phase of the project which is done by different parties. This system is also called *conventional* method (Masterman, 2000). Apart from the unique characteristic of TPS, Masterman (2000) highlighted a number of basic characteristics:

- Project delivery is sequential process
- The design of the project is largely completed before work commences on site
- The responsibility for managing the project is divided between the client's consultants and the contractor, and therefore, there is little scope for involvement of either of the parties in the other's activities
- Reimbursement of the client's consultants is normally on a fee and expenses basis, whereas the contractor is paid for the work completed on an admeasure or lump sum basis

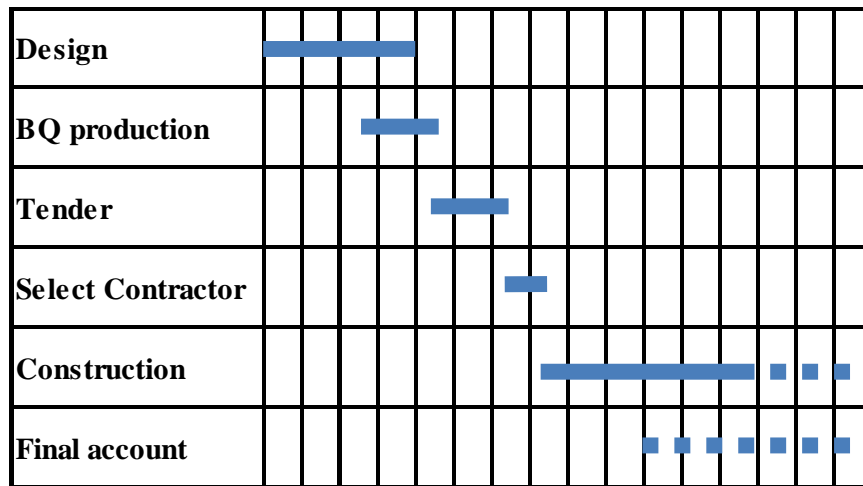


Figure 2.10 – Traditional Procurement Phases

The traditional construction procurement approach has been criticised for several issues: failure to form effective teams, separated approach to project delivery, time delay, lack of communication and coordination, rising costs, rework and wastages (Yu & Shen, 2013; Nasrun et al., 2014). Furthermore, knowledge is a valuable asset for organisations and it should be properly managed in order to improve the performance of project. Therefore, poor KM is another factor that can intensify the drawbacks to this type of procurement due to the separation of the designing and construction phase.

One type of the traditional procurement is called ‘two-stage tendering’ through which the contractors are assigned before the designing phase is finished (Masterman, 2000). In other words, an early appointment is achieved with the main contractor ahead of the completion of the design in order to help advice on best practise and provide best value to the client. Implementing this type of traditional procurement has its own advantages which are:

- Establishing relationships at an early stage between project members (between design and construction phase) will lead to more assured successful outcome
- Involving the contractors ahead of the completion of the design means providing their knowledge of previous similar projects to be available at early stage
- Pre-existing relationships between project’s members and the consultant will result in having better communication, sharing knowledge and understanding
- Involvement of contractors before finishing the designing means they can provide their knowledge and advise on identifying and resolving any buildability issues that may occur during the construction phase

By considering the above factors, it can be concluded that ‘two-stage’ tendering will facilitate managing knowledge, in terms of sharing and transferring, within the traditional-based construction project.

### 2.13.3 Knowledge Management Challenges within Traditional Project

As construction projects are temporary and unique, project members will shift to the next new project after the completion of a project. Therefore, much knowledge which is achieved by project members will be lost and dispersed, if it is not properly captured and shared at the end of the projects (Cheng, 2009). In other words, poor management of knowledge across construction projects, specifically projects undertaken by the TPS, will lead to a considerable amount of knowledge loss in which case ignoring it would be detrimental to the project performance. This is shown in Figure 2.11.

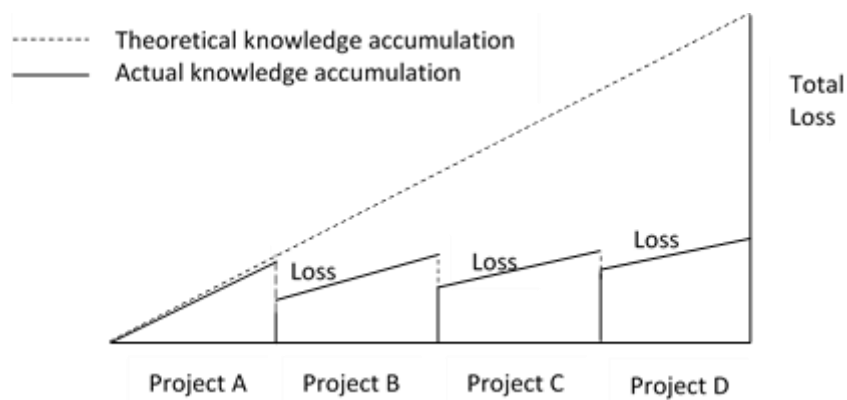


Figure 2.11 – Knowledge Accumulation and Loss Across Projects

Regarding to KM, Masterman (2000) identified two challenges of the traditional construction projects. First, the TPS suffers from *lack of management expertise*. Due to the nature of this system, the period of design and construction phase is lengthy. Therefore, good communication needs to exist between all members of project. Secondly, the TPS suffers from *lack of motivation during design and construction phase*. Designers are not motivated and well experienced to manage construction work, cost, and time of project effectively. However, involved people in construction phase are unable to contribute to the design of the project until too late (Masterman, 2000). Therefore, there is a need to motivate project members at both design and construction phase to use and share their experiences in order to improve the project performance.



The construction industry suffers from lack of KI between its phases (Pryke, 2005; Kamara et al., 2007; Harty & Schweber, 2010; Love et al., 2011; Zhu et al., 2014), especially in the TPS (CIOB, 2010), because many professional designers at the design phase are not skilful in construction means and methods and have little experience and tacit knowledge in construction practices. However, Ding and Ng (2010) mentioned that the literature about the way in which designers share their knowledge in the project environment is limited and needs more research in this context. Furthermore, Cheng (2009) highlights that different techniques are used to capture knowledge and share important information and knowledge for solving some intractable problems in different phases of the construction project, but the amount of knowledge loss in later phase is still much and not negligible (Figure 2.12). These issues are in line with the Construction 2025 report (2013) that specified two main weaknesses of the industry:

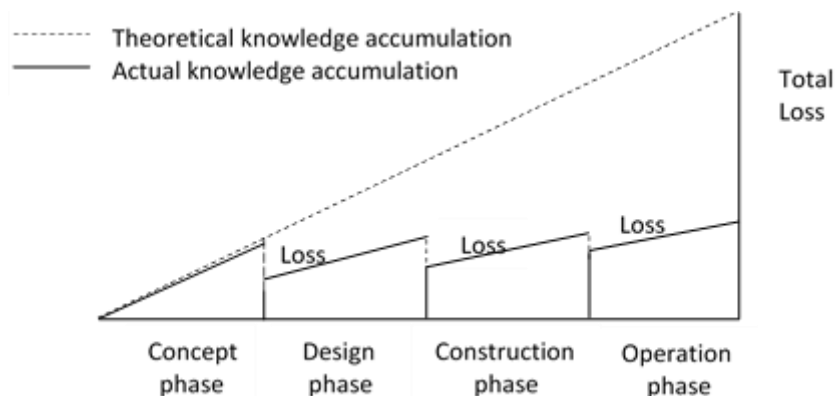


Figure 2.12 – Knowledge Accumulation and Loss between Project Phases

*Sector integration:* “Lack of integration often leads to fracture between design and construction management and a fracture between the management of construction and its execution leading to lost opportunities to innovate”

*Lack of collaboration and limited knowledge sharing:* “learning points from projects are often team-based and lost when the team breaks up and project ends. Low technology transfer”

According to CIOB report (2010), the traditional procurement method is the most efficient and suitable method only for projects up to £5m (Figure 2.13). However, it is the second method that highly needs restructuring (Figure 2.14) because it is primarily used in projects that overran in terms of costs and time (CIOB, 2010). Furthermore, this report indicates that the

lack of alterations to the clients' requirements, communication issues, and design team concerns are the most significant problems that arise during the procurement process. Therefore, the importance of tacit knowledge is more significance in knowledge-based industries like construction where common disputes exist between the design and construction phases, specifically in projects undertaken by the TPS. However, most design errors identified during the construction phase are due to problems within design documentation that are mainly caused by lack of experiences and tacit knowledge of design team in construction practices (Love *et al.*, 2013). Design team (architects, engineers and quantity surveys) mainly rely on their tacit knowledge (Heylighen & Neuckermans, 2000) which is achieved through their involvement in unique architectural and construction projects (Heylighen *et al.*, 2005; Panuwatwanich *et al.*, 2012). This knowledge is experience-based and ranges from technical to the specialist knowledge within the design and construction process.

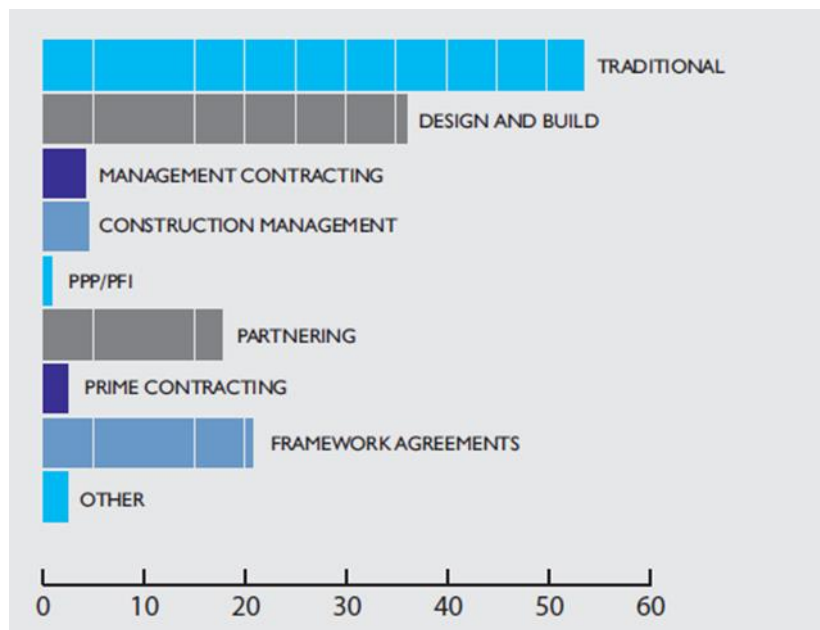


Figure 2.13 – The Most Procurement Method to be most Efficient and Suitable for the Projects up to £5m (CIOB report 2010)

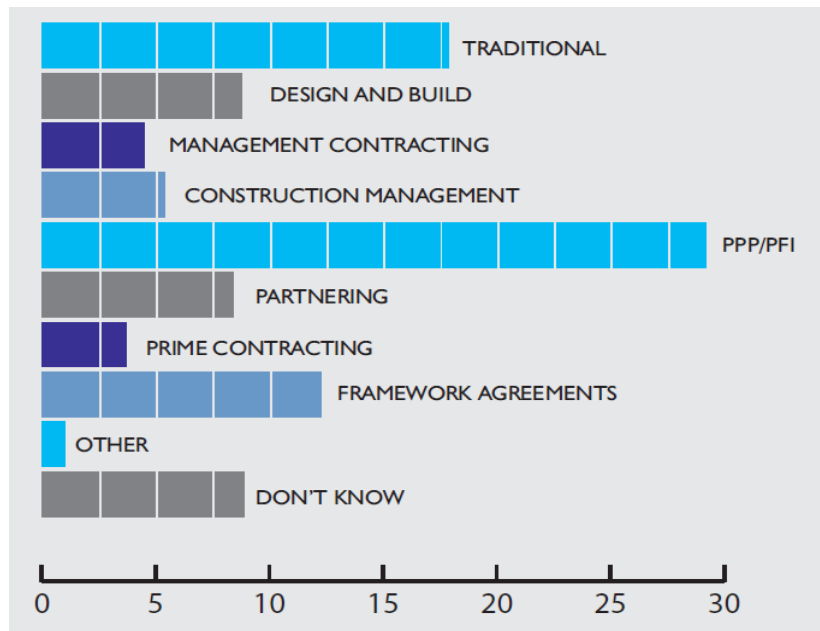


Figure 2.14 – The most Procurement Method in need of Restructuring (CIOB report 2010)

### 2.13.4 Construction Project Performance

There is a need for the construction industry to identify a number of parameters to be used by project managers and construction companies in order to measure the performance of a construction project (Cox et al., 2003). The UK construction best practice programme (CBPP) has identified a number of indicators as key to the performance for construction industry (BPRC, 1999). These key performance indicators (KPIs) can be classified in two main categories; Project performance indicators and Company performance indicators. The former category includes: Client Satisfaction – product, Client satisfaction – service, Defects, Predictability – cost, Predictability – time, Construction cost and Construction time; whilst the latter category includes: Profitability, Productivity and Safety. Project managers need to consider the KPIs while establishing KM strategies. The KPIs can also impact the type of procurement system which is chosen for the project.

According to construction statistics (2010), the predictability cost and predictability time, each consists of three indicators; one for design cost, one for construction cost and one for project cost. The table below represents the definitions used for the project performance indicators by construction statistics (2010). However, the predictability cost and predictability time indicators are more in line with the aim of this research.

Table 2.17 – Definitions of KPIs (Construction statistics, 2010)

Project KPIs	Definition
<b>Client Satisfaction – Product</b>	– How satisfied the client was with the finished product
<b>Client Satisfaction – Service</b>	– How satisfied the client was with the service of the consultants and main contractor
<b>Defect</b>	The condition of the product/facility with respect to defects at the time of handover
<b>Predictability – Cost</b>	<p><u>Design Cost</u>: actual cost of the design process at Available for Use less the anticipated cost of the design process at Commit to Invest, expressed as a percentage of the anticipated cost of the design process at Commit to Invest</p> <p><u>Construction Cost</u>: actual cost of the construction process at Available for Use less the anticipated cost of the construction process at Commit to Construct, expressed as a percentage of the anticipated cost of the construction process at Commit to Construct</p> <p><u>Project Cost</u>: actual cost of the combined design and construction process at Available for Use less the anticipated cost of the combined design and construction process at Commit to Invest, expressed as a percentage of the anticipated cost of the combined design and construction process at Commit to Invest</p>
<b>Predictability – Time</b>	<p><u>Design Time</u>: actual design duration of the design process at Commit to Construct less the anticipated duration of the design process at Commit to Invest, expressed as a percentage of the anticipated duration of the design process at Commit to Invest</p> <p><u>Construction Time</u>: actual duration of the construction process at Available for Use less the anticipated duration of the construction process at Commit to Construct, expressed as a percentage of the anticipated duration of the construction process at Commit to Construct</p> <p><u>Project Time</u>: actual duration of the combined design and construction process at Available for Use less the anticipated duration of the combined design and construction process at Commit to Invest, expressed as a percentage of the anticipated duration of the combined design and construction process at Commit to Invest</p>
<b>Construction Cost</b>	The normalised construction cost of a project in the current year, less the construction cost of a similar project one year earlier, expressed as a percentage of the construction cost of a similar project one year earlier
<b>Construction Time</b>	The normalised time to construct a project in the current year, less the time to construct a similar project one year earlier, expressed as a percentage of the time to construct a similar project one year earlier

## **2.14 Conceptual Framework**

The conceptual framework highlights the main issues to be studied. Jabareen (2009) defines conceptual framework as “a network or a plane”, of interlinked concepts that together provide a comprehensive understanding of a phenomenon or phenomena”. The conceptual framework developed for this research is presented in Figures 2.14 and 2.15 and highlights the process of TKI in terms of capturing, sharing, and transferring knowledge within the traditional construction project in the UK. This conceptual framework has been developed based on literature on KI and its processes.

### **2.14.1 Understanding the Conceptual Framework**

This section describes the components of conceptual framework for this research and how these components come together, through implementation of KI to facilitate the performance of the traditional construction project within the UK construction industry. It is important to mention that the process of KI facilitates both management problems occurs during a project’s lifecycle and the accumulation of knowledge for the forthcoming projects.

This framework (Figure 2.15) derived from a theoretical framework of KM (Section 2.8.2, Figure 2.7) which was developed by Carrillo et al. (2000) and depicts three main components that are the fundamental requirements of KI. For the purpose of this research, they are interlinked together within the traditional construction project context. These components are ‘Knowledge Integration Factors/Challenges’ (Section 2.11), ‘Knowledge Integration Means’ and ‘Knowledge Integration Process’ (Section 2.10). The ‘Knowledge Integration Factors’ refers to the challenges and factors that initiate the needs and challenges that exist in integrating knowledge. The main challenges that exist in implementing KI in the construction project context are the culture and organisational issues. The ‘Knowledge Integration Means’ refers to the techniques and technologies that are required to facilitate the process of KI. The ‘Knowledge Integration Process’ refers to activities, tasks, and processes that are required to capture, share, and the transfer of knowledge. The KI process will lead to improve the project performance.

Figure 2.16 illustrates the process of KI within the traditional construction project, where the design phase is separated from construction phase. The SECI model is considered as an

approach in this research (Section 2.8.1) and mainly focuses on Socialisation, Externalisation and Internalisation. In terms of KI, this research is focusing on capturing tacit knowledge, which is a source of project knowledge from both design and construction phase, and storing it in the 'knowledge base repository' in the explicit form (Externalisation). However, there will be amount of knowledge that will remain and be captured as tacit (Socialisation), and will be transferred to the next project as tacit. The captured knowledge, in both forms of tacit and explicit, will be shared among project members within and between design and construction phase, and will be transferred to the next project. The transferred knowledge could be in both forms of tacit and explicit.

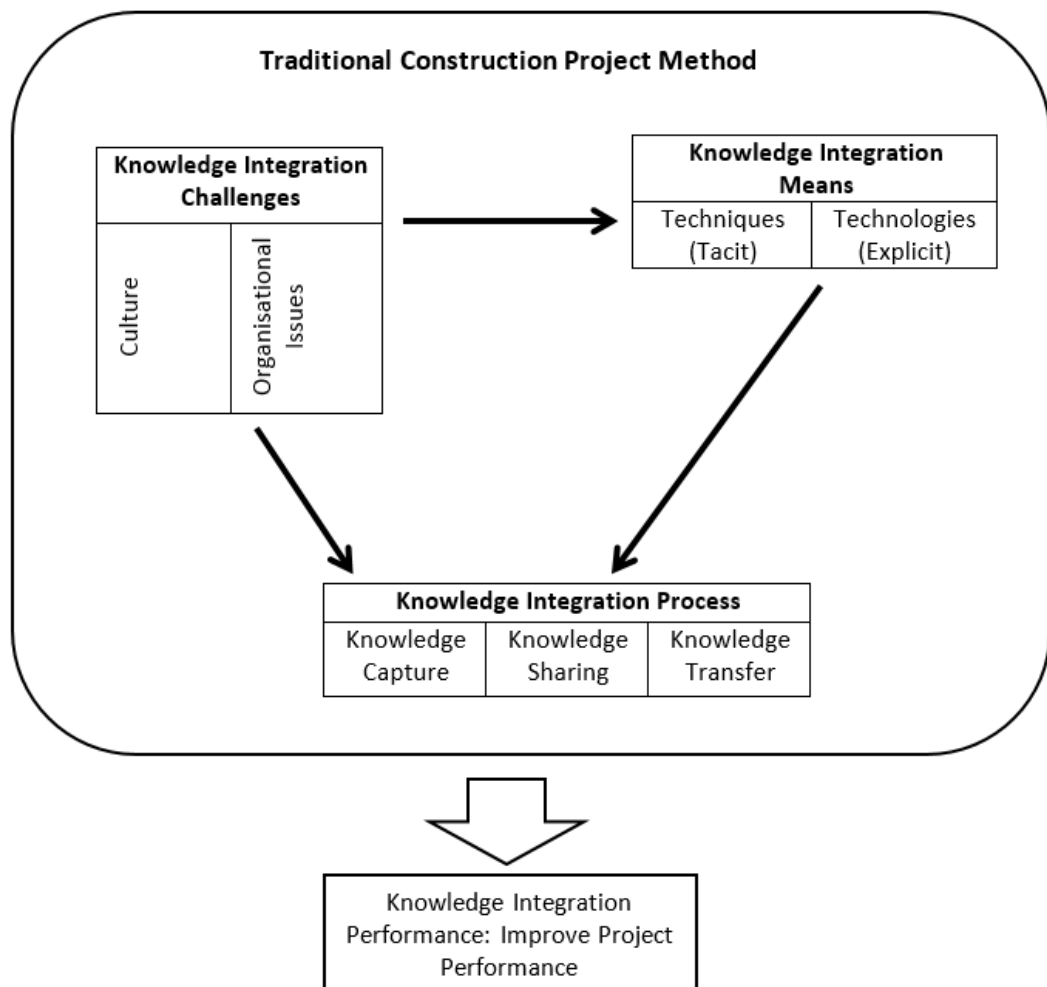


Figure 2.15 – Conceptual Framework on Tacit Knowledge Integration within the Traditional Construction Project

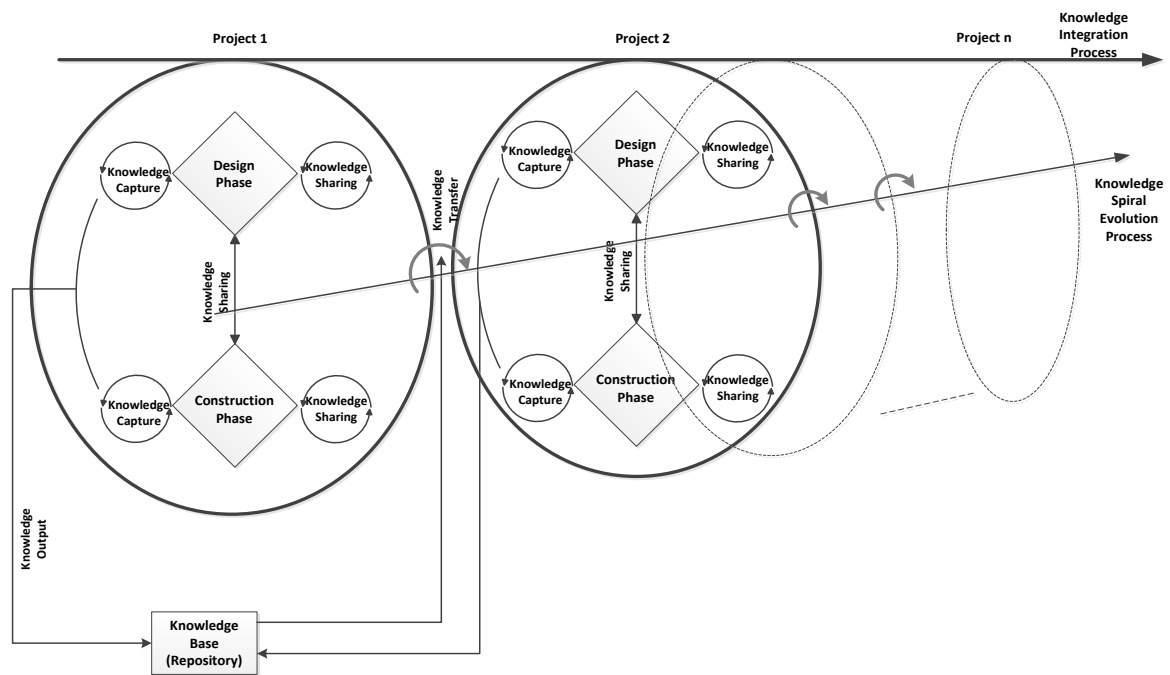


Figure 2.16 – Knowledge Integration Process Framework

## 2.15 Summary

An overview of the literature for this research were presented that included the general areas of KM and KI, specifically within the construction industry. In this regard, the characteristics and typologies of knowledge were presented. Furthermore, the main process of KM, knowledge capturing, sharing, and transferring were discussed. The chapter also outlined the approaches, techniques, and challenges of KI within a construction project.

## Chapter 3 – Research Methodology

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### **3.1 Introduction**

Research can be defined as the process followed by a researcher to systematically achieve the aim and objectives of a particular research. In other words, this process consists of methods that are used to collect data, the reasons that the obtained results are meaningful, and the explanations of any limitations that are related to them. Furthermore, achieving the aim and objectives is like having a set of 'things' to find out which means the set of activities that has to be finished in specific time in order to be useful (Becker, 1998).

Sekaran (2003) defines research as “an organised, systematic, data-based, critical, objective, scientific inquiry or investigation into specific problem, undertaken with purpose of finding answers or solutions to it”. In fact, research (research methodology) provides a set of required information and guidelines that enable researchers to make appropriate decisions in order to successfully deal with problems, solve them, and how the research should be conducted. Research methodology is the process of planning procedures for conducting the research in an accurate way to obtain the most valid results in order to achieve the aim of the research.

This chapter concentrates on an overview of the research process used for conducting this research. It highlights the concept of research, research philosophy, approach, methods and proposed data analysis that were used to achieve the study aim. This aim was to develop a framework for integrating tacit knowledge in terms of capturing, sharing, and transferring within a construction project undertaken through the traditional procurement system in the UK.

### **3.2 Concept of Research**

Smith and Dainty (1991) state that research is: “... *A systematic, careful inquiry or examination to discover new information or relationships and to expand/ verify existing knowledge for some specified purpose*”.

They believe that research is about investigating relationships and solving problems which in turn will lead to build a body of knowledge. In fact, the researcher should understand the research framework and all the assumptions around it in order to have a better understanding of weaknesses and strengths of these assumptions. In turn, the researcher could achieve a successful outcome for research (Smith & Dainty, 1991). According to Saunders et al. (2012),

research is characterised by a well-organised process which adopts the best use of opportunities and available resources and systematically employs the best methods for collecting and analysing data in order to address the research problems and increase knowledge.

Identifying the research type and research design are two important factors in conducting a research. Identifying the research design is a critical and complicated task because it determines the process of collecting and analysing of research data (Churchill, 1979). It also requires consideration and analysis of different resources for providing a reasonable link between theory and argument (Nachimas & Nachimas, 2008). The ‘Research Onion’ model, which was developed by Saunders et al. (2012), is adopted to carry out this research. The main feature of this model is its framework that enables the researcher to select proper strategies and approaches through its different layers. Figure 3.1 illustrates the research onion model.

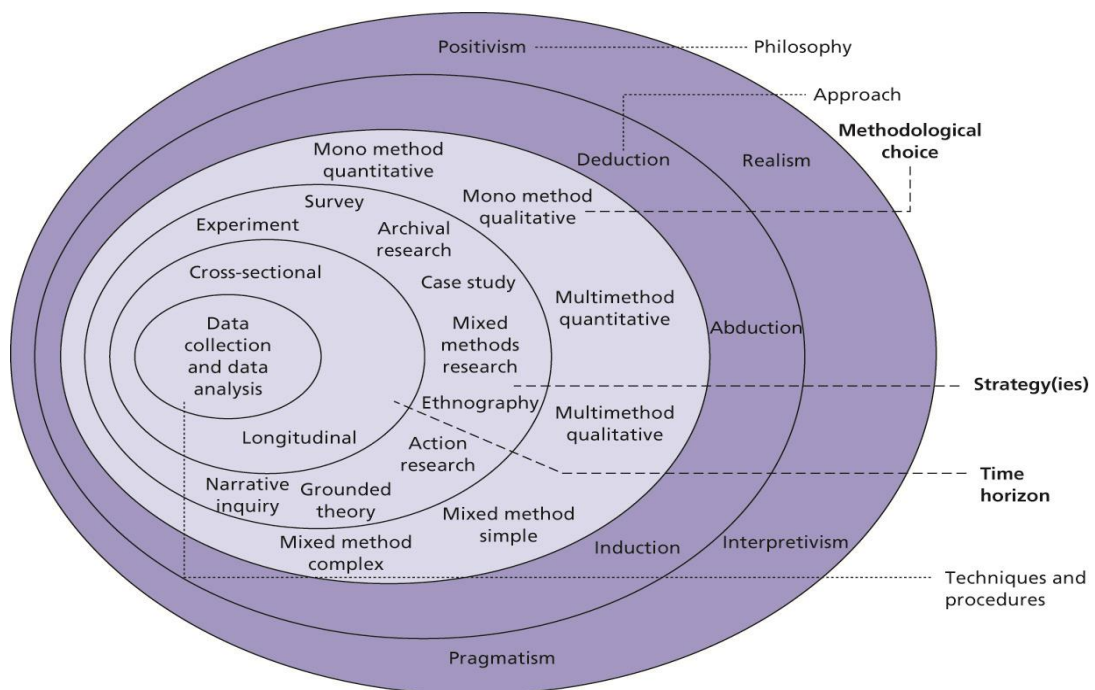


Figure 3.1 – The Research Onion (Saunders et al., 2012)

According to research onion model, the research process starts from the outer layer and peels away different layers of onion until it reaches to the centre of the onion which identifies the techniques that should be used to collect data in order to answer research questions. The first layer identifies the research philosophy that should be adopted for the research. The second layer considers the research approach that flows from the research philosophy. The next three

layers: methodological choice, research strategy or strategies, and choosing time horizon for the research, are the focus of the process of research design. The third layer considers different methodological choices which could be used for the research that are influenced by the research philosophy and research approach. The fourth layer considers the most applicable research strategy. The fifth layer concentrates on the time horizon of the research which depends on the research questions. The last layer is about different data collection methods that could be used for the research. Choosing the best data collection methods depends on the previous layers and research questions.

### **3.2.1 Types of Research**

According to Saunders et al. (2012), there are three main types of research; exploratory, descriptive, and explanatory. Identifying the type of research, based on the aim and objectives of the research will enable the researcher to have a better understanding of structuring the research methodology.

**Exploratory Research** is defined as a valuable way to discover and gain in depth knowledge about a topic of interest by asking open questions (Saunders et al., 2012). This type of research could be conducted through interviewing 'experts' in the subject, reviewing the literature, and conducting focus group interviews. Furthermore, this type of research could help clarify as well as give in depth understanding to an existing situation to ascertain the problems and create avenues for more accurate investigations in the future. According to Collis and Hussey (2003), the exploratory research is usually adopted for qualitative measures. They also state that this type of research is used to generate theories from the study of the situation or find and investigate hypotheses, ideas and patterns. The advantage of exploratory research is its flexibility and adaptability to change.

Chapman and McNeil (2005) mention that **Descriptive Research** seeks to answer questions on what, who and how many, and it "describes in detail a situation or set of circumstances". This type of research provides an accurate profile of people, events, or situations. It encompasses the study which informs about the status of a wide range of social indicators and initiates questions that may further necessitate the need to explore and explain why such phenomenon exists (Saunders et al., 2012). Furthermore, statistical or quantitative techniques will be adopted in descriptive research to collect and summarise the data, which means it aims

towards an overview of the various characteristics that exists in a phenomenon and not necessarily the reasons why the phenomenon exists (De Vaus, 2001). However, this type of research can facilitate the carrying out of exploratory and explanatory research (Saunders et al., 2012).

Collis and Hussy (2003) state that the **Explanatory Research** may adopt qualitative and quantitative methods in order to investigate and explain why and how a phenomenon is happening or has happened. Saunders et al. (2012) mention that the purpose of explanatory research is to explain the situation based on establishing “causal relationship between variables” by investigating a phenomenon. However, it is difficult to differentiate explanatory research with descriptive research as it seeks to answer the ‘why’ questions and any explanation involves description. DeVaus (2001) states that the explanation is used to find why phenomenon exists in order to suggest solutions; whilst the description only gives an overview of a phenomenon. In fact, the explanatory research is used to explain the relationships between variables in a situation or a problem.

This research focuses on construction projects undertaken by the TPS because it shows many challenges in terms of cost and time performance that are caused by lack of KM. The aim of this research is to develop a framework on how to integrate tacit knowledge, in terms of capturing, sharing and transferring, within a construction project context undertaken through the TPS, in the UK. It is expected that this framework helps to improve the awareness and understanding of individuals and organisation about KI and its impact on project performance. Therefore, this research is grouped under both an exploratory and explanatory research. This means that this research focuses on explaining the phenomena of TKI and what is happening in the construction industry, and then exploring the way in which to do this.

### **3.3 Research Philosophy**

According to Saunders et al. (2012), the term ‘Research Philosophy’ is about the nature and the development of knowledge. They also state that the research philosophy that the researchers adopt is related to their assumptions about how they view the world and reality. Furthermore, these assumptions highlight the differences that affect the way in which the researcher thinks about the process of research and will support and justify the research strategy and the methods that were chosen by the researcher as part of that study. Easterby-

Smith et al. (2008) state that there are three main reasons that pinpoint the importance of understanding the research philosophy in research methodology;

- Research philosophy helps to clarify research design, which helps to simplify the research by which data is collected and analysed
- Research philosophy enables the researcher to find out which research designs will work and which will not
- Research philosophy enable the researcher to identify and create research designs even if he doesn't have any past experience

There are three underlying assumptions relevant to research philosophies: *Ontological*, *Epistemological*, and *Axiological* assumptions.

### **3.3.1 Ontology**

The Ontology philosophy is about the nature of reality and phenomenon and also concerned about what we know in the world. According to Blaikie (2010), it is the starting point for most of the debate between philosophers. The Ontological assumption is more about what constitute reality, how things really are and work (Blaikie, 2010). In other words, it will answer the questions of “what knowledge is” and “what is the nature of reality”. Within this regard, Walter (2013) argued that the researcher initially establishes whether the reality of the phenomenon which is being investigated, is objective and external to the researcher or ‘socially constructed’ and only understood by examining the perceptions of human actors. Furthermore, it persuades researchers to ask some questions about the commitment to specific views and the way the world operates. Therefore, Ontology is about the conception and nature of reality.

Sarantakos (2013) states that ontology philosophy concerns the nature of reality and argues what exists, what it looks like, what parts make it up and the way in which these parts interact with each other.

The Ontology philosophy is assumed from two aspects which are defined differently by different authors. Easterby-Smith et al. (2012) refer to it as Realism and Nominalism (Idealism); whilst Saunders et al. (2012) use the term Objectivism and Subjectivism (Constructionism). In other words, the ontological position of the researcher is located along

to these two contrasting continuum. This is mainly based on the epistemological and axiological assumptions of the phenomenon which is being investigated by the researcher (Saunders et al., 2012). The Ontological assumption of Saunders et al., (2012), using Objectivism and Subjectivism, is adopted in this research.

According to Saunders et al. (2012), “under objectivism assumptions, social realities exist in authenticity external to, and independent of the social actor, while constructionism view reality as socially constructed. Hence, social phenomena are created through the perceptions and consequent actions of affected social actors”.

The Subjectivism (Constructionism) aspect of ontological assumption has the view that social phenomenon is created from the perceptions and reactions of social actors like people or stakeholders (Crotty, 2003).

The attempt of this research is to develop a framework on how to integrate tacit knowledge within a construction project context undertaken through the TPS in the UK. In order to arrive at a suitable framework, the involvement of stakeholders and project members are required with the understanding of the effect of KI on project performance. Obviously, this process implies different reactions of involved actors that lead to their ‘subjective’ perceptions about the subject matter. In addition, actions of actors as a group ‘socially constructed’ are important and should be considered. By considering research questions and the mentioned factors, it can be identified that this research will lean towards **Subjectivism**.

### **3.3.2 Epistemology**

The Epistemological assumption is about the way in which knowledge should be acquired and answers these questions: “how we know it” and “what is considered acceptable knowledge” (Saunders et al., 2012). In other words, it is an approach to what knowledge is acceptable with regards to its validation, method, and alternative ways of achieving and communicating this knowledge (Saunders et al., 2012, Easterby-Smith et al., 2012). Guba and Lincoln (1994) argue that the epistemology philosophy is relating to what the nature of relationship between the “would-be” (knower) is and what can be known. Saunders et al. (2012) state that “each philosophy is suited to achieving different research objectives relative to the research questions, which could rarely be answered only within one philosophical domain”. This means

that the selection of research philosophy depends on the research question and the nature of research inquiry. In other words, no research philosophy is better than the other.

The epistemology philosophy has two contrasting continuum which various authors have used different terminology to describe them. Proctor (1998) uses the term Positivism and Post-positivism as two contrasting continuum. Crotty (2003) refers to these contrasting ends as Objectivism and Constructionism; whilst Easterby-Smith et al. (2012) adopt Positivism and Social constructionism (phenomenology) to describe these contrasting ends. Saunders et al. (2012) refer to these contrasting ends as Positivism and Interpretivism. The terminology which is used by Saunders et al. (2012) to describe the two contrasting continuum of epistemology philosophy, is adopted for conducting this research.

In positivism assumptions Easterby-Smith et al. (2012) state that properties of the world should be measured through objective methods as the world exists externally. In other words, an objective that exists is not creation of human mind and is independent of human behaviour. Therefore, the researcher is a neutral observer and the reality is not mediated by the researcher's mind and senses when the investigated objects have an existence independent of the knower (Saunders et al., 2012).

On the other end of epistemological assumption continuum, there is another philosophy that different terminologies have been used by other authors to describe. This philosophy is known as Interpretivism (Saunders et al., 2012), Constructionism (Easterby-Smith et al., 2012) and Post-positivism (Crotty, 2003).

In the positivism assumption, reality is knowable, directly measurable and fixed. There is just one external reality (truth) which is criticised by new philosophical assumption (Guba & Lincoln, 1994). Regarding this new philosophical assumption, the reality is not an exterior and objective. It is socially constructed and interpreted by people (Saunders et al., 2012, Easterby-Smith et al., 2012).

For the interpretivism assumption the reality is not rigid and cannot be separated from the real world of individuals who observe it (Weber, 2004). Therefore, there is a relationship between individual attitudes, behaviour, and socio-cultural influencing issues. However, the interpretivism assumption claims that the reality is subjective to various factors to be

constructed like: culture, gender and cultural believe (Weber, 2004). The differences between positivism and interpretivism assumption are shown in Table 3.1.

Table 3.1 – Differences between Positivism and Interpretivism (adopted from Weber, 2004)

Metatheoretical Assumptions About	Positivism	Interpretivism
<b>Ontology</b>	Person(researcher)and reality are separate	Person(researcher) and reality are inseparable (life-world)
<b>Epistemology</b>	Objective reality exist beyond the human mind	Knowledge of the world is intentionally constituted through a person’s live experience
<b>Research Object</b>	Research object has inherent qualities that exist independently of the researcher	Research object is interpreted in light of meaning structure of person’s (researcher’s) live experience
<b>Method</b>	Statistics, content analysis	Hermeneutics, phenomenology, etc.
<b>Theory Truth</b>	Correspondence theory of truth: one-to-one mapping between research statements and reality	Truth as intentional fulfilment: interpretation of research object matches live experience of object
<b>Validity</b>	Certainty: data truly measures reality	Defensible knowledge claims
<b>Reliability</b>	Replicability: research results can be reproduced	Interpretive awareness: researcher recognise and address implications of their subjectivity

Regarding the Epistemology philosophy, this research will lean towards the **Interpretivism** stance, because it is concerned with subjective issues, the details of situation, and a reality behind these details.

In this research, the involvement and role of stakeholders, project members, are important, because the actors and their experiences, perceptions, and understandings in the construction industry are sources of knowledge. The focus will be on their feelings, awareness, and thinking regarding TKI in terms of capturing, sharing, and transferring and its impact on construction projects undertaken through the TPS. In other words, it is about understanding the phenomena via evaluating the meaning that participants, social actors, assign to those subjective issues. Furthermore, individuals take account the analysing and interpreting the environment in order to develop processes and methods (Saunders et al., 2012; Bryman, 2004). Thus, the researcher needs to be a part of what is being observed and interacted with



participants. This will enable the researcher to understand and gather relevant information to explain why and how the phenomenon exists.

### 3.3.3 Axiology

The term 'Axiology' is the science or theory of value, which originates from the German word 'Axiologie'. The Axiological assumption studies judgments about the value system and will answer "what is the role of values" and "what researcher values go into it" (Saunders et al., 2012). It can be located between 'value free' and 'value laden'. In other words, it is a philosophical assumption based on the value that the researcher attaches to the knowledge which is related to social enquiries in deciding whether the research is value free or value laden (Saunders et al., 2012). Resher (2004) states that the axiological assumption is related to the different way researchers perceive the value. In this regard, Healy and Perry (2000) say that each individual can recognise and evaluate knowledge differently because they have their own understanding and knowledge about reality. Thus, the researcher can subjectively construe the value of knowledge in many ways by using the experience and understanding they achieved from the knowledge research under study. As the research leans towards interpretivism, the value of the research will be subjective because the stakeholders involved in the phenomenon under study would have multiple and different perceptions on reality. Therefore, the entire analysis process and techniques that are adopted for research are highly affected by the researcher's values, which mean the researcher plays a significant role in the entire process of the research. In other words, the researcher is biased by cultural experiences, world views, and upbringing. Consequently, it can be concluded that the Axiology philosophy of this research will lean towards **Value Laden** (Saunders et al., 2012). The philosophical stance of this research is shown in Figure 3.2.

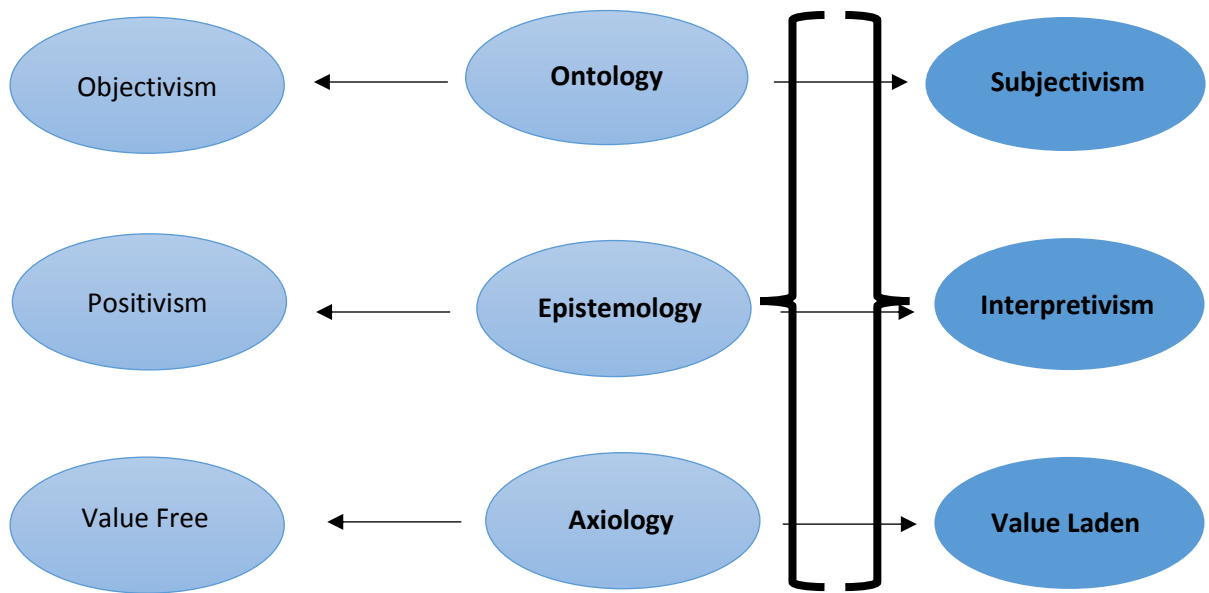


Figure 3.2 - Philosophical Stance of this Research

### 3.4 Research Approach

Creswell (2003) states that the research approach plays a significant role in enabling the researcher to meet the stated objectives. According to Saunders et al. (2012), there are three main methodological approaches; deductive (testing theory), inductive (building theory), and abductive.

#### 3.4.1 The Deductive Approach

The logic of Deductive approach is “when the premises are true, the conclusion must also be true” (Saunders et al., 2012). The origins of this approach is in the natural sciences, where laws present the basis of explanation, allow the anticipation of phenomena, predict their occurrence, and therefore, permit them to be controlled (Saunders et al., 2012). The researcher is led by this approach to develop a hypothesis (es) or theory. This approach also guides the researcher to design a research strategy for testing the hypothesis. In other words, the collected data is used to evaluate the hypothesis (es) related to an existing theory (Saunders et al., 2012). Regarding the generalizability, this approach differs from the inductive approach in that it generalises from the general to the specific; whilst the inductive approach is vice versa.

### **3.4.2 The Inductive Approach**

The *Inductive* approach leads the researcher to use the collected data to explore a phenomenon, identify patterns and themes, and create a conceptual framework. In other words, the theory is developed based on the analysis of collected data (Saunders et al., 2012). Furthermore, the strength of this approach is that it is particularly concerned with the nature of the context in which such events were taking place and under investigation in order to provide better understanding of that context. This is in contrast with the deductive approach which ignores the way in which individuals interpret their social world and only considers the cause-effect link to be made between particular variables (Saunders et al., 2012).

### **3.4.3 The Abduction Approach**

The *Abduction* approach is the combination of the deductive and inductive approach and it is used to explore, examine, and explain relationships between variables in a particular situation (Saunders et al., 2012). In other words, this approach is about moving back and forth between deductive (theory to data) and inductive (data to theory).

### **3.4.4 Rationale for Choice of Research Approach**

According to the above mentioned factors, the abduction approach is adopted to achieve the stated aim of this research which is to develop a framework on how to integrate tacit knowledge within a construction project context undertaken through the TPS, in the UK. Therefore, the existing literature will be investigated in order to enable the researcher to develop a conceptual framework which will be then taken to real life situation to investigate and gather relevant information and understand the perceptions and values of stakeholders in using KI process within the traditional-based construction project. Consequently, the ***abduction*** approach is adopted for this research. In other words, the combination of both deductive and inductive approaches will be used to test and review the conceptual framework where appropriate in order to answer the stated aim and objectives.

## **3.5 Methodological Choice**

Methodology is an approach that a study takes by considering philosophical or theoretical assumptions to develop strategies for collecting and analysing data. It differs from methods which are only used for collecting and analysing data. In other words, Methods are part of

methodology. The methodological choice refers to research design. This choice could be a single (Mono) or multiple (Multi or Mixed) method research design which is presented in Table 3.2. Identifying the research design is a critical and complicated task because it determines the process of collecting and analysing of the research data (Churchill, 1979). This identification also requires consideration and analysis of different resources for providing a reasonable link between theory and argument (Nachimas & Nachimas, 2008).

As mentioned in the previous section the research approach of this study is an abductive approach. Therefore, the multimethod research design is adopted to achieve the stated aim and objectives of this research. This means multiple data collection techniques will be used with associated analysis procedures during the interpretation and presentation of the research, but it is restricted within either a qualitative or quantitative design. In this research, multimethod qualitative research design is adopted. In other words, the incorporation of different qualitative data collection techniques will be used to clarify the different aspects of phenomenon, to reduce the number of key reasonable alternative conclusions that are obtained from the findings and their verification (Saunders et al., 2012).

Table 3.2 – Methodological Choice (Saunders et al., 2012)

Methodological Choice	Research Design	Example
<b>Mono method</b>	Single data collection technique and analytical procedure	Questionnaires (Quantitative) In-depth interviews (Qualitative)
<b>Multi method</b>	Use of multiple data collection techniques and analytical procedures (either qualitative or quantitative)	Questionnaires and observations (Quantitative) In-depth interviews and diary accounts (Qualitative)
<b>Mixed method</b>	Use of single and multiple data collection techniques and analytical procedures (both qualitative and quantitative)	Questionnaires and in depth interviews (Quantitative and Qualitative)

This research attempts to understand the phenomenon of KI in the real-life context in the construction project undertaken through the TPS in the UK. For achieving this, the survey and case study research strategy are suggested for collecting qualitative data. The analysed data from the qualitative findings can be contrasted and compared (triangulate) with the

documentary survey (secondary data) findings, which will facilitate the revision of framework.

Figure 3.3 illustrates this triangulation.

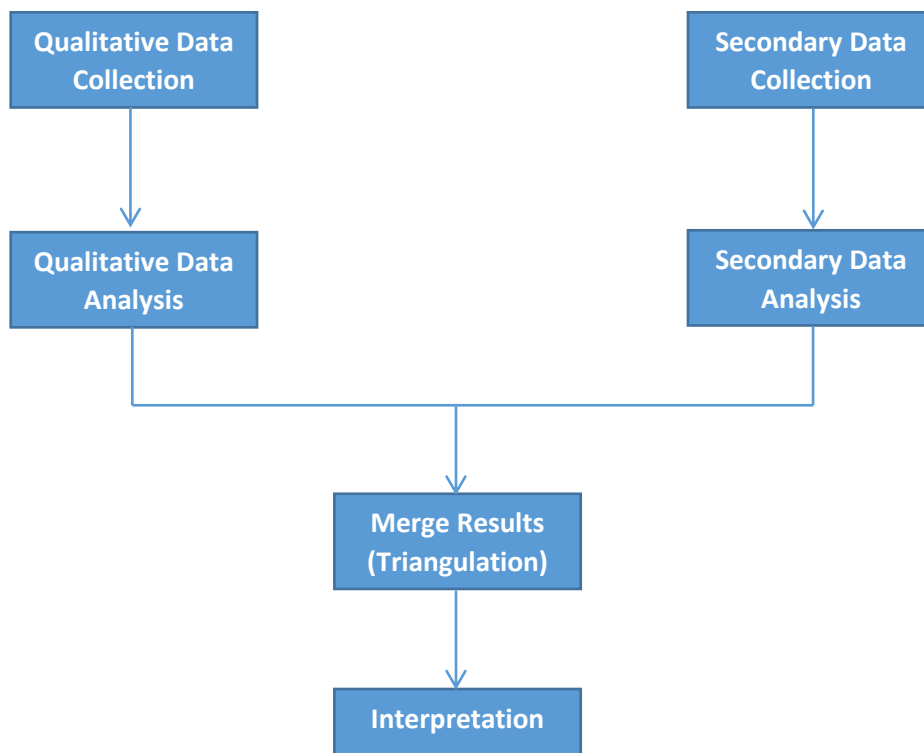


Figure 3.3 – Convergent Multimethod Research Strategy

### 3.6 Research Strategy

Research strategy provides a complete and directed process by which the research is conducted (Remenyi et al., 1998). Saunders et al. (2012) define strategy as a plan and set of action(s) for achieving a goal. Therefore, a research strategy could be defined as a set of action(s) of the way in which the researcher will answer the research question. Deniz and Lincoln (2005) define a research strategy as a methodological link that connects the philosophy of research to subsequent choice of method in order to collect and analyse data. Furthermore, Saunders et al., (2012) argue that the research strategy is guided by the research aim, objectives, approach, time, participant access, existing knowledge, and other available resources of data. Saunders et al. (2012) provide eight different research strategies: Experiment, Survey, Archival Research, Case Study, Ethnography, Action Research, Grounded Theory, and Narrative Inquiry. These strategies with their characteristics are presented in Table 3.3. Apart from the distinctive characteristic of each strategy, there are large overlaps

among them (Yin, 2014). The first two strategies are principally linked to the quantitative research design. The third and fourth strategies may link to either quantitative or qualitative or a mixed research design. The last four research strategies are exclusively linked to the qualitative research design (Saunders et al., 2012).

Table 3.3 – Research Strategy Characteristics (Saunders et al., 2012)

Research Strategies	Characteristics
<b>Experiment</b>	<ul style="list-style-type: none"> <li>• Suitable for laboratory research rather than the field</li> <li>• Unlikely to be related to the real world of organisation</li> </ul>
<b>Survey</b>	<ul style="list-style-type: none"> <li>• Most frequently used to answer ‘what’, ‘who’, ‘where’, ‘how much’ and ‘how many’ questions</li> <li>• Used for exploratory and descriptive research</li> <li>• Easy to explain and to understand research strategy</li> </ul>
<b>Archival research</b>	<ul style="list-style-type: none"> <li>• Makes use of administrative records and documents as the principal source of data</li> <li>• Allows research questions which focus upon past and changes over time to be answered</li> </ul>
<b>Case Study</b>	<ul style="list-style-type: none"> <li>• Suitable for research which wishes to gain rich understanding of the research context and processes</li> <li>• Ability to generate answers to the question ‘why’, ‘what’, and ‘how’</li> <li>• Not suitable for collection data for generalisation</li> </ul>
<b>Ethnography</b>	<ul style="list-style-type: none"> <li>• Used to study groups</li> <li>• Requires a longer term of field work study</li> </ul>
<b>Action Research</b>	<ul style="list-style-type: none"> <li>• Provides in depth understanding to specific phenomena, but the literature advises using it in the education context</li> </ul>
<b>Grounded Theory</b>	<ul style="list-style-type: none"> <li>• Used by many academic research studies in the building environment field</li> <li>• Criticised widely due to its confusing process and time required to be completed</li> <li>• Collecting data processes might require visiting the field several times</li> </ul>
<b>Narrative Inquiry</b>	<ul style="list-style-type: none"> <li>• Suitable for small, purposive samples</li> <li>• Intensive and time consuming</li> </ul>
<b>Mixed methods</b>	<ul style="list-style-type: none"> <li>• Allows answers to questions on what, how and why</li> <li>• Adopted to describe, explain and explore a phenomenon</li> <li>• Allows for diversity of views to aid interpretations</li> <li>• Allows for generalisation of the study or its relative importance</li> <li>• Allows for both qualitative and quantitative data to be employed in a single research</li> <li>• Allows combination of inductive and deductive approaches within a single research</li> </ul>

These research strategies could be either used alone or combined together within a mixed method. Yin (2014) identifies three conditions to determine when to use each of these

strategies; type of research question posed, extent of control a researcher has over actual behavioural events, and degree of focus on contemporary as opposed to entirely historical events. The relation of these conditions and five major research strategies (methods) are displayed in Table 3.4.

Table 3.4 - Relevant Situation for Different Research Strategies (adopted from Yin, 2014)

Strategy	Form of Research Question	Requires Control of Behavioural Event?	Focuses on Contemporary Events?
<b>Experiment</b>	How, why?	yes	Yes
<b>Survey</b>	Who, what, where, how many, how much?	No	Yes
<b>Archival</b>	Who, what, where, how many, how much?	No	Yes/No
<b>History</b>	How, why?	No	No
<b>Case study</b>	How, why?	No	Yes

As mentioned in the previous section the mixed method strategy is adopted for this research in order to have a better understanding of the problems, facilitate comparison of findings, and achieve the research aim and objectives of this study. The ‘case study research’ and ‘survey research’ are adopted as research strategies for this research (Section 3.6.3). These strategies are briefly discussed in the following sections.

### 3.6.1 Survey

Saunders et al., (2012) define ‘survey’ as a research strategy that is common in management and business research and mostly used to answer ‘what’, ‘who’, ‘where’, ‘how much’, and ‘how many’ questions. It is also used for descriptive and exploratory research. This strategy allows the researcher to easily compare the collected data from a sizeable population and have a control over the research process. This will enable the researcher to develop a model of relationships between variables and suggest possible reasons for those relationships. Regarding the time and cost, this strategy is more appropriate, because the researcher is not required to collect the data for the whole population and only needs to use the sampling, which enables the researcher to generate findings that are representative of the whole population (Saunders et al., 2012).

### **3.6.2 Case Study**

Saunders *et al.*, (2012) define 'case study' as a research strategy that explores and investigates the phenomenon within its context or within its real-life contexts. The importance of context is highlighted by Yin (2009); the boundaries between phenomenon (research topic) and the context within which the research topic is being studied are not always evident and distinguishable in real-life situations. Easterby-Smith *et al.* (2008) put forward this issue and noted that the case study is a flexible research strategy that allows researchers investigate a single case and/or multiple cases. It should be mentioned that the research philosophy of those who support a single case is interpretivist epistemology and those who support multiple cases is positivist epistemology. Furthermore, the 'case study' enables the researcher to deeply explore the context of the research and have a rich understanding of both the context and the processes being enacted (Eisenhardt & Graebner, 2007). In other words, the researcher is allowed to deeply explore individuals or events and one or a small number of organisations over time (Easterby-Smith *et al.*, 2008) by adopting the case study strategy which enables the answering of 'why?', 'what?', and 'how?' questions (Chetty, 1996; Yin, 2009). Furthermore, this strategy deeply considers the details of the various scenarios of both dependent and independent variables.

Consequently, the 'case study' research strategy is versatile and fits with different research methods and techniques to collect and analyse data, and also is suitable for conducting research that requires in depth investigation of understanding perceptions of a phenomenon.

### **3.6.3 Justification for Selecting Survey and Case Study**

As the aim of this research is to develop a framework on how to integrate tacit knowledge, in terms of capturing, sharing, and transferring within a construction project undertaken through the TPS, in the UK. The outcome of this research will provide means of improving the awareness and understanding of individuals at the organisational level about KI and its impact within the TPS. The phenomenon of this research not only requires participation of individuals who are involved in the construction sector in real-life context but also requires an understanding of the specific phenomenon; KI within a traditional-based construction project in the UK.



However, the 'survey' research strategy is suggested to find generic views and set of opinions about the approaches and techniques of KI that are currently used in projects. Furthermore, the 'case study' research strategy will be used to cover both the phenomenon under research and its related contextual conditions. In other words, it is suggested to find key challenges and approaches of TKI within a construction project context, undertaken through the TPS in the UK. As the philosophical position of this research is toward subjectivism, interpretivism and value laden, the research approach is also abductive, and hence, they support the use of both 'survey' and 'case study' as research strategy.

As mentioned previously, eight research strategies were introduced by Saunders et al., (2012). The first research strategy, *Experiment*, is not suggested for this study, because it requires the full control of researcher over the phenomenon being researched. Furthermore, the experimental strategy is suitable primarily for a quantitative research design and undertaken in a highly controlled context (Saunders et al., 2012). In fact, as the researcher does not have full control over the phenomenon of being studied and the research design is both qualitative and quantitative, the experimental research strategy is not appropriate for this research. The *Archival research* makes use of administrative records and documents as the principal source of data (Saunders et al., 2012). Bryman (1989) discusses that the term 'Archival' has historical connotations and may mislead, but it can refer to recent as well as historical documents. As this research attempts to understand the phenomenon in real-life context in construction sector in the UK, the archival strategy could be partially used in this research for collecting data like a case study that makes use of document analysis as one of its data collection techniques. The next research strategy is *Ethnography* which is use to study group and rooted in the inductive research approach (Saunders et al., 2012). In this strategy, the researcher is required to be part of the group which is under his study to observe, talk, and understand the culture of the group in order to be familiar with their behaviours, shared belief, interactions, and the events that shaped their lives that will enable the researcher to produce a detailed cultural accounts of the group (Saunders et al., 2012). Therefore, the ethnography research strategy requires more time and is appropriate for part-time researchers; therefore, it is not suitable for this research. The sixth research strategy is *Action Research*, which is used to promote organisational learning to produce practical outcomes through identifying issues, planning action, taking action, and evaluating action (Saunders et al., 2012). According to

Coghlan and Brannick (2010), this research strategy is about 'research in action rather than research about action'. Saunders et al., (2012) stated that this type of strategy is best suited for part-time researchers who have more time and can undertake the research within the organisation with which they are connected. In addition, as the nature of action research strategy is longitudinal, it is more appropriate for medium or long-term research projects rather than short-term research projects. In turn, the action research strategy is not appropriate for this research. The *Grounded Theory* research methodology can be used to refer to a methodological approach, a method of inquiry and the result of a research process (Bryant & Charmaz, 2007; Saunders et al., 2012). Grounded theory strategy uses data collection techniques for collecting data and analytic procedures which will lead to develop a theory that explains social interactions and processes in a wide range of contexts (Saunders et al., 2012). As this research is short-term and the aim of this research is not developing theory that is grounded in the data, the grounded theory strategy is not suitable for this particular research. The last research strategy is *Narrative Inquiry*. Saunders et al. (2012) state that the narrative inquiry will allow the researcher to analyse the linkages, relationships, and socially constructed explanations that occur naturally within narrative accounts in order 'to understand the complex processes which people use in making sense of their organisational realities' (Musson, 2004). This research strategy is more suitable for interpretive and qualitative research; however the nature of this strategy is intensive and time-consuming. As this research attempts to understand the phenomenon in real-life context in construction sector in the UK, the narrative inquiry strategy will be partially used in this research for collecting data.

According to the mentioned factors, research aim, objectives, and considering sections 3.6.1 and 3.6.2, the 'survey and 'case study' research strategies are more appropriate and a good fit for conducting this research. Survey strategy mostly used for descriptive and exploratory research where in this research it was required to deeply investigate TKI within the TPS in order to develop the TKI framework. In this regard, it was also required to use case study strategy which enabled the researcher to investigate and understand the perceptions of the research topic in the real-life context. The following sections provide further discussion on the case study design and its protocol.

### 3.6.4 Case Study Design

There are different ways to approach a case study design based on the epistemological standpoint of the researcher (Crowe et al., 2011). In other words, a case study can be designed to meet certain requirements of research; therefore, it can be a single case or multiple cases. However, carefully identifying a case study research design and details within a particular case will make case studies stronger and provide tools for researchers to study complex phenomena within their context (Baxter & Jack, 2008; Yin, 2009). Yin (2014) discusses four types of case study designs based on the 2x2 matrix that includes single- and multiple-case studies reflecting different design situations and, within these two variants there can be unitary or multiple units of analysis (Figure 3.4). The four types of case study designs are single-case holistic designs (TYPE 1), single-case embedded designs (TYPE 2), multiple-case holistic designs (TYPE 3), and multiple-case embedded designs (TYPE 4). These classifications enable the researcher to select a case according to the nature of the particular research prior to the research data collection (Yin, 2014).

According to Yin (2014), the first step in a case study design is deciding before collecting any data, whether the researcher is going to use a single case or multiple cases. Selecting single-case design requires a careful and precise investigation of the potential case in order to maximise the access needed for collecting the case study evidence. Therefore, identifying the unit of analysis (the case itself with an operational definition) is the major step in designing and conducting a single case. In the light of this, Yin (2014) states that the single-case study is an appropriate design and greatly justifiable under several circumstances and five conditions, that is having a *critical*, *unusual*, *common*, *revelatory*, or *longitudinal* case. These rationales have been briefly explained.

The first rationale for the single-case study is selecting a *critical* case, where the case represents a critical test of existing and well-formulated theory or theoretical proposition. The second rationale for the single-case study is where the case presents an *unusual* or an *extreme* circumstance, deviating from everyday occurrences. Therefore, a single case can be effectively utilised. The third rationale for the single-case study is the *common* case where the objective of the case is to capture the conditions and circumstances of an everyday situation. The fourth rationale is the *revelatory* case, when the researcher has an opportunity to observe and

analyse a phenomenon previously inaccessible to social science inquiry. Finally, a single-case study can be the *longitudinal* case when the same single case is being studied at two or more different points in time.

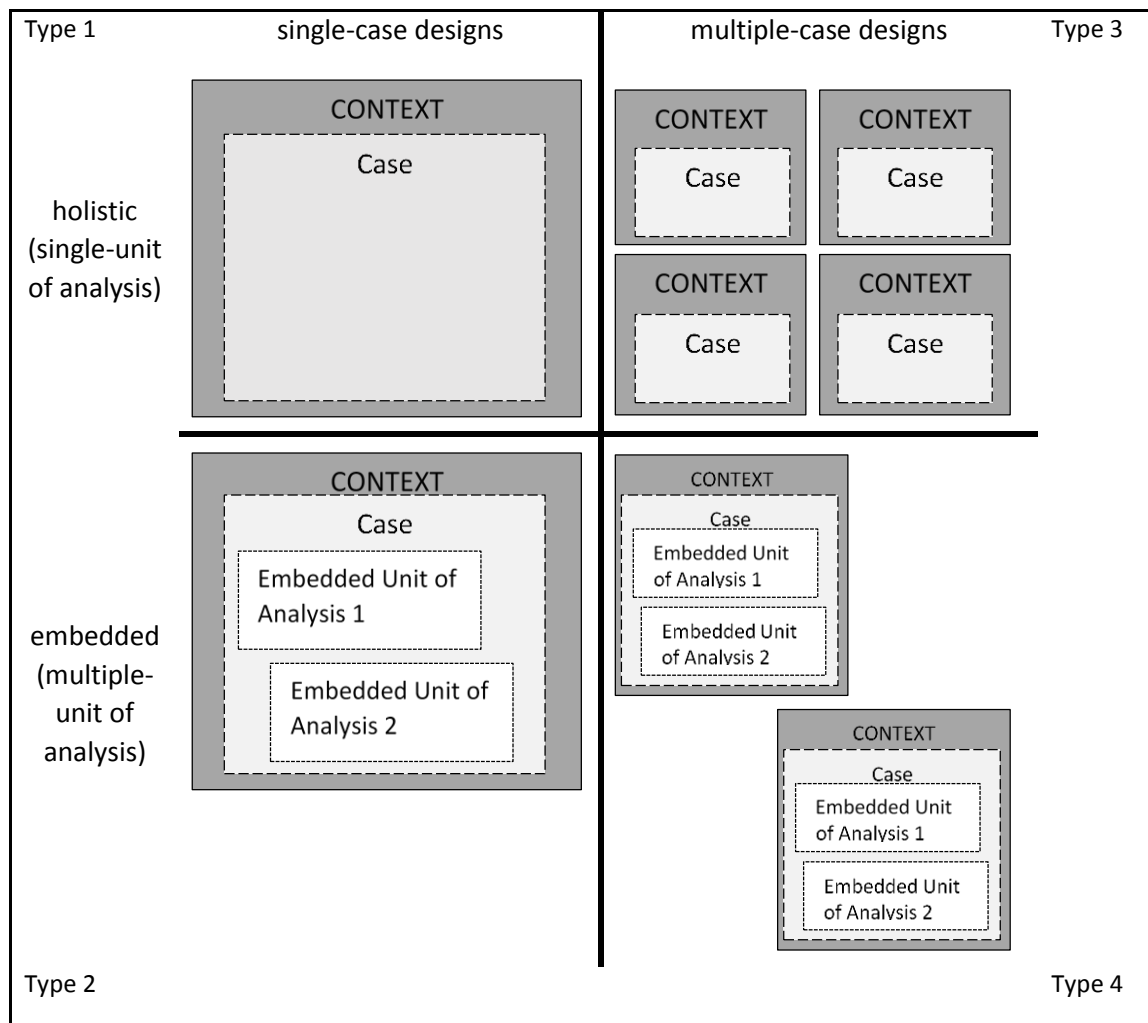


Figure 3.4 – Basic Types of Designs for Case Studies Adapted from Yin (2014)

Despite the mentioned conditions for selecting a single-case design, Yin (2014) states that results of a single-case design is quite hard to generalise to the benefit of a larger population, because the study samples in a single-case design are often extremely limited. Therefore, the multiple-case studies design is suggested because the evidence and results from multiple cases are often more robust and generalised (Yin, 2014). It has its own advantages and disadvantages compared to single-case designs. The extreme case, the critical case, and the revelatory case are associated with the single-case design which cannot usually be satisfied by multiple-cases. However, multiple-case studies considerably reduce the scepticism and

criticism that are associated with case studies and provide credibility to research outcomes. However, conducting a multiple-case study design can require more time and resources (Yin, 2009).

According to Yin (2014), conducting multiple-case studies research prevents the scepticism and criticism and produces stronger effects on the research process and its outcome. Therefore, researchers are advised by Yin (2014) to have at least two cases. The results of multiple-cases are stronger when replicating the pattern matching; such replications will increase the robustness of the original finding (Amaratunga & Baldry, 2001). In light of this, two or more case-study selections would fall within the direct replication logic (Yin, 2014). However, each case in multiple-case studies must be carefully selected, which is either a *literal* replication (predicts similar results) or *theoretical* replication (predicts contrasting results but for anticipatable reasons). One of the main factor and strength of using multiple-case studies is that it enables the researcher to use a variety of types of data, sources, and research methods as part of the investigation (Yin, 2014). For example, in a multiple-case with embedded design, each individual case may include the collection and analysis of quantitative data, including the use of surveys within each case study (Yin, 2014). In other words, the researcher can get access to variety of data from a wider spectrum through multiple-case studies. Therefore, the researcher is able to understand and explain the phenomenon being studied.

The single-case study design is not suitable for conducting this research because the phenomenon being studied does not represent a critical, unusual, or extreme case situation. Moreover, the phenomenon under study is not a common, neither revelatory, nor longitudinal case situation. Therefore, the multiple-case study design is the most suitable approach in the context of this research. However, multiple-case holistic designs (TYPE 3, Figure 3.4) were adopted for the conduct of this research because there is only one unit of analysis that needed to be studied in order to identify the process of TKI within a traditional construction project context in the UK. In other words, the researcher has the opportunity to understand the phenomenon in real-life of the processes of TKI in terms of capturing, sharing, and transferring within a construction project context undertaken through the TPS in the UK.

### **3.6.5 Case Studies Design Protocol**

Yin (2014) states that the Case Studies Design Protocol (CSDP) not only guides the researcher in conducting the data collection and also is essential in increasing the reliability of case study research. The CSDP (Figure 3.5) represents the sequential approach for conducting this research (Figure 3.5). The initial step is defining and designing the study which consists of theory development through the literature review and conceptual framework development. After that, selecting cases and designing data collection instruments are two important steps in this stage. The second stage is about preparing, collecting, and analysing the identified case studies. The final stage is the analysis and conclusion which includes conducting cross case analysis followed by a review of the conceptual framework, which leads to providing the conclusion and recommendations.

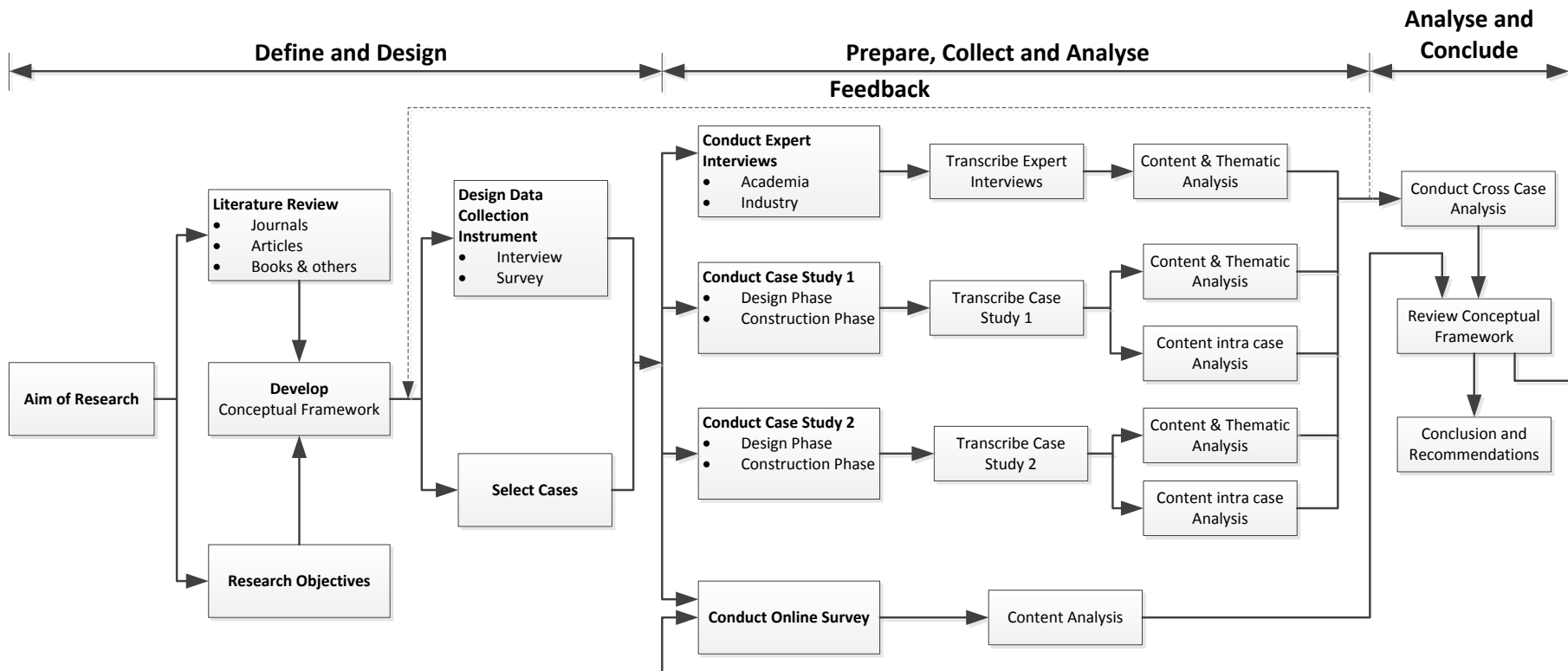


Figure 3.5 – Case Study Design Protocol adopted from Yin (2014)

### **3.6.7 The Unit of Analysis**

According to Baxter and Jack (2008), the researcher must consider what the case is while developing the research question(s). Miles and Huberman (1994b) define the case as “a phenomenon of some sort occurring in a bounded context. The case is, in effect, your unit of analysis”. Therefore, the unit of analysis in the context of this research is TKI within a construction project context in the UK. This unit of analysis is selected to draw a clear understanding of the process of KI in terms capturing, sharing, and transferring tacit knowledge within construction projects undertaken through the TPS. Therefore, the most appropriate strategy for adopting a case study design type is the multiple-case design with holistic single-unit of analysis (CASE TYPE 3, Figure 3.4). However, the research questions (section 1.5) of this research represent the requirements of TKI within construction projects undertaken through the TPS. This will leave the processes of KI, capturing, sharing, and transferring as the sub-category of the unit of analysis.

### **3.6.8 Case Study Selection**

The important factor that the researcher should consider during the design phase is selecting the case(s) to study. This is due to the uniqueness of the cases not because they are representative of other cases (Crowe et al., 2011). The first criterion that should be considered by the researcher in selecting a case is to maximise the understanding and perception of the researcher from a case (Stake, 1995). In light of this, the multiple-case design (Section 3.6.4) was adopted as the research approach after consideration of other case study design types. Case studies should be chosen considering the many ways of investigating and empirical descriptions of particular instances of a social phenomenon (Yin, 2009). In order to enrich the research process, two construction projects undertaken through the TPS were selected as case studies.

The cases are selected to reflect the building sector within construction industry. The projects were complex, large, and cost over £5m. The selected case studies differ in that one of them is a completed project and the other is an ongoing project at the construction phase. However, the cases will be selected from same organisation involved at the designing phase. The purpose is to analyse and compare the process of KI in projects that have been undertaken by the same organisation. In addition, most of the problems and errors occurred in the project



lifecycle are related to the designing phase. The case study screening, phase, stages, and key activities are further discussed in Chapter 5.

In order to have a different perspective and better understanding on the relevant issues in the context of this research, four expert interviews in each case were conducted as part of the main case study interviews (see section 3.10 for rationale of conducting experts' survey). Prior to the case studies' interviews, an expert's opinion survey (interviews) was conducted in order to get a better perceptions of the context of this research and facilitate the preparation for the case studies' interviews. This is further discussed in Chapter 4.

Table 3.5, 3.6 and 3.7 are the case study design summary, the criteria for selecting the case study and interviewees selection that should be met by the researcher.

Table 3.5 – Case Study Design Summary

<b>Unit of analysis: Tacit knowledge Integration within construction projects in the UK</b>					
<b>Case study Design Type</b>	<b>Case Study Approach</b>	<b>Type and size of Project</b>	<b>Type of Procurement</b>	<b>Number of Project</b>	<b>Stage of Project</b>
Multiple-Holistic	Replication - Literal	Building Project – Complex and large	Traditional	2	1- Completed 2- Ongoing project at construction phase

Table 3.6 – Case Studies Selection Criterion

<b>Criteria</b>	<b>Case Requirements</b>	<b>Research Requirements</b>
<b>1</b> The case should be an on-going construction project	The project should be undertaken through traditional procurement system and at its construction phase. The type of project should be building projects	Project must provide the opportunity for purposes of research. Provide input of experts at both design and construction stage.
<b>2</b> The case should be a finished construction project	The completed project undertaken through traditional procurement system. The type of project should be building projects.	Project must provide the opportunity for purposes of research. Provide input of experts at both design and construction stage.

Table 3.7 – Interviewees Selection

Project phase	Interviewee	Number of Interviewees
Design	- Architect	1 (x2)
	- Engineer	1 (x2)
Construction	- Project Manager/Site Manager	1 (x2)
	- Site Engineer/ Site Quantity Surveyor	1 (x2)
<b>Total Number of Interviewees for both cases</b>		<b>8</b>

### 3.7 Time horizon

Saunders et al. (2012) state that there are two types of time horizon in designing a research; *Cross-sectional* and *Longitudinal*. The former is used to study a particular phenomenon in a particular time. Remenyi et al., (1998) state that cross-sectional studies take a snapshot of a single moment in time when trying to understand and identify variables for particular phenomenon. However, this type of approach does not provide definitive information on the way in which situations develop over time and how something is done at the time of the study. In other words, it does not consider the situation before and after the snapshot is taken. The latter is adopted for the studies that require a long time period to provide rich data and results. In other words, the longitudinal approach requires a long time period to monitor and observe the progress of a situation over time (Remenyi *et al.*, 1998). This research is undertaken for an academic course and is about TKI within a construction projects context undertaken through the TPS in the UK. Therefore, the time horizon stance of this research is cross-sectional.

### 3.8 Data Collection Methods

As mentioned in Section 3.4, the research approach in this study is abductive. This means data collection is used to explore a phenomenon, identify themes and patterns, locate these in conceptual framework, test this through subsequent data collection, etc. (Saunders et al., 2012). In other words, this approach is to clarify the different aspects of phenomenon, to reduce number of key reasonable alternative conclusions that obtained from findings, and also to obtain verification of findings. There are generally two types of data: primary and

secondary. The methods of collecting data are further discussed in the context of this research.

It should be mentioned that secondary data include both qualitative and quantitative data that are used most frequently in the case study and survey research strategy (Saunders et al., 2012). The main sub-groups of secondary data are:

- documentary data
- data that are compiled from multiple sources
- survey-based data

According to Saunders et al. (2012), the documentary secondary data includes written materials; minutes of meetings, diaries, notices, transcripts of speeches, reports to shareholders, and administrative and public records. Furthermore, it also includes journals, newspapers, books, and magazine articles. However, documentary secondary data also include non-written materials like drawings, video and voice recordings, films, pictures and television programmes, organisation databases, DVDs, and CD-ROMs (Robson, 2002). These types of data can be analysed both quantitatively and qualitatively. However, the main use of documentary secondary data is to triangulate findings based on other data that are collected through other data collection tools like interviews or questionnaires.

In this research the documentary survey (secondary data) was used to develop the research background information and build the project through collecting data from books, journals, and conference papers. This documentary survey covers the first objective of the study. Furthermore, semi-structured interviews were used in the expert surveys and case studies for collecting the primary qualitative data. An online open-end questionnaire was also used for validating the developed framework (further detailed about the data collection methods that are used in this research are discussed in Section 3.10).

### **3.8.1 Qualitative Methods of Data Collection**

According to Saunders et al. (2012) and Collis and Hussey (2003), the qualitative data collection method is the process of generating, obtaining, recording or using non-numerical data through in-depth semi structured and grouped interviews, and direct observation. Although the qualitative data collection method provides in-depth data and information, it

could be costly and consume more time than quantitative data collection methods (Collis & Hussey, 2003).

**Observation** is the systematic process of observing, recording, describing, analysing and interpreting people's behaviour (Saunders et al., 2012). There are two types of observation; participant and structured. The participant observation is qualitative and used to discover "the meanings that people attach to their actions"; whilst the structured observation is quantitative and is used to record "the frequency of those actions" (Saunders et al., 2012).

An **Interview** is a purposeful discussion between two or more individuals in which one individual (the interviewer) asks questions and the others (interviewees) willingly answer questions. Furthermore, interviews enable the researcher to collect reliable and valid data that are relevant to the research question(s) and objectives. There are three classification of interviews; structured, semi-structured and unstructured interviews (Saunders et al., 2012).

- *Structured* interviews use questionnaires which are developed upon predetermined and standardised set of questions. Therefore they are called 'interviewer-administered questionnaires' (Saunders et al., 2012). Furthermore, these types of interviews are also referred to as 'quantitative research interviews', because structured interviews are used to collect quantifiable data.
- *Semi-structured* interviews are non-standardised interviews. Therefore, they are referred to as 'qualitative research interviews' (Saunders et al., 2012). In these types of interviews the researcher uses a list of themes and questions which might be changed in each interview based on the answers of the previous interview.
- *Unstructured* interviews are informal and used to explore in-depth a general area of interest. The interviewer only needs to have a clear idea about the interested topic that he wants to explore. There is no need to have a predetermined list of questions and the interviewees are free to talk about their beliefs in relation to the topic area (Saunders et al., 2012).

### 3.8.2 Sampling

Saunders et al., (2012) state that the sampling techniques provide a range of methods that enables the researcher to reduce the amount of data that are needed to collect by considering

only data from a sub-group rather than all possible elements. In other words, the sampling data is used to generalise about all the possible cases from which the sample has been selected. This procedure requires identifying the population and size of the sample. Furthermore, the need for sampling emerges when time and budget constraints prevent the researcher to survey the whole population and when it is not possible and practicable to survey the entire population (Saunders et al., 2012). Generally, sampling techniques are divided into two categories; Probability or representative sampling and *Non-probability* or judgemental sampling.

Saunders et al., (2012) stated that **probability sampling** is mostly used in survey-based research strategies and the target samples are selected from the population with an equal chance (probability). In other words, the probability sampling enables the researcher to estimate statistically the characteristics of the population from the sample which will lead to the achievement of the objectives and answer research question(s) of the study. According to Saunders et al. (2012), the probability sampling process includes four stages:

1. Identify a suitable sampling frame based on the research question(s) or objectives
2. Decide on a suitable sample size
3. Select the most appropriate sampling techniques and select the sample
4. Check that the sample is representative of the population

There are five main probability sampling techniques; Simple Random, Systematic, Stratified Random, Cluster and Multi-stage (Saunders et al., 2012).

The **non-probability sampling** does not rely on a statistical theory and the probability of selected sample from the population is not known (Saunders *et al.*, 2012). The sampling techniques are selected based on the researcher subjective judgement. Furthermore, the researcher may be dictated to implement one or a number of non-probability sampling techniques based on the research question(s), objectives, and choice of research strategy, limited resources, or the inability to specify a sampling frame. This type of sampling has five techniques: Quota, Purposive, Snowball, Self-selection and Convenience (Saunders et al., 2012).

## 3.9 Data Analysis Method

Analysing data depends on types of data which is either non-numeric or numeric. Therefore, there are two types of methods for analysing data; qualitative and quantitative.

### 3.9.1 Qualitative Method

Qualitative data refers to non-numeric data or data that have not been quantified and can be a product of all research strategies (Saunders et al., 2012). According to Saunders *et al.* (2009) and Denscombe (2010), there are five different methods for analysing qualitative data; content analysis, thematic analysis, grounded analysis, discourse analysis, and comparative analysis.

The *Content analysis* is a systematic technique for obtaining ideas that have been decided in advance and the data for constructs by means of transcription and coding the sentences that are compressed into the theme.

The *Thematic analysis* is a highly inductive analytical approach whereby themes emerge from the data collected and not imposed by the researcher.

The *Grounded analysis* uses categorisation and coding collected data in order to derive theories and concepts from meanings within the data.

The *Discourse analysis* is based on conversation; the way in which individuals talk and what persuades them to talk. The conversation or speech is analysed as performance rather than the state of the mind

The *Comparative analysis* refers to comparing data from different individuals until no new issue arises. This type of analysis is connected to the thematic analysis.

#### 3.9.1.1 Semi-Structured Interview Data Analysis

As mentioned in Section 3.8, semi-structured interviews were used to collect qualitative data. These interviews were digitally recorded with an average duration of 60 minutes. Easterby-Smith et al. (2008) state that “full record of the interview should be compiled as soon as possible after it has taken place”. This view is supported by (Saunders et al., 2012) who believe that there is a need to “create a full record of the interview soon after its occurrence to control

bias and to produce reliable data for analysis". The important factor about qualitative data analysis is exploring the meaning through what is experienced and reported by the interviewees and what is observed by the interviewer. The aim of analysing qualitative data is to identifying pattern, concepts, themes and meanings. The qualitative data analysis is described by Bogdan and Biklen (2003) as "working with the data, organising them, breaking them into manageable unit, coding them, synthesis them and searching for patterns". The process of qualitative data analysis begins with transcribing interviews followed by open coding of the data, which is the categorisation of data in order to identify patterns, themes, and meanings that emerges from the data. In this process, the whole data is initially explored and then the researcher reconstruct it again in a more meaningful way. This categorisation enables the researcher to compare and contrast between patterns, and deeply reflect on certain patterns of the data in order to understand them.

According to Richards (1999), a content analysis software package such as NVivo 10.0 could be used to synthesis and manage themes from large amount of qualitative data by organising data into manageable nodes (themes). The semi-structured interviews are analysed using the content analysis method to organise data into general themes. In order to make sense of the data, open coding of the data is used, which is the process of recording the number of responses that a particular interviewee gives to a question. Then thematic content coding of the interview transcripts is used to analyse responses. Initially, each transcript is individually analysed for identifying key themes. In the next stage common themes shared between interviewees are identified. These common themes are merged into new nodes as shown in Figure 3.6.

Furthermore, Interpretive Structural Modelling (ISM) is a quantitative technique to analyse qualitative data. This approach has been used by researchers to identify and represent interrelationships among various variables related to the issue (Raj & Attri, 2011). Although, there are other approaches for analysing qualitative data by using quantitative technique like Interpretive Ranking Process (IRP), Analytic Hierarchy Process (AHP), and Total Interpretive Structural Modelling (TISM), all these approaches express factors by ranking and not the interrelationship between the factors. Since the objective is not to rank the challenges in relation to performance of TKI but influence on themselves affecting the process of TKI within the TPS, the ISM approach is employed for conducting this research.

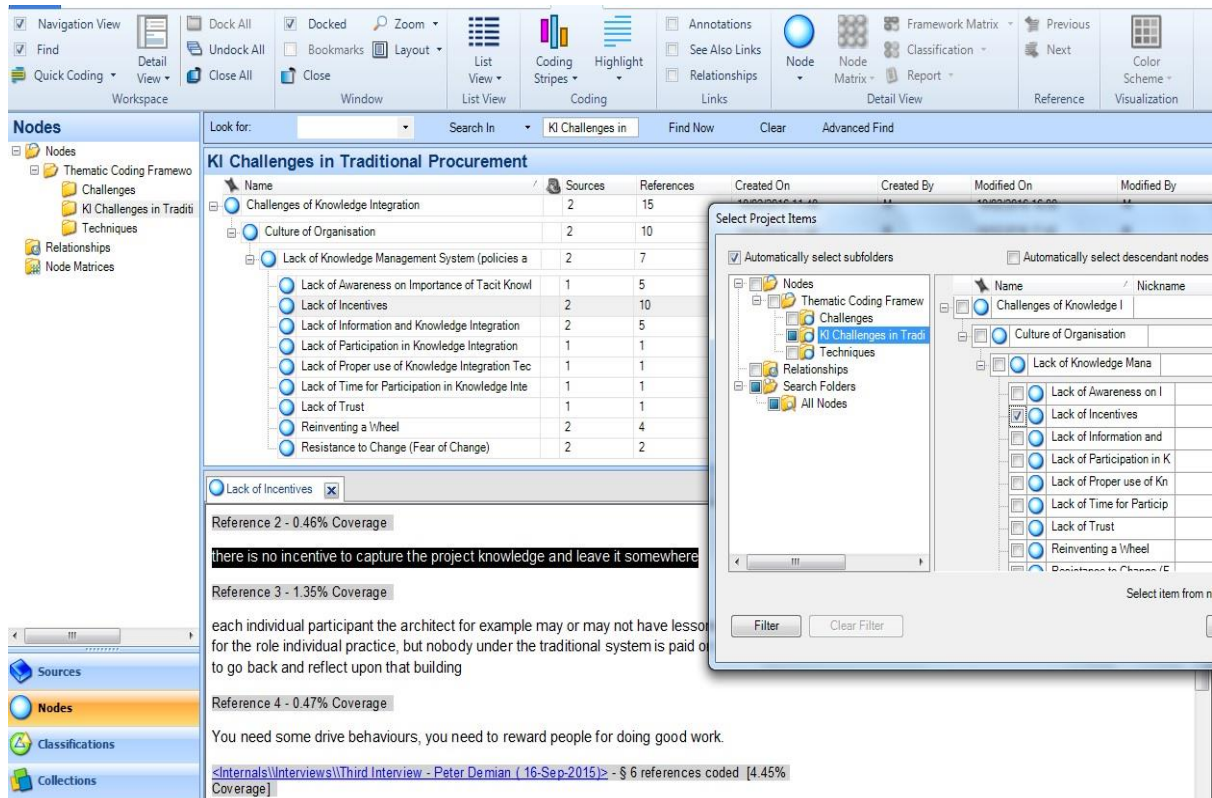


Figure 3.6 – Snapshot of Content Coding in Nvivo 10.0

### 3.9.1.2 Interpretive Structural Modelling – ISM

The ISM approach uses practical experience and knowledge of experts based on various management techniques like brain storming, nominal group technique, etc. to unravel a complicated system into several elements and construct a multilevel structural model (Warfield, 1976). In other words, it is a well-established approach that can be used to identify and summarise relationships among specific variables which define an issue or a problem.

The ISM technique is an interactive learning process that develops a comprehensive systematic model through structuring a set of directly and indirectly related variables. The ISM-based model represents the structure of a complex issue or problem in a designed pattern. This model depicts the direct and indirect relationships between the variables that describe the situation more accurately. In other words, it develops insights into collective understandings of these relationships. The process of ISM is further discussed in Chapter 4 Section 4.5.



### **3.10 Rationale for the Choice of Research Methods**

As mentioned in previous sections the research approach of this study is an abductive approach, and the multimethod qualitative research design was adopted to achieve the stated aim and objectives of this research. This means different qualitative methods were used to collect and analyse data during the interpretation and presentation of the research.

The researcher is required to collect data through a documentary survey in order to form the background information and develop a conceptual framework which would be then taken to a real life situation to investigate, gather relevant information, and understand the perceptions of stakeholders in using the KI process within the traditional-based construction project. This documentary survey covers the first objective of the research (Table 3.9). Furthermore, an expert's opinion survey was used to collect qualitative data through interviews with four experts. These experts were from both academia and industry and were selected based on their experiences and engagement in the traditional-based construction projects. It enables the researcher to investigate the second, third, and fourth objectives of this research. An online open-end questionnaire is conducted to collect the experts' opinion on the developed framework. In this research the target population is professionals who are involved and experienced in the traditional-based construction project in the UK construction industry. As it is difficult to identify and access to all members of the desired population, a random probability sample is drawn from the population by professional bodies such as RICS and CIOB which have a member database. These databases are used with permission to draw the random probability sample for the online questionnaire survey. The questionnaire is distributed among 180 designers and contractors.

As discussed in Section 3.6.4, multiple case studies are used in this research. The criteria for selecting the case studies are explained in Table 3.6 and will be further discussed in Chapter 5. Two construction projects undertaken through the TPS in the UK are considered as case studies for this research (See Sections 5.2 and 5.3 in Chapter 5). The projects are required to be already/substantially completed or on-going and they are selected based on accessibility and opportunity to access data (Table 3.5 and 3.6). The semi-structured interview is used as one of the main data collection instruments for collecting qualitative data in this research. The researcher interviewed at least two professionals from both design team and construction

team involved within the traditional-based projects (one from senior level, and one from operational level, Table 3.7). The qualitative data collected from interviews would address second, third, and fourth objectives of this research (Table 3.9).

In this research, the content analysis approach (Sections 3.9.1 and 3.9.1.1) is used to analyse the collected qualitative data, from semi-structured interviews in the experts' survey and case studies with the aid of content analysis software package such as NVivo10 that uses a code-based and word-based approach. The data is transcribed, coded, and analysed thematically. This software enables the researcher not only to auto-code the large volumes of transcripts quickly but also to use queries for finding a theme for the data. Furthermore, the ISM approach is used by the researcher to identify the relationships between the identified variables from analysis of semi-structured interviews. The online questionnaire survey is mainly based on open-end questions. Therefore, a content analysis approach is used to analyse the collected data.

### **3.11 Validity and Reliability**

Saunders et al. (2012) indicate that the validity and reliability are two important factors in assessing the quality of research. Gibbs (2007) states validity in qualitative research as “the verification process of the findings employed by the researcher”. On the other hand, reliability refers to consistency of findings if the same data collection and analysis techniques are applied by a different researcher or repeated on another occasion (Saunders et al., 2012). Yin (2014) highlighted that the aim of reliability is to minimise the biases and errors in a study. Therefore, the case study tactics and procedures, recommended by Yin (2014), is adopted in order to maximise the validity and reliability of this research. Table 3.8 indicates the case study tactics for validity and reliability.

Table 3.8 – Case Study Tactics for Validity and Reliability

Tests	Case Study Tactic	Phase of Research in which Tactic Occurs	Action Taken in this Research
<b>Validity</b>	<ul style="list-style-type: none"> <li>• Use multiple sources of evidence</li> </ul>	– Data collection	<ul style="list-style-type: none"> <li>• Triangulation of collected data (from both the design and construction team) using semi-structured interview</li> </ul>
	<ul style="list-style-type: none"> <li>• Establish chain of evidence</li> </ul>	– Data collection	<ul style="list-style-type: none"> <li>• Each interview will be recorded and transcribed. Other responses received from respondents will be used to integrate the responses and further used in triangulation</li> </ul>
	<ul style="list-style-type: none"> <li>• Use replication logic in multiple-case studies</li> </ul>	– Research design	<ul style="list-style-type: none"> <li>• Two case studies with the same type of procurement system (One completed and one in process). Semi-structured interviews used in CS1 will be slightly changed (regarding the facts and conclusions of CS1) and used in CS2.</li> </ul>
<b>Reliability</b>	<ul style="list-style-type: none"> <li>• Use case study protocol</li> </ul>	– Data collection	<ul style="list-style-type: none"> <li>• Develop a CSDP</li> <li>• Each case followed the same data collection procedure. Consistent set of questions used in each interview</li> </ul>
	<ul style="list-style-type: none"> <li>• Developing the case study database</li> </ul>	– Data collection	<ul style="list-style-type: none"> <li>• Interview transcripts and other sources (documents and field notes ) are verified and entered into database</li> </ul>

### 3.12 Ethical Approach to the Research

The university’s code of ethics provide the guidelines on the principles and procedures for conducting a research. An ethical approval was submitted and granted by the University of Salford Research Ethics committee for conducting this research (Appendix I). The ethical approval is critical and includes the informed consents, anonymity of respondents, and confidentiality of information.

Potential participants were provided by the participant information sheet and consent form in order to be familiar with the purpose of the research and decide whether they would like to participate in this research. The signed consent form was obtained from participants, prior commencement to the interview. The researcher keeps the anonymity of participants and avoided including any personal information of participants at any point in the research. The researcher only had access to the collected data that were stored in a password protected computer, and to the paper records that were kept in a locked file.

### 3.13 Summary

This chapter outlined an overview of the research process used for conducting this research. The concept of research, research philosophy, approach, methods and proposed data analysis that were used to achieve the study aim were presented. The summary of adopted research methodology is illustrated in Table 3.9, and how achieving each research objective is presented in Table 3.10.

Table 3.9 – The Summary of Adopted Research Methodology

Research Methodology	Type	Adoption
<b>Research Philosophy</b>	Epistemology	Lean towards Interpretivism
	Ontology	Lean towards Subjectivism
	Axiology	Lean towards Value Laden
<b>Research Approach</b>		Abductive
<b>Methodological Choice</b>	Multimethod	Qualitative
<b>Research Strategy</b>	Mixed methods	Survey and Case Study
<b>Research Method Data Collection</b>	Qualitative	Documentary Survey – Secondary Data Semi-structured Interviews Online Survey – Open-end Questionnaire
<b>Research Method Data Analysis</b>	Qualitative	Content Analysis

Table 3.10 – Research Objectives Achievement Overview

Research Objectives	Research Strategy	Research Techniques	Data Collection Type/ Analysis
<b>To establish and document the specific areas of tacit knowledge integration within construction project context</b>	Literature review of research documents related to tacit knowledge integration	Documentary Survey	Qualitative
<b>To investigate different approaches and techniques that are currently used in construction projects with respect to knowledge integration</b>	Literature review Survey Case study	Experts' Survey: Semi-structured interviews with 4 experts Case study: Semi-structured interview (Design team and contractors)	Qualitative
<b>To explore key challenges of knowledge integration process within construction project context, undertaken through the traditional procurement system</b>	Literature review Case study Survey	Experts' Survey: Semi-structured interviews with 4 experts Case study : Semi-structured interview (Design team and contractors)	Qualitative
<b>To critically analyse the success factors for tacit knowledge integration within construction project context, undertaken through the traditional procurement system</b>	Literature review Case study Survey	Experts' Survey: Semi-structured interviews with 4 experts Case study : Semi-structured interview (Design team and contractors)	Qualitative
<b>To develop and validate a framework on how to integrate tacit knowledge within a construction project undertaken through the traditional procurement system</b>	Literature review Case study Survey	Online Survey: Open-end Questionnaire Case study : Semi-structured interview (Design team and contractors)	Qualitative

## Chapter 4 – Experts' Interview

### Findings

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## **4.1 Introduction**

This chapter highlights findings from the experts' survey and interviews conducted as part of data collection method for this research. The preliminary data analysis in this chapter is in line with the philosophical stance of this research (Chapter 3, Section 3.3). The findings are presented according to the research area in the traditional procurement context: TKI, Approaches and Techniques, and Challenges.

The survey consists of interviews with four experts in both academia and construction industry. A semi-structured interview was developed and four interviews were conducted. Furthermore, the interviews were audio-recorded and additional notes were taken. Finally, the recordings were analysed in order to get general ideas about the research, compared with the findings from documentary survey and used further for developing semi-structured interviews for the case studies.

This chapter starts with the criteria for selecting the interviewees for the experts' survey followed by the findings of survey according to the research objectives. Then the transcripts of the interviews are analysed using the content analysis method and the NVivo software. The outcomes are presented and compared with the outcomes of the literature synthesis in order to identify the challenges of KI within the TPS. Lastly, the ISM method is used to identify and summarise the relationships between the identified challenges.

## **4.2 Selection of Interviewees**

As mentioned in the research methodology chapter (Chapter 3, Section 3.10), the interviewees are selected from both academia and industry. The selected interviewees have years of experience of working in the construction field and are involved in various KM and traditional-based construction projects. The two respondents from academia and two respondents from industry were carefully chosen based on their understanding and knowledge of these concepts: Tacit Knowledge, Knowledge Capturing, Knowledge Sharing, Knowledge Transferring, and Construction Project undertaken through the TPS. The table below illustrates an overview of the interviewees' profile.

Table 4.1 – Interviewees’ Profile

Respondents	Profile	Total Experience
R1	Professor of construction management/procurement, with experience in Industry within organising, managing and procuring construction projects	20 years
R2	Lecturer in construction management, with experience and understanding of BIM implementation, knowledge management and design-construction integration	10 years
R3	Knowledge Transfer Partnerships with experience of construction engineer and understanding of BIM implementation	8 years
R4	Architecture with in-depth experience of being project manager and Site manager	25 years

### 4.3 Experts’ Interview Findings

This section elaborates on the research findings from the experts’ survey interviews. As outlined in Chapter 3 Sections 3.8 and 3.10, semi-structured interviews are designed to address the first three objectives (Section 1.3). These findings are generally categories according to objectives of the research (Section 4.3.1 - 4.3.3) and are further analysed through qualitative content analysis (Chapter 3 Section 3.9.1) with the aid of the computer software package NVivo 10 which is further discussed in Section 4.4.

#### 4.3.1 Tacit Knowledge Integration within Traditional Procurement Project

The respondents highlighted that tacit knowledge is more important than explicit knowledge in a construction project because it is the experience that people achieved during project implementation, which is stored in person’s brain. In other words, managing tacit knowledge means trying to get access to the stored knowledge in person’s brain.

*R1: “Tacit knowledge probably is the most important because that’s the knowledge of how to do stuff; explicit knowledge is who has got the power.”*

*R3: “Tacit knowledge by its definition can only reside in people’s head, so managing tacit knowledge means managing people’s brain, managing people means keeping employees in the company and getting novice employees to learn from experienced employees.”*



The respondent expressed that the people at manager level are more aware of the importance of knowledge, but it is not managed properly due to existing challenges in both different types of procurement and the KM system.

*R2: "I think people are rational and have common sense; they are aware of the importance of managing knowledge, but the problem is that the person who has to pay the price of the extra effort needed to capture is not the same person who will benefit from it in the future"*

*R4: "However, the facts that make managing tacit knowledge more difficult are the poor knowledge management system that exists in construction organisation and the nature of different procurement types that exist, specifically in the traditional procurement system, due to the separation of design and construction phase."*

Despite this fact, people at both the organisational and project level are not well aware of the importance of tacit knowledge and TKI, specifically in the TPS. It has been noted that project members are encouraged to walk away at the end of project and not share their information and knowledge in the TPS (*R4: the traditional procurement system by definition encourages people to walk away at the end and not to share information.*)

Further probing of the respondents about the TKI within the construction project undertaken through the TPS, it was highlighted that knowledge and information does not integrate properly in the process of traditional-based construction project.

*R1: "In the traditional system that information and knowledge does not flow properly in the process, because architects, engineers and contractors are incentivised to do the opposite, are incentivised to keep that knowledge because that is what they are selling in the marketplace so they don't want to give that knowledge to somebody else who can replicate it. They want to control by themselves"*

Therefore, not only are knowledge and experiences not captured and shared but also mistakes and problems are not documented and, therefore, have potential to occur in future project by designers, engineers, and contractors. Thus, these professionals cannot benefit from the learned material and experiences from the current project for use in future projects. The

respondents agreed that learning from previous projects and applying those lessons would prevent problems in current projects; the aim of TKI.

*R2: "We can address this problem. We can get this forth sight by learning from previous projects, and in particular learning the tacit knowledge from previous projects, and if we learn how in previous projects certain decisions let the problems in construction phase, perhaps we can apply these lessons learnt to prevent those problems in our project, prevent those problems from occurring at the construction phase."*

This happens because the TPS itself does not make the project team to be aware of the consequences of their decisions (specifically the design decisions) and incentivises them to keep their knowledge. In other words, there are no incentives for project members to take the extra effort and participate in KM.

*R4: "I think people involved in project undertaken through traditional procurement system do not have that incentive to keep what they learnt during the project."*

Furthermore, the respondents stated that tacit knowledge at the design and construction phase are different. The tacit knowledge at design phase is more problematic and harder to manage because the design phase is more complex.

*R3: "I think it is particularly difficult and problematic in design phase to manage the tacit knowledge as all of the expertise and the skills in design are almost linked to tacit knowledge."*

*R1: "The individual, architect or firm might make a mistake in a design and they might take it forward to any other commission that they have.....I think if the designers only have experience the traditional system, the traditional system does not expose them enough to the consequences of the design decisions, so it is likely that they may repeat the same mistakes from one project to another."*

Therefore, there is a need to integrate this tacit knowledge within the process of a traditional construction project in order to minimise the potential mistakes and increase the productivity of project members in future projects. However, this integration requires a knowledge

repository which is better to be in position of the designing organisations in this type of procurement.

### **4.3.2 Approaches and Techniques of Knowledge Integration**

The respondents highlighted that, Post-Project Review (PPR), Post-Occupancy Evaluation (POE) and Soft-Landing mechanism have been used for capturing knowledge in the traditional-based construction project. They also expressed the need to pay more attention to the process of lessons learned and the process of procurement for capturing project knowledge.

*R1: "Post-Occupancy Evaluation, Soft-Landing mechanisms are attempts to capture whether or not the building is performing as it should, there are less I think fewer examples of the process lessons, the process of procurement, the process of bringing that building to the marketplace...."*

*R2: "I think it is down to the organisation to insist the POE or PPR happen, and the organisation can say to the employees we are going to have PPR after every single project. It has to happen."*

However it was highlighted that PPR usually occurs separately in each group after the completion of a project and there is no integration between the design and construction team during PPR.

*R4: "... If PPR happens, it usually happens in design team or construction team separately exactly after the completion of project which means PPR in design team and construction team are not integrated"*

It should be mentioned that these mechanisms, by their definition can be used to capture knowledge only after the completion of a project. Conducting PPR at the end of the project to review the lessons learned confronts two shortcomings. First, the knowledge which is generated during the project and achieved by the project's members may be forgotten if it is not captured regularly. Secondly, the key project's members are usually recruited for the next project before the formal completion of the project. Therefore, organisations need to pay more attention to these shortcomings and techniques to implement them properly and

regularly in order to capture the tacit knowledge and benefit from the knowledge in future projects.

*R3: "I think POE and PPR have an important role to play, but these things are things that the organisation does, not the individuals. As an organisation has to see the value of those and do them properly and invest money in them, and investing in those two means that they are seeing benefits of it in future projects"*

It was noted that in the further probing of the respondents about the techniques of capturing, sharing and transferring project knowledge in the TPS are more informal.

*R1: "I think under the stylised traditional procurement system, the techniques are informal. because the traditional procurement system, the contractual mechanisms are geared up to be about on the contract clauses about managing cost, managing time, managing completion."*

Respondents expressed that techniques like PPR, POE, group meetings, project briefings and review sessions are mostly used for capturing and sharing project knowledge.

*R2: "We can capture tacit knowledge perhaps by audio recording conversation between two people; novice and expert near water cooler, like informal chatting, and maybe there are some tacit knowledge going (sharing) from the expert to the novice.....We can get this forth sight by learning from previous projects, and in particular learning the tacit knowledge from previous projects..... nowadays, a lot of communication happen electronically using email, BIM system..."*

*R4: "...usually it is through meetings, PPR, POE, project briefing and reviewing sessions. By these techniques project members have this opportunity to discuss about issues face-to-face, which is really important in terms of transferring their idea and experiences. However, after meetings project members use phone calls or informal chatting for communication."*

One respondent mentioned the importance of capturing and saving knowledge by using BIM. In other words, BIM can be used as a knowledge repository in the process of KI.

*R3: “Nowadays, organisations use BIM in order to improve the performance of project, but BIM is not about modelling and managing information. It also includes the knowledge, it can be used for capturing and saving knowledge; it can be used for sharing knowledge between project members. Organisations also could benefit from it by using the knowledge and lessons they learnt in future projects. For example, the COBie file includes all data and information and are mostly used for exchanging information between project members. The government has a plan to implement BIM level 2 by 2016 and BIM level 3 by 2025 in all construction projects”*

The important factor highlighted by the respondent is that the process of capturing tacit knowledge should be a continuous day-to-day process rather than at the end of project task, because tacit knowledge is the way in which people learn and it is the experiences they achieved during project life cycle that are vital.

*R3: “I think because you are saying tacit knowledge it has to be a day to day, continuous process.”*

### **4.3.3 Challenges of Knowledge Integration**

Discussion under the TPS showed that the main challenge in the process of KI is that the system itself that suffers from lack of KM policies and strategies. The respondents agreed that usually the system does not include a mechanism to enable project members to capture and share knowledge of the project.

*R1: “The traditional procurement system encourages people to store information on their sides of their contractual boundary and encourages them not to share information ..., .... traditional system posing together for one project and then they despond and go to the next project. There is no incentive to capture the project knowledge and leave it somewhere. Each individual participant the architect for example may or may not have lessons learned for the role individual practice, but nobody under the traditional system is paid or rewarded to go back and reflect upon that building, ... under the traditional system there isn’t usually a mechanism for them to all share and learn around the issues of the project.”*

Furthermore, it was highlighted that the separation of the design phase and the construction phase is the biggest challenge that will lead to lack of integration.

*R2: "I think the biggest challenge in traditional procurement is the separation between design and construction phase. So when people make decisions in the design phase, they don't think so much about construction, but if I can isolate the challenge in traditional procurement, it is the lack of integration between design and construction"*

However, lack of motivation and incentive to capture for sharing the project knowledge are examples of challenges of KI which was highlighted by the respondents.

*R3: "My feeling is that because people, who will use this knowledge in the future, are the ones who stand to benefit... It is difficult to incentivise those people at design phase to capture their knowledge, especially when you talk about tacit knowledge. If there is no incentive in capturing stage (at design phase), then there should be more effort in the construction phase"*

*R4: "Most of designers do not have that incentive to participate in knowledge management and interest to save the knowledge they achieved during a project and use it in future project... They aware of it but there is no incentive"*

It is important to familiarise project members with the importance of KI (in terms of capturing, sharing and transferring, which could be done by incentivising project members to participate in KI process). Further probing of the respondents on challenges of KI, it was seen that in the TPS, it depends on the individual concerns and internal mechanism of companies to consider and be aware of the importance of tacit knowledge and implementation of KI.

*R1: "I think it depends upon the individual concerns and individual companies, some would be aware and some will not. It depends on their own internal mechanisms whether they are learning.... ,... Culture is one of them and it is how and what the companies are paid to do by their clients."*

Furthermore, the internal mechanism of organisations plays a key role in enabling individuals to learn and benefit from KI. This internal mechanism represents the culture of the

organisation. In other words, the organisational culture is the main challenge in this type of procurement.

*R4: "As we discussed, lack of incentive and insufficient time for implementing knowledge integration are the challenges in this type of procurement.... Now is the culture of organisation a challenge? I think absolutely it is"*

However, it was stated by respondents that involved individuals at different stages of the project are required to capture project knowledge in order to improve their knowledge and experiences. This is highly dependent on the culture of the organisation and the incentives that exists among project members.

*R2: "I think the most important one is incentive. I think other challenges depend on how you capture the knowledge. This captured knowledge helps people to increase their experiences and react faster to a problem when it occurs."*

Furthermore, respondents expressed that 'fear of change' and 'lack of trust' along with 'insufficient time for integrating knowledge' are other challenges that exist in this type of procurement.

*R3: "If you do something a little bit more explicit with technology that you have to use certain tools, there are lots of technology challenges like fear of change and not wanting to adopt new technology and all these things. It is also the same with using BIM system in organisation."*

*R4: "However, another challenge could be lack of trust; project members usually don't have trust to share their knowledge as they have fear of losing their job in future"*

#### **4.4 Analysis of Experts' Interview Findings**

This section elaborates on the research findings from the experts' survey interviews. As outlined in Chapter 3 Section 3.10, the qualitative data collected from the semi-structured experts' survey interviews were analysed with the aid of computer software package. The process started with the qualitative content analysis of the interviews' transcripts, with the aid of NVivo software, which generates codes according to the identified concepts within transcripts, as shown in Figure 4.1 (Chapter 3, Sections 3.9 and 3.10). These codes and

concepts were further used to create cognitive maps highlighting the experts' survey interviews outcome.

This section is structured in three sub-sections including cognitive maps on the challenges of KI within the TPS from both the academic and industry perspective. Each cognitive map is explained with the concepts that were elicited from interviewees, before presentation of synthesised findings of both academic and industry. Finally the identified challenges from both the academic and industry perspective are summarised and presented in Table 4.2.

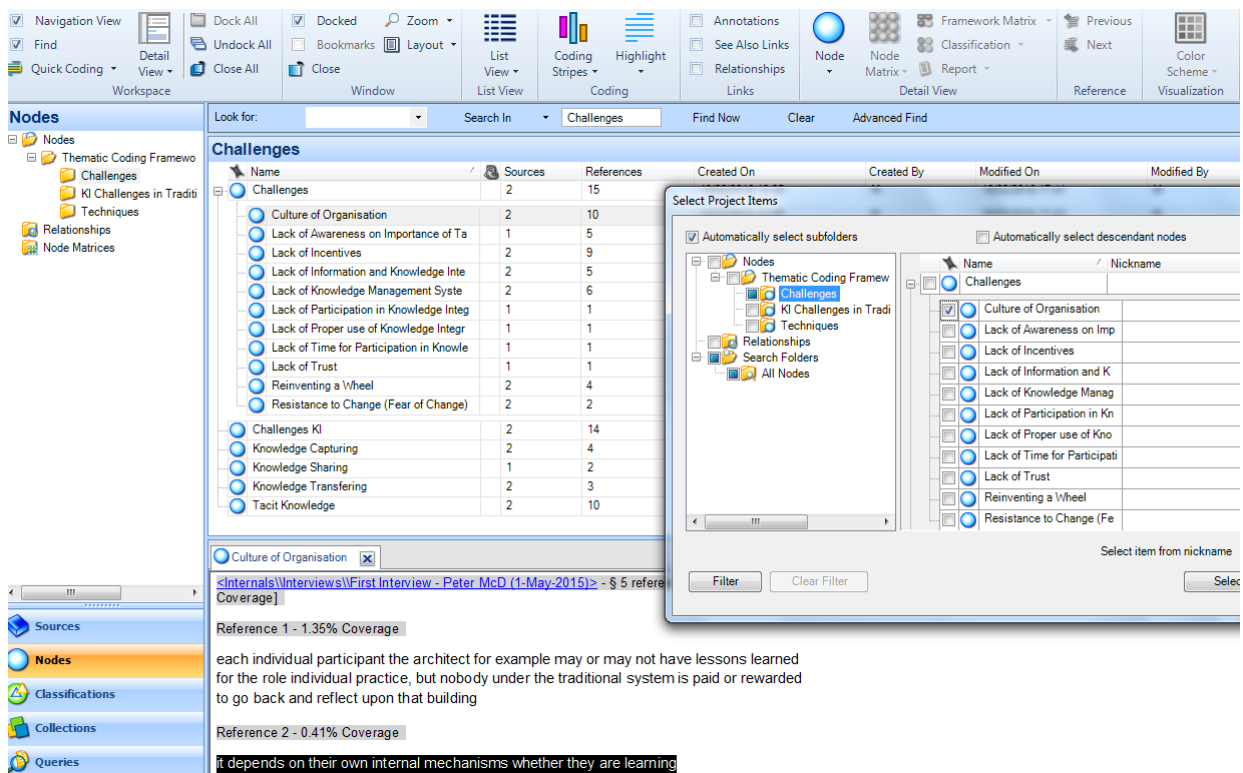


Figure 4.1 – Snapshot of Content Coding in NVivo

#### 4.4.1 Academia Perspective

Figure 4.2 illustrates the summary of challenges of TKI as elicited from Respondent 1 (R1) and Respondent 2 (R2). This highlights the main challenges of TKI within the traditional-based construction project in terms of capturing, sharing and transferring knowledge from the academic viewpoint.

R1 and R2 stated that the TPS by its definition is the challenge for integrating tacit knowledge because it does not motivate project members to keep the knowledge and experiences that they achieved during the project process (concept 20). As described by R2, project members



are encouraged not to share their information and knowledge in the TPS. Both R1 and R2 addressed that this will lead to improper flow of information and knowledge between project members (concept 12). Furthermore, they mentioned that this system itself tries to ignore the importance of KI by not incentivising project members, and encouraging them to walk away at the end of project (concept 17).

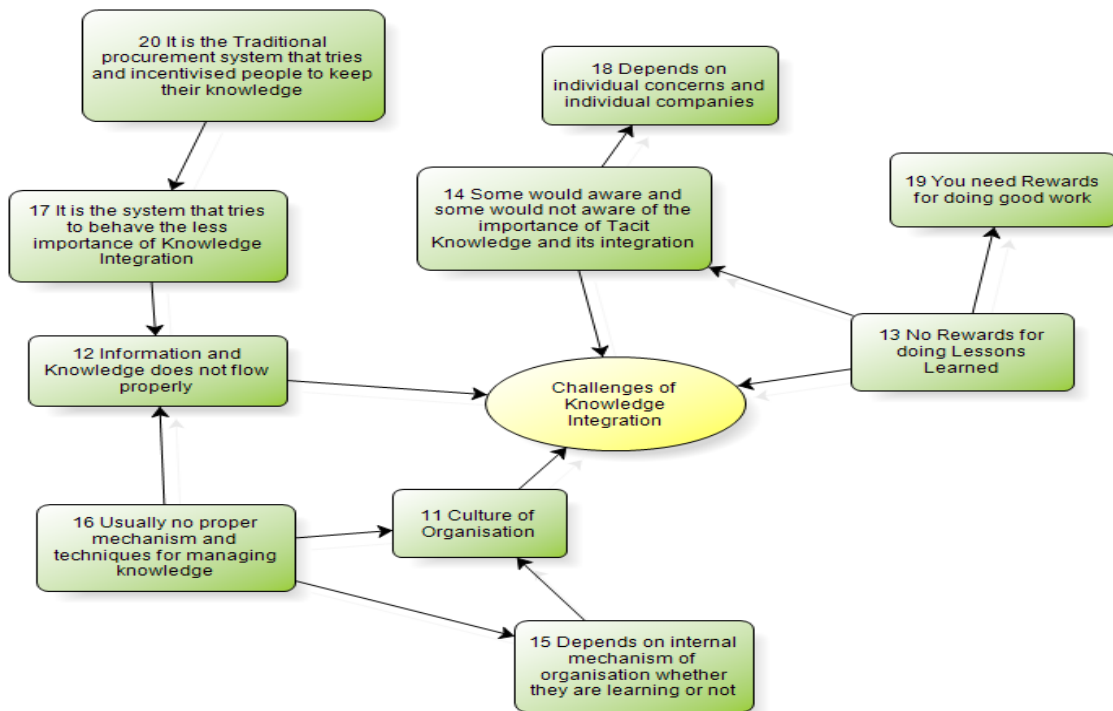


Figure 4.2 – Cognitive map of Tacit Knowledge Integration Challenges as elicited from Academia

R1 and R2 said that usually there is no proper mechanism for project managers for managing tacit knowledge in this type of procurement in terms of sharing and learning around the issues of the project (concept 16). However, R1 noted that this lack of management strategies depends on the internal mechanism of organisations (design and construction) whether they are aware of the importance of TKM and learned about the various mechanisms and techniques (concept 15). R1 and R2 mentioned that these are related to the organisational culture (concept 11) for the improvement of awareness of the project managers about the importance of TKM and implementing proper KM mechanisms. They highlighted that the culture of the organisation is the main challenge and root of other challenges of TKI in a traditional-based construction project. However, R1 stated that the awareness on the importance of tacit knowledge and its integration depends on the concerns of individuals and companies (concept 18) and how they see the benefits of this integration and using the lessons

learned; some would aware of this importance and some would not (concept 14). In this regard, R1 and R2 suggested that organisations and project managers should increase their awareness of the importance of TKI and also put rewards and incentivise project members to participate in TKI process and improve their performance (concept 19). They also mentioned that the TPS usually does not incentivise and gives rewards to project members for capturing and sharing knowledge of lessons learned (concept 13).

#### 4.4.2 Industry Perspective

Figure 4.3 presents the summary of challenges of TKI as elicited from Respondent 3 (R3) and Respondent 4 (R4). This highlights the main challenges of TKI within the traditional construction project, in terms of capturing, sharing and transferring knowledge from the industry viewpoint.

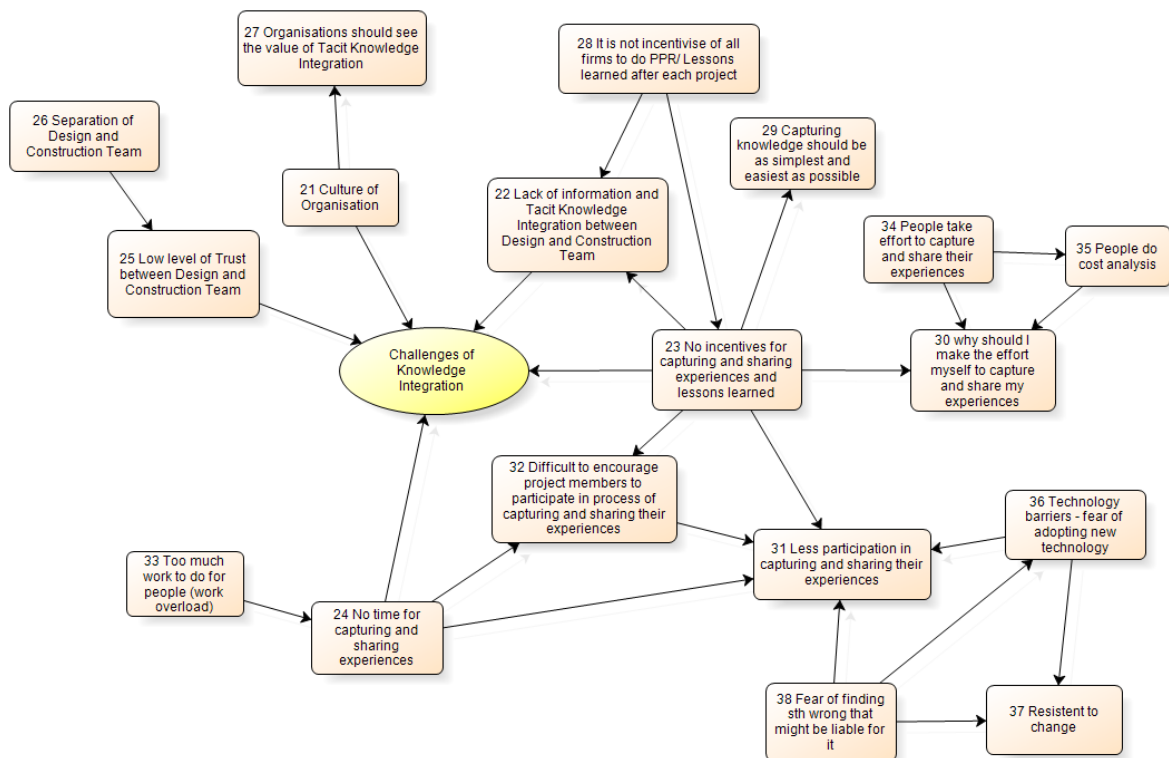


Figure 4.3 – Cognitive map of Tacit Knowledge Integration Challenges as elicited from Industry

R3 and R4 mentioned that the level of trust between designers and engineers are low (concept 25) in the TPS and is related to its nature, which is based on separation of design and construction team (concept 26). R4 stated that the value and benefits of TKI is not well explained for organisations (concept 27), which is related to the attitudes of project manager to prioritise and deeply explain the importance of KM (concept 21). R3 stated that collaboration between the design and construction team in terms of information and knowledge is low (concept 22) and that this is mainly happens as the organisations are not incentivised to do lessons learned or PPRs after finishing the project (concept 28) and also are not incentivised to share their experiences (concept 23). R4 noted that capturing lessons learned should be simple and easy (concept 29) because individuals take effort and spend time to capture and share their experiences (concept 34) and do cost analysis (concept 35). Therefore, if they are not motivated and incentivised, there is no reason to make the efforts and spend more times to capture and share their experiences (concept 30).

However, R3 argued that lack of incentives and motivation from manager level will make it difficult to encourage project members to participate in the process of capturing and sharing their experiences (concept 32 and 31). Also R4 mentioned that less participation of project members in the process of capturing and sharing their experiences (concept 31) involves other reasons like technology challenges (concept 36) and fear of being liable for mistakes (concept 38). Further, R4 stated that project members are usually afraid to adopt new technology not only because of having less information about it, but also they afraid of being liable for the problems that might occur by implementing new technology. Therefore, they are resistant to change (concept 37). However, both R3 and R4 concluded that one of the main challenges of low participation in the process of capturing and sharing lessons learned and experiences by project members is the high number of workloads (concept 33) and having less time for capturing experiences and collaborating with other project members (concept 24).

#### **4.4.3 Synthesis of the Knowledge Integration Challenges**

Sections 4.4.1 and 4.4.2 discussed the challenges of TKI within the TPS representing the academic and industry perspective. Figure 4.4 presents a synthesis of challenges of TKI elicited from the experts' survey interviews (Section 4.4.1 and 4.4.2). The green and bisque colour concepts are those identified by interviewees from academia and industry, respectively.

Comparing the identified challenges from Section 4.4.1 and 4.4.2 reveals that not only are some challenges (concepts 11 and 21, 12 and 22, 13 and 23) similar to each other, shown in blue colour, but also that there are some relationship between them.

Respondents, from both academia and industry, highlighted that the TPS by definition encourages project members to walk away at the end of project; therefore, there will not be sufficient time for project members to capture the lessons they learned through the project and share it with each other. Moreover, the awareness of the project members about the importance of tacit knowledge and its integration is low in this type of procurement system, which is highly dependent on the organisational culture and the approaches that managers take in order to integrate knowledge.

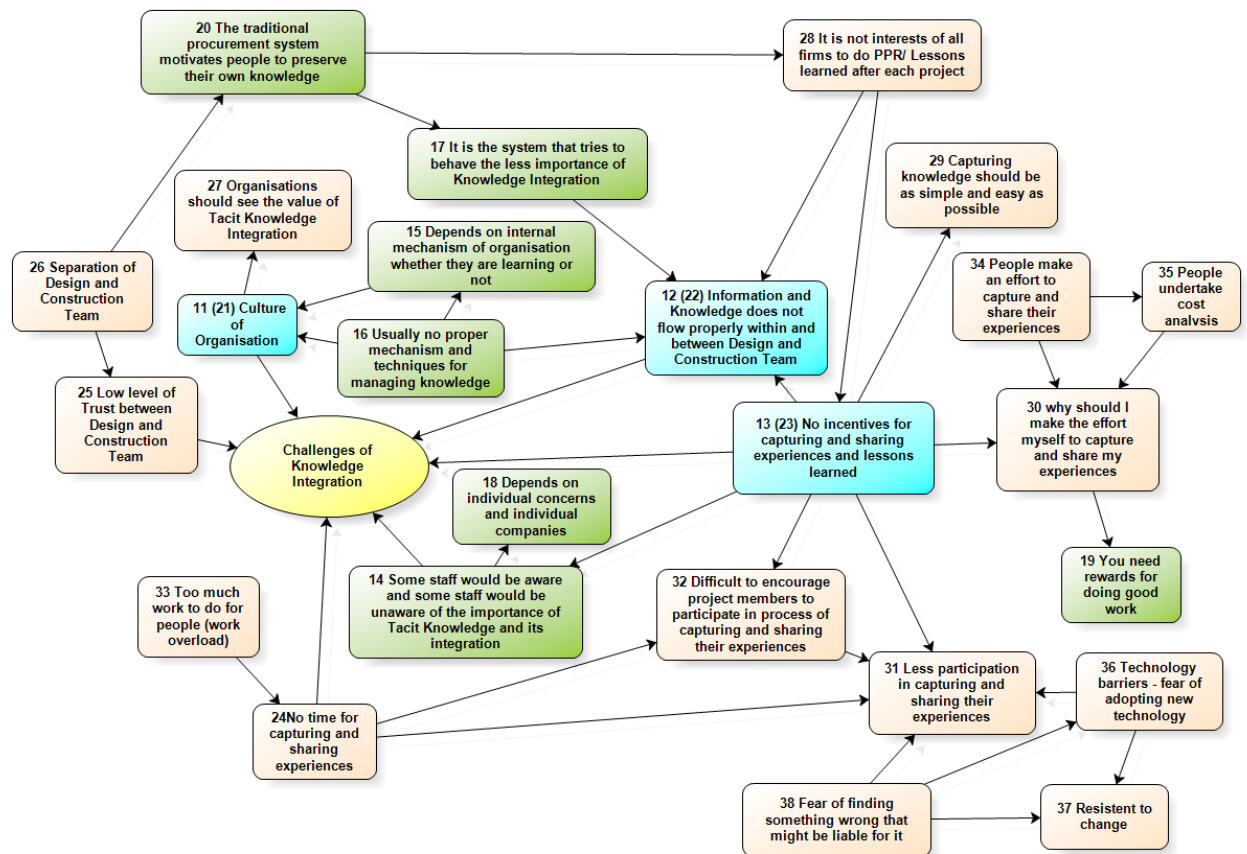


Figure 4.4 – Synthesis of Challenges of Knowledge Integration within the Traditional Procurement System

Figure 4.4 consists the synthesis of all challenges of KI within construction projects undertaken through the TPS that were elicited from the experts' survey. The identified challenges are in details and most of them are related to each other. In order to have a categorised and summarised list of challenges, these findings are compared with the findings from literature and Sections 4.3.1 and 4.3.3, and the result is presented in Table 4.2. This table shows how the summarised challenges are in line with the concepts in Figure 4.4. Further, these challenges are explained in detail ISM (Interpretive Structural Modelling) approach is used to identify their relationships (Section 4.5).

Table 4.2 – Knowledge Integration Challenges in Traditional Procurement System

Variables	Concepts
<b>V1</b> Lack of Awareness on Importance of Tacit Knowledge and Its Integration	14,18,27
<b>V2</b> Lack of Participation in Knowledge Integration	13(23),31,32
<b>V3</b> Lack of Time for Participation in Knowledge Integration (Time Pressure)	24,31,32,33
<b>V4</b> Lack of Information and Knowledge Integration	12(22)
<b>V5</b> Lack of KM System (policies and strategies)	12(22),15,16,28
<b>V6</b> Reinventing a Wheel (high potential of same mistakes and problem occurrence)	17,21
<b>V7</b> Lack of Incentives	13(23),28,32
<b>V8</b> Lack of Proper use of Knowledge Integration Techniques	16,29,36
<b>V9</b> Lack of Trust	11(21),25,26
<b>V10</b> Culture of Organisation	11(21)
<b>V11</b> Resistance to Change (Fear of Change)	11(21),14,37,38

### **V1. Lack of Awareness on Importance of Tacit Knowledge and Its Integration**

The awareness of construction organisation members has been seen to be relatively low as regards to the importance of tacit knowledge and its integration (Kamara et al., 2002; Hari et al., 2005). It is necessary to prioritise and improve the awareness of project's members on the benefits of tacit knowledge, and how its integration will lead to improve project process and performance (Ekambaram et al., 2014).

### **V2. Lack of Participation in Knowledge Integration**

Project members are reluctant to participate in the KM process as they are not well informed about the importance of KM. However, it is not well specified and incentivised in their contract to participate in this process. Inevitably, project members would be reluctant to share their knowledge (Ekambaram et al., 2014).

### **V3. Lack of Time for Participation in Knowledge Integration (Time Pressure)**

According to McDermott and O'Dell (2001) and Ekambaram et al., (2014), lack of time would prevent knowledge holders from sharing and transferring their knowledge in a temporal-based project, like a construction project, even when the available technology is efficient. Furthermore, project members have no time for sharing and transferring their knowledge because they will be recruited in another project on completion of the present project or they are involved in several projects within the same time frame (Ekambaram et al., 2014). Furthermore, project members are usually overloaded with various tasks to complete in a specific time. Therefore, they hardly allocate time to participate in the KI process.

### **V4. Lack of Information and Knowledge Integration**

The construction industry suffers from the lack of KI between its phases (Pryke, 2005; Kamara et al., 2007; Harty & Schweber, 2010; Love et al., 2011; Zhu et al., 2014), especially in the TPS (CIOB, 2010) because the design and construction phases are separated in this type of procurement and the lack of integration is further compounded by project members being recruited quickly for another project on completion of the current project.

### **V5. Lack of KM System (Policies and Strategies)**

The TPS suffers from lack of KM expertise and system (Masterman, 2000). However, much knowledge which is gained by project members is lost and dispersed, if it is not properly captured and shared at the end of the projects (Cheng, 2009). In other words, poor management of knowledge across construction projects, specifically projects undertaken by the TPS, will lead to a significant amount of knowledge loss in which case ignoring it would be detrimental to the project performance. The poor KM system means using less and inappropriate techniques for capturing, sharing and transferring knowledge in projects. However, appropriate policies and strategies for managing knowledge in projects highly depends on the existence of the supporting organisational culture.

### **V6. Reinventing a Wheel (high potential of same mistakes and problem occurrence)**

Ignoring tacit knowledge and its integration will lead to the spending of more time and energy to develop solutions that might already exist when a problem occurs (Ekambaram et al., 2014).

#### **V7. Lack of Incentives**

It is necessary for the project's members to be motivated to participate in the KI process, capturing, sharing, and transferring of knowledge, otherwise no or inadequate knowledge will probably be integrated (Ekambaram et al., 2014). One reason that knowledge holders are reluctant to participate in the KI process is the lack of incentives and motivation from project managers, specifically in the TPS (Hari et al., 2005; Bessick & Naicker, 2013). This system by its definition does not incentivise project members to collaborate and participate in the KI process.

#### **V8. Lack of Proper Use of Knowledge Integration Techniques**

Different factors are involved in the lack of properly using KI techniques. Project members usually are not aware and well-trained in these techniques. This is highly dependent on the culture and KM strategies of the organisation.

#### **V9. Lack of Trust**

Trust is important for effective KI in a construction project (Ekambaram et al., 2014). However, it is very important but low in projects undertaken through the TPS because the project members in the design and construction phases are separated. The low level of trust means that the awareness level of the knowledge holders about the importance of the KI and its impact on project performance is low and they are reluctant to share their knowledge with other members in different phase of project. However, lack of trust also depends on the supporting culture of the organisation and knowledge manager to encourage and motivate the knowledge holders to participate in the KI process and build trust among project members.

#### **V10. Culture of Organisations**

Organisational culture is highlighted as the most important factor in the process of capturing, sharing, and transferring knowledge that creates a link between knowledge sharing and business problems (McDermott & O'Dell, 2001). Existence of the supporting culture is highly important in managing knowledge among individuals in an organisation and project. This is mainly dependent on the attitudes of the knowledge manager to encourage and motivate knowledge holders and build reward and recognition systems by using different techniques and technologies (Hari et al., 2005). Organisational culture should prioritise and increase the

awareness level of its members of the importance of KI. This is highly dependent on having a standard working process and existence of trust between project members.

#### **V11. Resistance to Change (Fear of Change)**

It is the main challenge to the capturing, sharing, and transferring of knowledge in the construction industry. Individuals and experts are reluctant to share their knowledge, because they consider knowledge as power (Hari et al., 2005). Furthermore, they also do not tend to learn from others' experiences, because they are afraid of the negative impact of admitting mistakes among their team members. However, the knowledge manager should consider the issue regarding knowledge holders who are reluctant to participate in KI process when they feel the insecurity of their job.

### **4.5 Interpretive Structural Modelling – ISM**

As mentioned in Chapter 3 Section 3.9.2.1, the ISM-based approach can use practical experience and the knowledge of experts based on various management techniques; like brain storming, nominal group technique, etc. to decompose a complicated system into several elements and construct a multilevel structural model (Warfield, 1976). In other words, ISM can be used to identify and summarise relationships among specific variables, which define an issue or a problem. The various steps involved in the ISM approach are as follows (Charan et al., 2008):

**Step 1:** *Identify and select the relevant variables.* In this research the challenges of KI in TPS have been identified.

**Step 2:** *Structural self-interaction matrix (SSIM) is developed.* This matrix is used to indicate the pair wise relationship among variables of the system under consideration

**Step 3:** *Determine the reachability matrix.* The SSIM matrix is used to develop the reachability matrix. However, the transitivity of the contextual relationships is a basic assumption made in ISM. This means if variable A is related to variable B and variable B is related to variable C, then variable A is related to variable C.

**Step 4:** *Decompose the reachability matrix into different levels.* The developed reachability matrix from step 3 is partitioned into different levels in order to create a structural model, a directed graph (digraph), and the transitive links are removed.



### 4.5.1 Structural Self-Interaction Matrix (SSIM)

The SSIM is a contextual relationship among the variables and is developed based on opinions of experts. For this purpose, the experts from academia (2 experts) and industry (2 experts) were consulted for identifying the nature of the contextual relationship among the variables. In order to analyse the variables, a contextual relationship of 'leads to' and 'facilitates' type must be chosen. This means that one variable leads to another or one variable facilitates another variable. Therefore, the contextual relationship between the identified variables is developed.

Considering the contextual relationship for each variable and the existence of a relationship between any two variables ( $i$  and  $j$ ), the associated direction of the relationship is questioned in a pair wise manner. Four symbols are used to denote the direction of the relationship among variables (Attri et al, 2013):

1. **V** is used when variable  $i$  will facilitates or influences variable  $j$  (the relation from variable  $i$  to variable  $j$ )
2. **A** is used when variable  $i$  will be facilitated or influenced by variable  $j$  (the relation from variable  $j$  to variable  $i$ )
3. **X** is used when variable  $i$  and  $j$  will facilitate and influence each other (both direction relations)
4. **O** is used when variables  $i$  and  $j$  are unrelated (no relation between the variables)

Based on the contextual relationships, the SSIM is developed as shown in Table 4.3.

Table 4.3 – Self-Structural Interaction Matrix

Variable	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11
V1		V	V	V	A	V	O	V	O	A	V
V2			A	V	A	V	A	A	X	A	A
V3				V	A	V	A	A	X	A	A
V4					A	V	A	A	A	A	A
V5						V	V	V	V	A	V
V6							O	A	O	A	O
V7								V	X	O	V
V8									X	A	A
V9										A	X
V10											V
V11											

#### 4.5.2 Reachability Matrix

The next step in the ISM approach is to transform the SSIM into a binary matrix, called the initial reachability matrix by substituting four symbols V, A, X and O to 1 or 0. The rules for this substitution are as follows:

- A. If the  $(i, j)$  entry in the SSIM is V, then the  $(i, j)$  entry in the reachability matrix becomes 1 and the  $(j, i)$  entry becomes 0.
- B. If the  $(i, j)$  entry in the SSIM is A, then the  $(i, j)$  entry in the reachability matrix becomes 0 and the  $(j, i)$  entry becomes 1.
- C. If the  $(i, j)$  entry in the SSIM is X, then the  $(i, j)$  entry in the reachability matrix becomes 1 and the  $(j, i)$  entry becomes 1.
- D. If the  $(i, j)$  entry in the SSIM is O, then the  $(i, j)$  entry in the reachability matrix becomes 0 and the  $(j, i)$  entry becomes 0.

Following these rules, the initial reachability matrix is illustrated in Table 4.4.

Table 4.4 – Initial Reachability Matrix

Variable	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11
V1	1	1	1	1	0	1	0	1	0	0	1
V2	0	1	0	1	0	1	0	0	1	0	0
V3	0	1	1	1	0	1	0	0	1	0	0
V4	0	0	0	1	0	1	0	0	0	0	0
V5	1	1	1	1	1	1	1	1	1	0	1
V6	0	0	0	0	0	1	0	0	0	0	0
V7	0	1	1	1	0	0	1	1	1	0	1
V8	0	1	1	1	0	1	0	1	1	0	0
V9	0	1	1	1	0	0	1	1	1	0	1
V10	1	1	1	1	1	1	0	1	1	1	1
V11	0	1	1	1	0	0	0	1	1	0	1

The final reachability matrix is developed by considering the concept of transitivity, which was described in step 3 of SSIM approach. The 1\* entries indicate the incorporate transitivity. The final reachability matrix along with the dependence and 'Driving Power' is shown in Table 4.5. In this table the 'Driving Power' of each variable indicates the total number of variables (including itself) which it may help to achieve. However, the 'Dependence Power' of each variable indicates the total number of variables which may help achieving it. The driving and dependence power will be used in the MICMAC (Matrice d'Impacts Croises-Multiplication Applique An Classment) analysis (Section 4.6.5), where the performance measures will be classified into four groups or clusters: Autonomous, Dependent, Linkage and Independent.

Table 4.5 – Final Reachability Matrix

Variable	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	Driving Power
V1	1	1	1	1	0	1	0	1	1*	0	1	8
V2	0	1	1*	1	0	1	1*	1*	1	0	1*	8
V3	0	1	1	1	0	1	1*	1*	1	0	1*	8
V4	0	0	0	1	0	1	0	0	0	0	0	2
V5	1	1	1	1	1	1	1	1	1	0	1	10
V6	0	0	0	0	0	1	0	0	0	0	0	1
V7	0	1	1	1	0	1*	1	1	1	0	1	8
V8	0	1	1	1	0	1	1*	1	1	0	1*	8
V9	0	1	1	1	0	1*	1	1	1	0	1	8
V10	1	1	1	1	1	1	1*	1	1	1	1	11
V11	0	1	1	1	0	1*	1*	1	1	0	1	8
Dependence Power	3	9	9	10	2	11	8	9	9	1	9	

### 4.5.3 Level Partitions

According to Warfield (1974), the reachability and antecedent set are derived from the final reachability matrix. The reachability set for each variable consists of the variable itself and the other variables that it may impact; whereas the antecedent set for each variable consists of the variable itself and the other variables that may impact it. Following that the intersection of these sets is obtained for all variables. Subsequently, the variables for which the reachability and intersection sets are the same occupy the top-level in the ISM hierarchy. The top-level variables are those that will not lead the other variables above their own level. After identifying the top-level variable, it is removed from the other remaining variables. Then the same process is continued until levels of all variables are identified. These levels help in building the diagram and the final model of ISM.

The reachability set, antecedent set, intersection and the participation level of variables are shown in Table 4.6 where variable 6 (Reinventing a wheel) is found to be at level I. Therefore, variable 6 should be positioned at the top of the ISM model.

Table 4.6 – Partitioning of Variables

Variable	Reachability set	Antecedent set	Intersection	Level
V1	1,2,3,4,6,8,9,11	1,5,10	1	IV
V2	2,3,4,6,7,8,9,11	1,2,3,5,7,8,9,10,11	2,3,7,8,9,11	III
V3	2,3,4,6,7,8,9,11	1,2,3,5,7,8,9,10,11	2,3,7,8,9,11	III
V4	4,6	1,2,3,4,5,7,8,9,10,11	4	II
V5	1,2,3,4,5,6,7,8,9,11	5,10	5	V
V6	6	1,2,3,4,5,6,7,8,9,10,11	6	I
V7	2,3,4,6,7,8,9,11	2,3,5,7,8,9,10,11	2,3,7,8,9,11	III
V8	2,3,4,6,7,8,9,11	1,2,3,5,7,8,9,10,11	2,3,7,8,9,11	III
V9	2,3,4,6,7,8,9,11	1,2,3,5,7,8,9,10,11	2,3,7,8,9,11	III
V10	1,2,3,4,5,6,7,8,9,10,11	10	10	VI
V11	2,3,4,6,7,8,9,11	1,2,3,5,7,8,9,10,11	2,3,7,8,9,11	III

### 4.5.4 Formation of ISM-based Model

The final reachability matrix will be used to develop the structural model. If a relationship exists between the variables  $j$  and  $i$ , it is depicted by an arrow pointing from  $i$  to  $j$ . The resulting diagram is called 'Diagraph' where the top level variable is positioned at the top of the diagram and the second level variables are positioned at the second level and so on till the lowest

variable is positioned at the bottom of the diagram. Finally, by removing the transitive links, as described in step 4 of ISM approach, the diagraph is converted to the ISM model which is shown in Figure 4.5.

It can be seen in Figure 4.5 that ‘culture of organisation’ is a very significant challenge in integrating knowledge in the TPS, as it comes at the base of the ISM hierarchy. This challenge affects all other challenges positioned above its level, and together will lead to the variable at the top level. It should mention that variables positioned at the same level have the same impact on each other. The ISM model highlights the major challenges of KI and provides a means for analysing the interaction between these challenges. However, these challenges need to be overcome for the success of KI in the TPS.

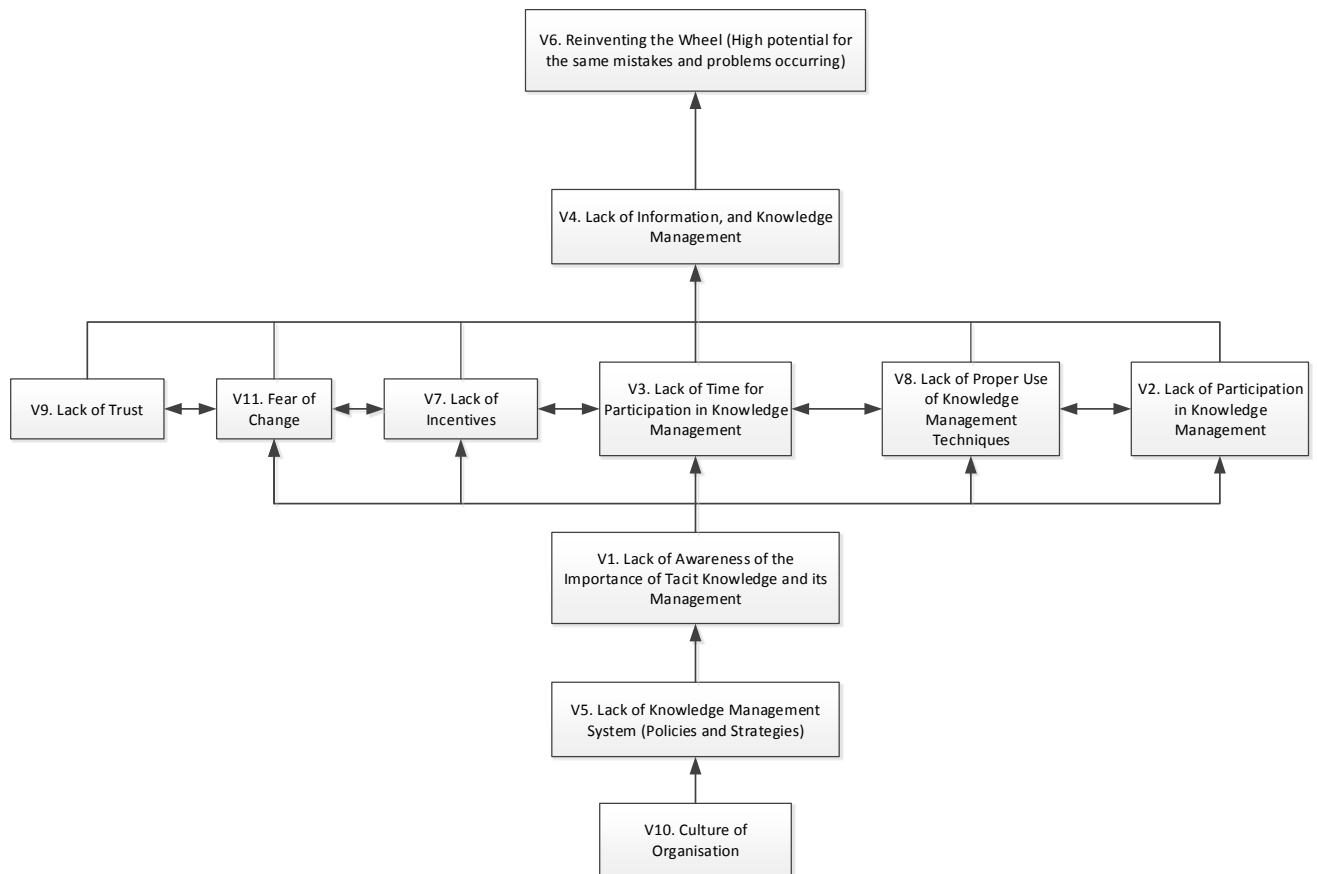


Figure 4.5 – ISM based model of KI Challenges in Traditional Procurement System

#### 4.5.5 MICMAC Analysis – Classification of Challenges

The MICMAC analysis is used to analyse the driving and dependence power of variables which were identified in the final reachability matrix (Table 4.5). The variables are categorised into four clusters according to their driving and dependence power:

- Autonomous
- Independent
- Linkage, and
- Dependent

This classification of variables is in accordance with the one that is used by Mandal and Deshmukh (1994). The driving and dependence power diagram is presented in Table 4.7.

The first cluster consists of *autonomous* variables that have little dependence and driving power. In other words, the autonomous variables are relatively disconnected from the system. Table 4.7 illustrates that no variables are laid in an autonomous cluster. This means that all variables influence integration of knowledge in TPS.

The second cluster consists of *dependent* variables that have a high dependence power and low driving power. In this case, variable 6 (Reinventing a wheel) has the maximum dependent power and minimum driving power and comes at the top level of the ISM model. It is followed by variable 4 (Lack of Information and Knowledge Integration).

The third cluster includes *linkage* variables that have a high dependence power and strong driving power. This means that any action on these variables will influence other variables and also have a feedback effect on themselves. Six variables lie in this category namely: Lack of Trust, Fear of Change, Lack of Incentives, Lack of Time for Participation in Knowledge Integration, Lack of proper use of Knowledge Integration Techniques, Lack of Participation in Knowledge Integration.

The fourth cluster consists of *independent* variables that have low dependence power and strong driving power. Variables that lie in this cluster play a significant role in the integration of knowledge in TPS and are placed at the lowest level in the ISM model. Therefore, they need to be highly prioritised by managers. In this case, three variables lie in the independent cluster:

Lack of Awareness on Importance of Tacit Knowledge and its Integration, Lack of KM system (policies and strategies), and Culture of Organisation.

Table 4.7 – Clusters of Variables of Knowledge Integration Challenges in the Traditional Procurement System

<b>Driving Power</b>	11	V10										
	10		V5	<b>INDEPENDENT</b>					<b>LINKAGE</b>			
	9							V7	V8, V9, V11			
	8			V1					V2, V3			
	7											
	6											
	5											
	4											
	3			<b>AUTONOMUS</b>					<b>DEPENDENT</b>			
	2									V4		
	1										V6	
		<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>9</b>	<b>10</b>	<b>11</b>
		<b>Dependence Power</b>										

## 4.6 Discussion

Integrating knowledge is critical in construction projects that are undertaken through the TPS due to the separation of the design and construction phases in this type of procurement. In other words, the TPS is confronted with challenges in order to integrate tacit knowledge. For example, this system by definition encourages project members to walk away at the end of project. Therefore, project members will not have the opportunity to integrate the knowledge that they achieved through the project, in terms of capturing and sharing with each other (Sections 4.3.1, 4.3.3).

The findings obtained through the experts' interviews analysis establish that tacit knowledge at the design phase is more problematic and harder to manage, because of the complexity of the design phase (Section 4.3.1). This tacit knowledge is mainly the personal and company's experience. Moreover, the experts' interviews analysis identifies a set of challenges that exist in this type of procurement (Section 4.4): Lack of Awareness on Importance of Tacit Knowledge and Its Integration, Lack of Participation in Knowledge Integration, Lack of Time for Participation in Knowledge Integration (Time Pressure), Lack of Information and

Knowledge Integration, Lack of KM System (Policies and Strategies), Reinventing a Wheel (high potential of same mistakes and problem occurrence), Lack of Incentives, Lack of Proper Use of Knowledge Integration Techniques, Lack of Trust, Culture of Organisations and Resistance to Change (Fear of Change).

An ISM-based model (Figure 4.5) was developed to identify the relationships and hierarchy among the identified challenges from the experts' interviews. This model analyses the interaction between the identified variables which represent strategic information to project managers and supports their decisions related to KM processes. The dependence and driving power diagram (Table 4.7) from MICMAC analysis, presents the relative importance and interdependencies among the challenges of integrating knowledge in the TPS, which will enhance project managers decisions. Furthermore, this MICMAC analysis is complementary to ISM model and shows that variables at the lowest level in the ISM model should be allocated in the 'Independent' cluster, which means these variables are the drivers to other variables and have the lowest dependence power. On the other hand, the variable on the top in the ISM model should be allocated in the 'Dependent' cluster, which in this case the 'Reinventing a wheel' variable (V6) is located in the dependent cluster with the highest dependent power and the lowest driving power.

Moreover, findings indicate that the awareness of project members about the importance of tacit knowledge and its integration is low in this type of procurement system. This is highly dependent on the organisational culture and the approaches that managers take in order to integrate knowledge (Section 4.4). According to findings from literature and the experts' interviews analysis (Section 4.4.3 and Figure 4.5), it is highlighted that the organisational culture and KM systems (policies and strategies) are two key of KI in the TPS. It is up to the culture of the organisation to provide trust and incentives among project members, which will lead to decrease their resistance to change (fear of change) and motivate them to participate in the KI process. This could mainly be done by considering effective management approaches. According to the techniques that have been used in the traditional-based construction project, it is noted that techniques like PPR, POE, Group Meetings, Project Briefing and Reviewing Sessions are mostly used for the capturing, sharing, and transferring of knowledge (Section 4.3.2). Furthermore, respondents emphasised that the knowledge capturing process should



be continuous and day-to-day process. Furthermore, the BIM technology could be used as a repository for capturing and saving tacit knowledge.

## 4.7 Summary

This chapter presents the outcome of the experts' survey interview on TKI within construction projects undertaken through the TPS. The experts' survey interview elicited several challenges that need to be addressed within the TKI process. These challenges were synthesised with the analysis of the documentary survey (literature review) and generated 11 challenges (Section 4.4.3) and were analysed through the ISM approach (Section 4.5) in order to identify the hierarchy and relationships between them. These challenges are:

- Lack of Awareness on Importance of Tacit Knowledge and Its Integration
- Lack of Participation in Knowledge Integration
- Lack of Time for Participation in Knowledge Integration (Time Pressure)
- Lack of Information and Knowledge Integration
- Lack of KM System (Policies and Strategies)
- Reinventing a Wheel (high potential of same mistakes and problem occurrence)
- Lack of Incentives
- Lack of Proper Use of Knowledge Integration Techniques
- Lack of Trust
- Culture of Organisations
- Resistance to Change (Fear of Change).

The result concluded that the culture of the organisations and lack of KM System (policies and strategies) are the two key challenges of TKI in the TPS.

## Chapter 5 – Case Study

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## 5.1 Introduction

Chapter 4 discussed the experts' interview findings and presented a structural model of the KI challenges in the TPS that illustrates both hierarchy of challenges, according to their importance, and the relationships that exist between them (Figure 4.5). The aim of this chapter is to present and synthesis the research findings of the empirical investigation. This chapter is structured into five broad sections.

First, the case study screening process and selection of the case studies are discussed in depth. Second, the background to the case studies' organisations is presented. This explains the nature and business sectors of each organisation. Third, the case study phases, stages, and key activities are presented. Fourth, the findings of the exploratory phase are presented. This elaborates on the findings of the challenges, techniques and CSFs of TKI within CS1 and CS2. Finally, an ISM and MICMAC analysis are used to identify the relations and classify the challenges of TKI that were found from CS1 and CS2.

## 5.2 The Case Study Screening

As discussed in Section 3.6.4 and 3.6.8 of Chapter 3, multiple-case holistic designs were selected for the cross-sectional investigation to study a particular phenomenon in a particular time. The research topic is to understand the process of TKI within a construction project context, undertaken through the TPS. Two case studies were selected for the cross-sectional investigation in this study (see Section 3.6.8 in Chapter 3). This section outlines the process of selecting the representative case studies.

In order to select the case study projects, initially, a criterion was developed based on the focus of the research. This study focuses on the TKI within the construction project undertaken through the TPS. The first consideration was given to organisations operating within the construction industry. Secondly, construction projects within building sector, undertaken through TPS were sought for the study. Further to specifications of TPS, the selected projects were complex and large with the value over £5m. Fourthly, the stages of selected cases were considered; one completed and one in process, and also the value of having the same designing organisation. The purpose is to analyse, compare and evaluate the process of TKI within projects that have been designed by same organisation.

Using the findings of the literature review, expert’s survey, and case studies, this research developed a framework of how to integrate tacit knowledge within a construction project undertaken through the TPS. Therefore, it was required to revise the conceptual framework (Section 2.14 in Chapter 2) with empirical evidence collected from the case studies.

Accordingly, three organisations were reached based on university contacts (referred to hereinafter as “A”, “B” and “C”) for the two case studies (referred to hereinafter as “1” and “2”). All three organisations work under a variety of procurement systems, but for the selected case studies they worked under the TPS and involved with building projects. Organisation A is a UK based company involved with a wide variety of construction activities, including project designing, cost management, construction management, and project management. Organisations B and C are also UK based companies facilitating all aspects of the construction process including Shell and Core, Fit-Out and refurbishment.

Table 5.1 – Application of the Organisations and Case Study Selection Criteria

Criteria	Organisation	Organisation	Organisation
	A	B	C
<b>Involvement with construction activities</b>	√	√	√
<b>Involvement with projects in building sector</b>	√	√	√
<b>Involvement with large scale projects with value over £5m</b>	√	√	√
<b>Involvement in designing process</b>	√	X	X
<b>Involvement in construction process</b>	X	√	√
<b>Case Study</b>			
<b>Case Study 1 – Completed Project</b>	√	√	X
<b>Case Study 2 – Ongoing Project</b>	√	X	√

Table 5.1 describes the application of research criteria for the purpose of selecting the representative cases. As mentioned in Section 3.6.8 (Chapter 3), two case studies that satisfied all mentioned criteria were selected. Case study 1 was selected as the representative case for the completed construction project undertaken through the TPS with the involvement of organisation A and B. Case study 2 was selected as the representative case for the ongoing construction project undertaken through the TPS with the involvement of organisation A and

C. Having discussed the case study screening process, the background to the case studies is introduced in the next section.

### **5.3 Background to Case Study Organisations and Projects**

The UK construction industry is considered in the scope of this research. This research focuses on TKI within a construction project undertaken through the TPS in the UK (as discussed in Section 1.6 in Chapter 1). Miles and Huberman (1994b) define the case as “a phenomenon of some sort occurring in a bounded context. The case is, in effect, your unit of analysis”. Therefore, the traditional construction projects are considered as suitable cases for addressing the research aim and questions of this study (as discussed in Section 3.6.7 in Chapter 3).

The search for selecting the suitable cases was conducted throughout the early stage of this research. The cases were selected to reflect the building sector within the construction industry. The projects were complex, large, and with costs over £5m. The selected case studies differ in that one of them is a completed project and the other is an ongoing project at the construction phase. Furthermore, the cases were selected from same designing organisation in order to analyse and compare the process of TKI in projects that have been undertaken by the same organisation. The background of the organisations involved in selected case studies are briefly discussed below.

#### **Organisation A**

Organisation A: Bimddon LLP (a pseudonym, for confidentiality reasons, hereinafter “Bimddon”) is a UK based independent global consultancy involved with a wide variety of construction activities. They provide cost, construction, and project management as well as project designing services for clients throughout the world. The designing services include architectural, interior design, workplace strategy, designing for sustainability, master planning and Designing for heritage.

Bimddon was established in the 1830s with a base in the south part of the country. Today they have over 700 dedicated staff based in 15 offices across countries like the UK, Turkey, Brazil, Germany and Russia, working on projects executed on different procurement systems, specifically on a traditional contract. Bimddon is involved in projects from different sectors including, education, health, commercial, housing, and hotels. Having a diverse cross section

of international architects and designers, Bimddon has at least 20 different languages spoken in the base studio alone. Bimddon has operated as a Limited Liability Partnership since 2004.

### **Organisation B**

Organisation B: The 3Styles Group (a pseudonym, for confidentiality reasons, hereinafter “3Styles Group”) is a UK based construction, residential, property and services group formed in early 1990s with the purpose of investing in building, maintaining and renewing places across the different construction sectors including housing, industrial, education, health, residential, infrastructure, leisure, and hotel projects. However, the roots of business go back to 1920s.

3Styles offers over 90 years of construction knowledge and experiences to their clients. The group has over 10,000 employees in the UK, the Middle East, and Asia. The 3Styles Group has a large network of regional offices and strong local relationships to ensure that they understand the client’s requirements at any stage of the built environment lifecycle. Having the ability to provide a reliable construction service delivering on programme and cost whilst enhancing the latest construction practices and techniques, have enabled the Group to respond rapidly to any changes in the client’s needs. The 3Style Group covers different construction procurement systems including traditional contract, design and built, and PPI.

### **Organisation C**

Organisation C: Balbo Ltd (a pseudonym, for confidentiality reasons, hereinafter “Balbo”) is one of the UK’s leading contractors established in late 1890s in south part of the country. Today, the business delivers over £160m of building projects across the UK and has nearly 800 employees. Having over 120 years of construction knowledge and experience, Balbo offers planning, design, delivery, maintenance, refurbishment and energy solutions to building projects in different sectors including education, housing, healthcare, hotel, leisure, commercial and retail.

Balbo works under all forms of contracts and offers a distinctly superior service in different types of building work. This extends from the simple and straightforward on a relatively small scale to the most comprehensive and demanding large-scale projects.

### 5.3.1 Case Study 1 (CS1) – St Jefferson’ Hospital – A&E/HO

The A&E/HO project was a 96 weeks programme of work, started in 2009 for St Jefferson’ Hospital NHS Foundation Trust (a pseudonym, for confidentiality reasons, hereinafter “St Jefferson’ Hospital”). The project at A&E/HO (a pseudonym, for confidentiality reasons, hereinafter “A&E/HO”) included full refurbishment of the Accident and Emergency (A&E) and building Haematology and Oncology (HO) department with minimum impact on nursing operations and patients. The project valued £15.8m and undertaken through the TPS.

The project was in process within a functioning hospital environment. With a very restrictive regime for any noisy works, the programming and forward planning aspect of the project was critical together with the flexibility to manage the unexpected aspects that a functioning hospital A&E environment can suddenly produce.

The A&E refurbishment project included the refurbishment and remodelling of the A&E department, building Haematology and Oncology (HO) department on the first floor above the interim critical care unit (ICCU, one block away to A&E department), and the building of a bridge between two units. Particular care was required during building the bridge as the bridge was being built directly over a live Audiology department which was located beside ICCU.

The A&E department was refurbished in terms of:

- Multi departmental moves (removal of partitions, ceilings, light fittings, redundant fixtures, and fittings) to suit the re-modelled layout
- Space efficiency and reorganisation
- Installation of new fixtures, finishes, M&E installations, and new equipment
- Relocation of some existing fixtures, fittings and equipment

The HO department was built to include a new six-theatre suite with 24/7 support facilities. The theatres were located above ICCU to provide a better and safer treatment for cancer sufferers.

The Bimddon was appointed as the preferred contractor for designing the re-configuration of the hospital. The designing process took almost eight weeks to be completed and to be

tendered to contractors by the client and to be completed. Contractors sent their proposals including the construction process and proposed price. Then the client selected the best proposal and appointed the 3Styles Group as the preferred partner for implementing this project.

The Bimddon and 3Styles Group were in contact with each other based on the contract that they had with the client. According to their contract, the client asked Bimddon to communicate with the 3Styles Group, if any designing issues were raised during construction phase.

### **5.3.2 Case Study 2 (CS2) – 10 Vanquis Square**

The 10 Vanquis Square project is a refurbishment and building of a great two distinct buildings into a residential hotel scheme. The vision is to refurbish one building, demolish, and build another building into a high-end luxurious hotel, spa and residential development. In keeping with the building's landmark status, Four Seasons Hotels will operate the development with the intention that both the hotel and apartment will be positioned at the high end of the market. The building itself will comprise of a distinctive collection of spaces harmoniously arranged whilst restoring the original circulation and geometries in the form of 41 spacious apartments, 100 hotel guest rooms, a private members' club, two restaurants, and a spa. The key criteria of this project:

- Create a world class hotel of the highest standard, having a design of world class architectural quality
- Propose a scheme for the redevelopment of the existing building that maximises the site's potential by restoring the original circulation and geometries, reinstating the sequence of spaces, and utilising the exceptional areas
- Provide quality residential apartments on the upper floors that integrate with the existing building
- Incorporate all servicing, parking, plant, and the hotel facilities below ground to retain the existing building in its former grandeur
- Propose a development with a positive relationship with its setting, respecting the townscape and amenity considerations of its neighbours



The 10 Vanquis Square started in 2012 and is anticipated to be finished by December 2017. The project size is 490,000 sqft and has been undertaken through the TPS with the value of approximately £250M.

The Bimddon was appointed as the preferred contractor for designing this project. The client decided to appoint the construction contractor a bit earlier before finishing the design in order to increase the efficiency and reduce the number of designing flaw. Therefore, the client selected the best proposal among the received proposals and appointed Balbo Ltd as the preferred partner for implementing this project. The Bimddon and Balbo Ltd were in contact with each other based on the contract that they had with the client. According to their contract, the client asked Bimddon to correspond with Balbo Ltd, if any designing issues were raised during the construction phase.

## **5.4 Case Study Phase, Stages and Key Activities**

Basic information about the case study organisations and case study projects were discussed in previous sections (Sections 5.3, 5.3.1 and 5.3.2). This section describes the research process of the case studies in terms of the key phases and activities carried out.

Figure 5.1 illustrates several components of case studies: phase, stages and key activities. The key activities are listed in chronological order in one phase: an exploratory phase and four stages. The first and second stages include preparation, collection, and analysis of collected data from CS1. The third and fourth stages include preparation, collection, and analysis of collected data from CS2; followed by the synthesis of the findings from both CS1 and CS2. During the exploratory stage, the challenges of capturing, sharing, and transferring tacit knowledge were explored. Also, the approaches and techniques that were used by organisations in case studies to tackle challenges were explored. The exploratory phase, which included the findings and analysis stages, was sub-divided into three sections: preparation, data collection, and data analysis.

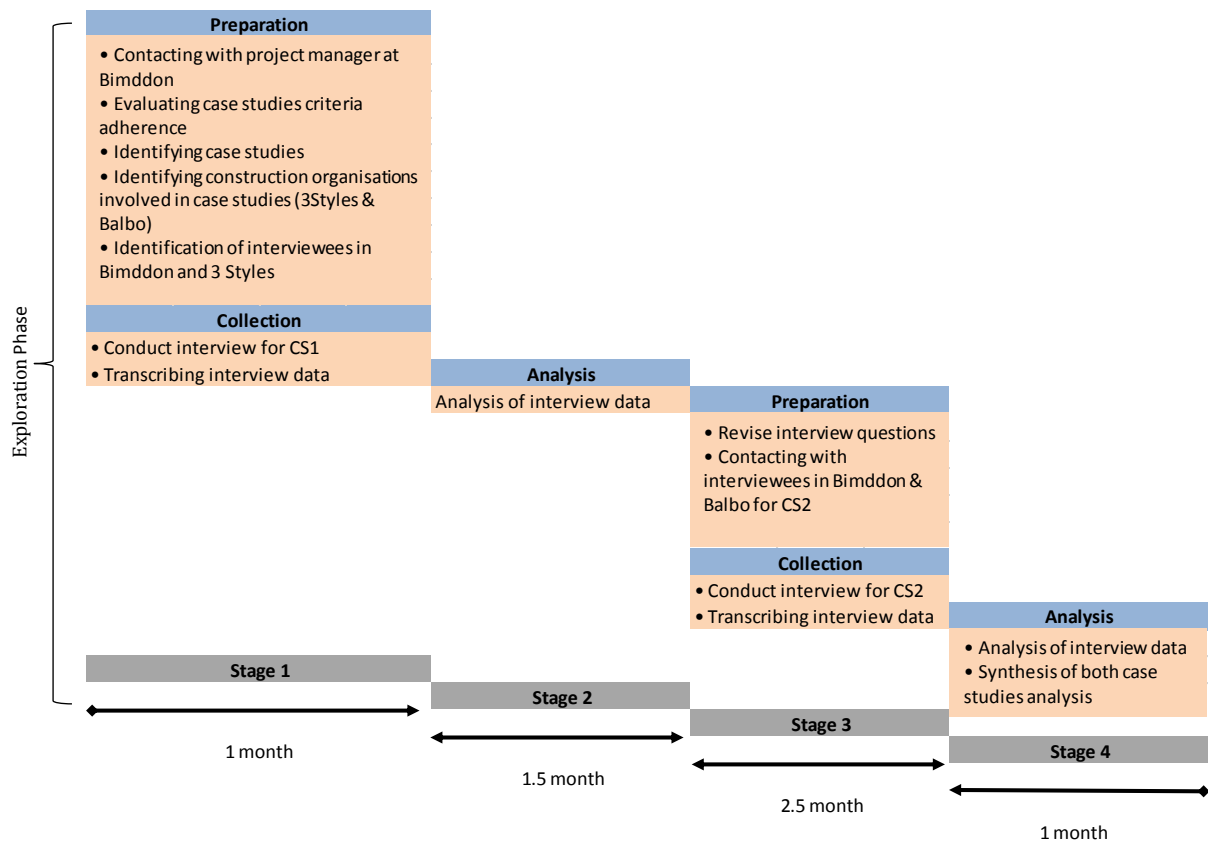


Figure 5.1 – Overall Case Studies Research Process

The case study research started in October 2015 with the exploratory phase and was completed in March 2016. This included the preparatory work, data collection and analysis. The preparatory work included the initial discussion with the project managers for Bimddon, 3Styles Group and Balbo to inform them the aim, scope, and objectives of this research. This period also included data analysis of CS1 and the time for restructuring the interview questions for CS2. Data was collected mainly through semi-structured interviews (Sections 3.8 and 3.10 in Chapter 3 for a detailed discussion on data collection techniques):

- Semi-structured interviews with the organisations employees who were involved in both case studies including project managers (one from each organisation), architects (two from Bimddon), and engineers (one from 3Styles Group and one from Balbo) to explore the challenges of TKI and the approaches that organisations take for tackling challenges.

The semi-structured interviews from CS1 and CS2 were transcribed and analysed using a content analysis technique with the aid of NVivo software. The findings from CS1 and CS2

were synthesised in order to have a better understanding of the challenges and techniques of TKI.

This section briefly described the overall research approach undertaken within the case studies. The findings of exploratory phase of CS1 and CS2 are presented in the next section.

## **5.5 Findings in the Exploratory Phase – Case Studies**

### **5.5.1 Introduction**

The aim of the exploratory phase of case studies was to explore TKI within a construction project undertaken through the TPS. Further, the approaches that organisations used for integrating tacit knowledge (within CS1 and CS2) and challenges that existed for integrating tacit knowledge were explored with the interview participants. The results of the interviews were summarised according to CS1 and CS2. The cognitive maps of factors affecting TKI are illustrated in Sections 5.5.3 and 5.5.4. Each cognitive map is explained before a synthesised result is presented.

This section is divided into four parts: the first part briefly describes the interviewees who participated in the exploratory phase; the second and third part presents the findings of CS1 and CS2; the fourth part presents and discusses the synthesised findings of CS1 and CS2.

### **5.5.2 Description of Interviewees**

As mentioned in the research methodology chapter (Sections 3.8 and 3.10 in Chapter 3), semi-structured interviews were used for collecting data during the exploratory phase. This section describes interviewees who were involved in semi-structured interviews in CS1 and CS2. The project, job title, and experience of interview participants are summarised in Table 5.2.

Table 5.2 – Project, Job Title and Experiences of Interview Participants

Interviewee	Case Study	Job Title	Experience with organisation	Total relevant experience
<b>PMG1</b>	CS1, CS2	Project Manager	15 years / Bimddon	25 years
<b>ARC1</b>	CS1	Architect	8 years /Bimddon	13 years
<b>SMG1</b>	CS1	Site Manager	10 years / 3Styles	18 years
<b>ENG1</b>	CS1	M&E	4 year 3 months/ 3Styles	11 years
<b>ARC2</b>	CS2	Architect	3 years 7months / Bimddon	6 years
<b>SMG2</b>	CS2	Site Manager	15 years / Balbo	35 years
<b>ENG2</b>	CS2	M&E	6 years 5months / Balbo	16 years

One project manager was interviewed for both CS1 and CS2. PMG1 was involved in both projects as the designing team project manager who was responsible for managing studio principle, interior designer, architectures, and their assistants. PMG1 joined Bimddon in 2001 as an interior designer and after two years he became a project manager and leads many projects. He possesses 15 years of experience with Bimddon and 25 years in total. ARC1, one of the architects in CS1, was in charge of remodelling the A&E department and designing a bridge between A&E and HO department. ARC1 left the Bimddon UK branch after eight years and moved to the Brazil branch.

A site manager, SMG1, and an M&E consultant were interviewed for CS1 from the 3Styles Group. SMG1 with eight years of experience joined 3Styles Group in 2006 as a site manager. SMG1 was responsible for managing all activities on the site and also being in touch with Bimddon. ENG1 was associate mechanical director in CS1 and was responsible for all M&E installations in A&E and the HO department.

ARC2 with 3 years of experience joined Bimddon in 2013 as a second architect for the 10 Vanquis Square project. ARC2 is responsible for designing hotel rooms. SMG2 was interviewed as a site manager for CS2 from Balbo. SMG2 joined Balbo in 1999 as a site foreman. During that time in Balbo SMG2 was in charge of the construction management of many projects. After SMG2 left the company in 2010, Balbo recruited him in 2012 for this specific project because of the experience. SMG2 has 35 years of experience in total. In CS2, SMG2 is managing all activities on site and communicating with both M&E and the civil and structural

consultants. SMG2 is also responsible for communicating with the Bimddon designing team for any designing issues that might arise on site. ENG2 joined Balbo in 2010 as an M&E consultant. ENG2 has six years of experience with Balbo and 16 years in total. In 10 Vanquis Square project, ENG2 is working with SMG2 on site and also was appointed by Balbo, due to the contract that they have with the client, to give M&E consultancy to the Bimddon designing team at the early stage of design.

### **5.5.3 CS1 – St Jefferson’ Hospital – A&E/HO**

As detailed in Section 5.3.1, the CS1 is about full refurbishment of the Accident and Emergency (A&E), and building Haematology and Oncology (HO) department. Figure 5.2 presents the themes captured from the CS1 interviews analysis. Figure 5.3 illustrates a summary of techniques and challenges affecting TKI, as elicited from PMG1, ARC1, SMG1 and ENG1. This highlights the main factors of TKI within the traditional construction project (CS1) in terms of capturing, sharing, and transferring knowledge.

PMG1 and SMG1 stated that one of the main factors that affect TKI in the TPS is the contractual boundaries (concept 1101). This system by its definition does not allow contractors to be involved in project process from the beginning. Furthermore, they mentioned that it is the contract that dictates what type of information and knowledge and who is responsible for sharing them between organisations involved in a project (concepts 1102 and 1103).

*“I think contractual boundaries is the main challenge in traditional procurement system. Organisations only communicate with each other according to their contract..... It is the contract that dictates what type of information and who is liable for sharing it. Also, it depends on the contract how to communicate with other contractors and share experiences.”*

CSI - Tacit Knowledge Integration Challenges		0	0
<input type="radio"/>	Clear Objectives	4	6
<input type="radio"/>	Contractual Boundaries	4	9
<input type="radio"/>	Identifying lessons learned	4	6
<input type="radio"/>	Incentives	4	9
<input type="radio"/>	No effort to keep experts' knowledge before they leave the compa	4	23
<input type="radio"/>	No proper guidelines	4	10
<input type="radio"/>	People are not open to share their ideas	4	20
<input type="radio"/>	Recruiting experts	4	10
<input type="radio"/>	Time pressure to reach the deadline	4	14
<input type="radio"/>	Trust	4	6

Figure 5.2 – Screenshot Showing Nodes on Tacit Knowledge Integration in CS1

As described by ARC1 and ENG1, designers and contractors are not incentivised to share their experiences with each other. As previously mentioned, the sharing and communicating depends on their organisations' contract with the client and the KM policies that were taken by their organisations in A&E/HO project (concept 1104 and 1106). Moreover, PMG1 and SMG1 stated that this lack of incentives and contractual boundaries led project members from Bimddon and the 3Styles Group not to be open in sharing their experiences with each other (concept 1105).

*“As the project was traditional, our team members were involved in another project when ‘3Styles Group’ contact us. It was clearly mentioned in our contract how to communicate and respond to ‘3Styles Group’.”*

SMG1 indicated that a meeting request was sent to Bimddon for any unforeseen circumstances which were related to designing (concept 1107). ARC1 and SMG1 mentioned that this led to both organisations having problems in establishing communication with each other in the A&E/HO project (concept 1108).

*“We had problem in communicating with ‘Bimddon’. We had to send them meeting request with the full details of our request and waiting for their reply which normally took 4days at least.....During A&E/HO project, we were contacted by Bimddon for a meeting which was about a bit alteration in position of the bridge. In meeting, PMG1 mentioned that the client decided to make a new path across the bridge for ambulances to reach A&E. This modification required redesigning the bridge from both architectural and structural views. The A&E and HO department needed a bit alteration*

*in the joint places of the bridge because the A&E was fully refurbished and the HO department was nearly finished. This modification was costly, time consuming and tricky, as we were working in a live hospital environment. Basically, the meeting was for discussing on how to reduce the cost. Our team worked with Bimddon team on redesigning the bridge. The initial estimation by Bimddon for this modification was £2m and eight weeks over the timescale, but our involvement and discussion reduce it to £1m and six weeks over the total project budget”*

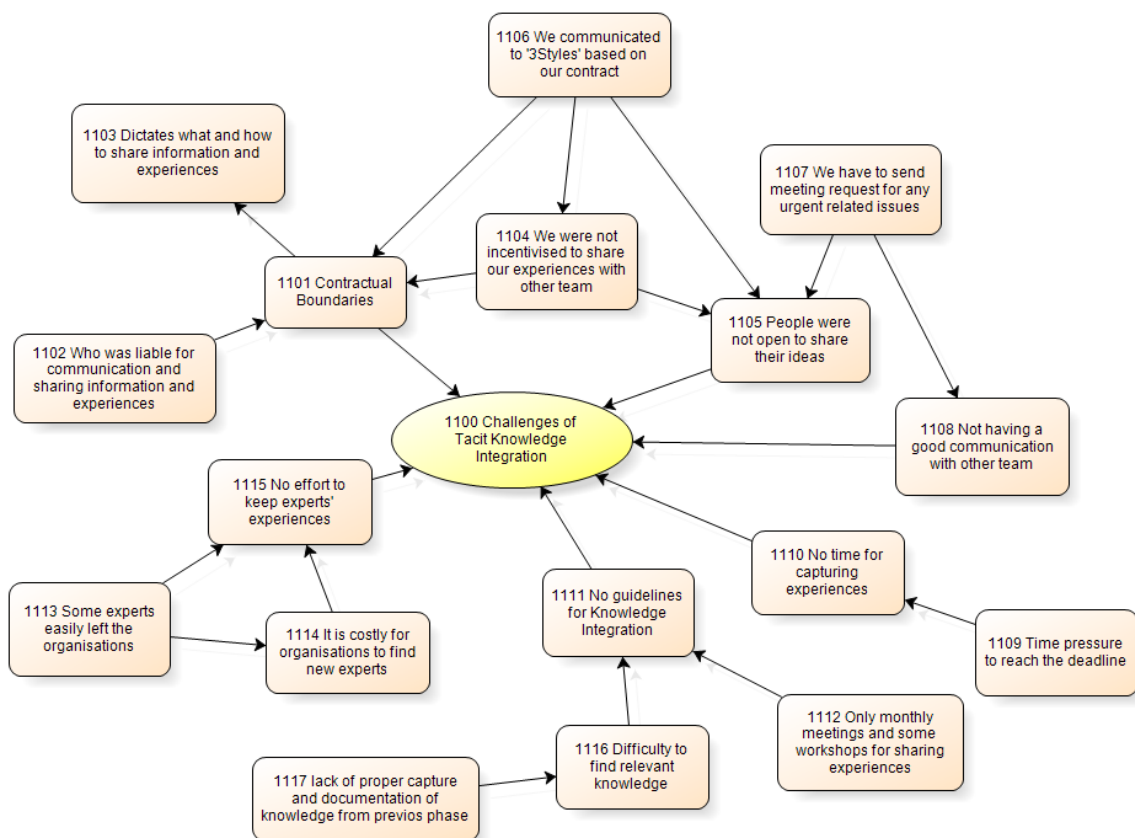


Figure 5.3 – Cognitive map of Challenges of Tacit Knowledge Integration as elicited from CS1

PMG1 and SMG1 described that construction project’s members as confronted with time pressure to reach the deadlines (concept 1109). Therefore, they always had to struggle in finding time for capturing experiences. PMG1 stated that the client asked Bimddon to do the modification after the project was handed to the 3Styles Group for construction. It took time for redesigning and when it was finished, PMG1 did not have time to capture the experiences and update the A&E/HO project’s profile in Bimddon because of involvement in another project (concept 1110).

*“I don’t think it gives enough time to actually reflect thoroughly and identify what works and what doesn’t work. So I think the challenge is actually giving the time to capture the knowledge and then use it for another project.”*

ARC1 and ENG1 mentioned that they only had monthly meetings and some workshops for discussion and sharing their experiences within their group (concept 1112). However, PMG1 and SMG1 stated that they documented their meetings in order to capture their experiences and knowledge, but it was difficult to find the relevant knowledge whenever it is needed (concept 1116). This means that knowledge was not efficiently captured and documented from the previous phase (concept 1117). Furthermore, they mainly stated that there were no guidelines for integrating knowledge in the A&E/HO project (concept 1111).

*“...with my understanding of your terminology on ‘tacit knowledge integration’, I have to say that we did not have any guidelines. In A&E/HO project, we only shared our experiences and tried to document them in our meeting, but they are only documented and kept in project’s profile in organisation, and we always had difficulty in finding relevant information”*

PMG1 and SMG1 stated that the experts’ knowledge is an asset for the organisation, but there was no effort by organisations to keep experts and it would have been costly for organisations to find new experts (concept 1113, 1114 and 1115).

*“...Keeping experts is really important, as their experiences are assets of organisations. ARC1 was an expert in her field, especially in Hospital projects, she left Bimddon and it was costly and time consuming for our organisation to recruit new expert with her quality.”*

The findings from CS1 are used to revise the interview questions with participants in CS2.

#### **5.5.4 CS2 – 10 Vanquis Square**

As detailed in Section 5.3.2, the CS2 is about refurbishment and building of two distinct buildings into a residential hotel scheme. The themes captured from the analysis of semi-structured interview in CS2 are shown in Figure 5.4. Figure 5.5 illustrates a summary of techniques and factors affecting TKI as elicited from PMG1, ARC2, SMG2 and ENG2. This



highlights the main factors of TKI within the traditional construction project (CS2) in terms of capturing, sharing, and transferring knowledge.

Node	Value	Value
CS2 - Tacit Knowledge Integration Challenges	0	0
Awareness on Importance of Tacit Knowledge and Its Integration	4	10
Contractual Boundaries	4	10
Culture of Organisation	4	14
Fear of Change	4	4
Incentives	4	7
Information and Knowledge Integration	4	9
Knowledge Management System	4	18
Participation in Knowledge Integration	4	10
Proper use of Knowledge Integration Techniques	4	23
Time and Participation in Knowledge Integration	4	6
Trust	4	6

Figure 5.4 – Screenshot Showing Nodes on Tacit Knowledge Integration in CS2

PMG1 and SMG2 stated that having no guidelines for capturing, sharing and transferring experiences is one of the factors that affect TKI (concept 2201). They mentioned that they only had project reviews and monthly meetings in their team to share their experiences and write down the lessons learned, but there was no protocol for using them in the next project (concept 2202). However, ARC2 argued that this happened because managers do not see the importance of tacit knowledge transfer (concept 2203). PMG1 and ENG2 mentioned that the lack of adequate documentation of knowledge from the previous phase (concept 2221) and low level of shared knowledge and activities between project’s phases (concept 2220) mean that there were no guidelines for integrating tacit knowledge in the CS2 project. However, this lack of shared activities depends on the contracts.

*“As a company we do have a protocol, after each meeting we learn the lesson learnt, so we can written down what worked and what didn’t work and what we should proceed forward and what we should do differently. So in terms of capturing knowledge, it is only happened when something is completed, but in terms of transferring we still don’t have any protocol to use it. Individuals use their own experiences.”*

PMG1 and SMG2 stated that the details of contract are one of the most factors that affect TKI in the TPS (concept 2204). Sharing experiences and information in the TPS is based on the

contract of contractors. PMG1 mentioned that their communication with 'Balbo Ltd' was based according to their contract (concept 2206) and that they were responsible for the content of information and knowledge to be shared with 'Balbo Ltd' (concept 2207).

However, ARC2 described that communication between contractors are poor and based on their contract with the client in construction project undertaken through the TPS. This means that there is no ethos of sharing knowledge (concept 2205). PMG1 and SMG2 mentioned that this was due to the fragmentation nature of this type of procurement system (concept 2219).

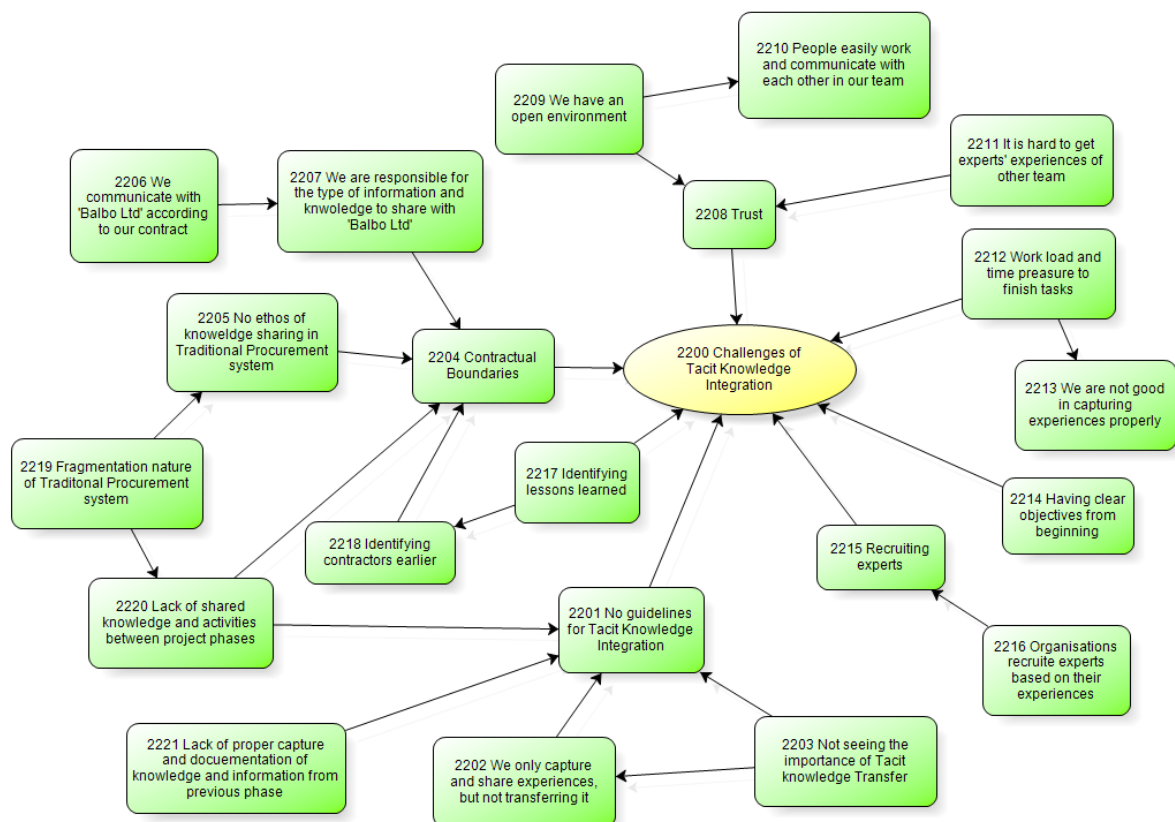


Figure 5.5 – Cognitive map of Challenges of Tacit Knowledge Integration as elicited from CS2

*“I think it goes back to what type of contract has been used because that dictates exactly how the team works.....In the traditional, because we are liability for the design, we are responsible for the type of information and knowledge to share with ‘Balbo Ltd’..... If they have any issues regarding to details and construction design, they have to contact us, and it is up to us to resolve it..... Although their communication is according to their contract, but it takes time, as they have to send*

*their request through email with full details of issue and asking for meeting, then we will arrange a date to discuss about the issue and resolve it..... In the traditional, the ethos of sharing knowledge is not there, and it depends on the contracts how much knowledge you shared.”*

PMG1 and SMG2 explained that they built an open environment for their team members (concept 2209). This means that team members trusted each other in sharing their experiences (concept 2208). Furthermore, ARC2 and ENG2 stated that this open environment led the communication between their team members to be more effective (concept 2210), but communication with other contractors required following contractual clauses (concept 2211). However, they mentioned that the work load and time pressure to finish tasks are factors that affect the participation in TKI (concept 2212). PMG1 and SMG2 stated that this work load and time limitation led their team not to be effective in capturing experiences (concept 2213).

*“We have friendly environment. Internally, within the department our team members easily approach each other. We are working together as a one team. I think this is because we trust each other. The project managers creates this environment and gave us this feeling..... We have a discussion every month and that is essentially where the leaders from each part of project would basically discuss their projects, what’s going right and what’s going wrong.....I think in terms of capturing experiences, it is a bit difficult, because of the work load and time constraints. We are under pressure to complete tasks, so we don’t get enough time to do it. ”*

As suggested by PMG1 and ARC2, having clear objectives is important and has an indirect impact on the process of TKI because it helps to identify what you are trying to achieve (concept 2214). PMG1 and SMG2 stated recruiting experts is another factor that indirectly affects TKI: organisations recruit people according to their experiences (concepts 2215 and 2216). ENG2 stated that ‘Balbo Ltd’ recruited SMG2 for 10 Vanquis Square project after he left the company because of his specific experiences that had been acquired in similar projects.

*“When there is clear objectives, it is easy to identify what you are trying to achieve and by then it is easy to actually see what works and what being used then in project..... In*

*terms of recruiting people, we are specifically looking at people, who have worked on hotel scheme, who have worked on great solicit and so in terms of ensuring you have a right knowledge for the project.....Ironically, we had a site manager who was working in our practice and then left the company. After two years he was recruited by our organisation and appointed for this specific project. So that is how they want to ensure that the knowledge stays during a project.”*

ARC2 and SMG2 mentioned that identifying lessons learned are important and enhance TKI (concept 2217). However, PMG1 stated that asking a client identify a contractor earlier in 10 Vanquis Square project was one of the lessons learned from the A&E/HO project (concept 2218). The 10 Vanquis Square project was undertaken through two-stage tendering in the TPS.

*“I mean you have different types of traditional. You have a two-stage of traditional which provides you the ability to have the contractors early on. We learnt our lessons from A&E/HO project and in the first meeting that we had with client, we explained the benefits of using two stage project and appointing the contractors very early on, so they still have some kind of control of design.”*

The findings from CS2 needs to be compared with the CS1 findings in order to fulfil the objectives of this research.

### **5.5.5 Synthesis of CS1 and CS2 Findings**

Sections 5.5.3 and 5.5.4 discussed factors (challenges) affecting TKI, as elicited from interviewees in CS1 and CS2. The synthesis of these factors from both CS1 and CS2 is presented in Figure 5.6. The bisque and green colour concepts are those that were identified by interviewees from CS1 and CS2. Comparing the identified factors in Sections 5.5.3 and 5.5.4 reveals that some factors are similar to each other: Concepts 1101 and 2204, Concepts 1109 and 2212, Concepts 1111 and 2201, and Concepts 1117 and 2221.

Challenges of Tacit Knowledge Integration		
Name	Sources	References
Challenges of Tacit Knowledge Integration	0	0
Contractual Boundaries	8	15
Culture of Organisations	8	19
Information and Knowledge Integration	8	14
Knowledge Management System (Policies and Strategies)	8	23
Lack of Awareness of the Importance of Tacit Knowledge Inte	8	15
Lack of Incentives	8	12
Lack of Participation in Knowledge Integration	8	15
Lack of Proper Use of Knowledge Integration Techniques	8	28
Lack of Time	8	12
Lack of Trust	8	11

Figure 5.6 – Screenshot of Nodes on TKI, Synthesis of CS1 and CS2

Respondents, from both CS1 and CS2 highlighted that ‘contractual boundaries’ is one of the main challenges that affects integration of tacit knowledge in projects undertaken through the TPS. This is due to the fragmentation nature of this system through which the communication of contractors is based on their contract. In other words, it is the contract that dictates how to communicate and share their experiences. They stated that there were no guidelines to integrate tacit knowledge in CS1 and CS2 in terms of capturing, sharing, and transferring knowledge. Additionally, their organisations used some techniques like monthly meetings, workshops, Communities of Practice (CoPs), face-to-face dialogues, emails and meeting minutes for capturing and sharing their experiences and information. They explained that there were no guidelines for using the meetings’ minutes which were documented in the project’s profile (captured experiences and information from previous projects) and it required individual concerns to take time to look for them. In other words, there was not a well-organised knowledge repository that could be used by members. In addition, respondents highlighted that contributing in the knowledge capturing process requires allocating time, which is difficult because project members are always under pressure to reach the deadlines and finishing tasks. Moreover, they all agreed on the importance of tacit knowledge and its integration, and mentioned being aware of this factor and implementing TKI depended on the organisational culture and KM policies that were adopted by organisations.

Figure 5.7 illustrates the synthesis of all challenges to TKI within construction projects undertaken through the TPS identified by interviewees in CS1 and CS2. In order to have a summarised list of challenge, these findings were compared and combined with findings in section 4.4.3 and presented in Table 5.3. This table shows how summarised challenges are in line with concepts in Figure 5.7. Furthermore, themes captured from analysis of this synthesis are shown in Figure 5.6.

Table 5.3 – Knowledge Integration Challenges in the Traditional Procurement System

	<b>Variables</b>	<b>Concepts</b>
<b>V1</b>	Lack of Awareness of the Importance of Tacit Knowledge Integration	2202, 2203
<b>V2</b>	Lack of Participation in Knowledge Integration	1105, 1110, 1117(2221), 2202,2213
<b>V3</b>	Lack of Time	1109, 1110, 2213
<b>V4</b>	Lack of Information and Knowledge Integration	1111(2201), 1116, 1117(2221), 2219
<b>V5</b>	KM System (policies and strategies)	1104, 1105, 1108, 1111(2201), 1115, 1116, 2203, 2213, 2214, 2215, 2216, 2217, 2219
<b>V6</b>	Lack of Incentives	1104, 1105, 1108, 1113, 2205
<b>V7</b>	Lack of Proper use of Knowledge Integration Techniques	1116, 2202, 2213, 2217
<b>V8</b>	Lack of Trust	2208, 2209, 2211
<b>V9</b>	Culture of Organisations	1104, 1105, 1108, 1111(2201), 1115, 1116, 2203, 2213, 2214, 2215, 2216, 2217, 2219
<b>V10</b>	Contractual Boundaries	1101(2204),1102,1103,2205,2206,2220

Further, these challenges are explained in detail, which are used by ISM approach to identify the relationships between them (Section 5.6).

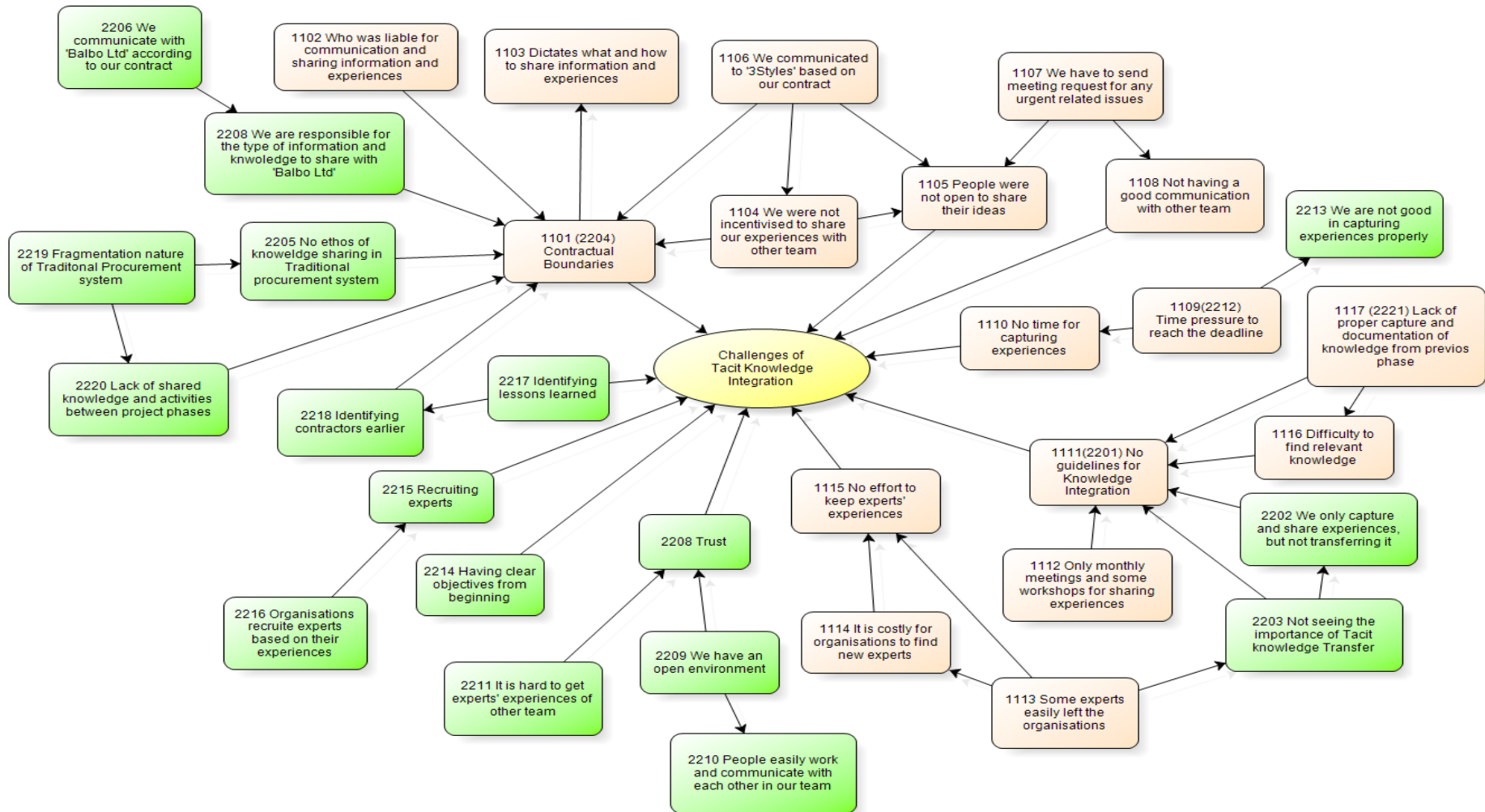


Figure 5.7 – Synthesis Cognitive map of Challenges of Tacit Knowledge Integration as elicited from CS1 and CS2

## **5.5.6 Challenges**

### **V1. Lack of Awareness of the Importance of Tacit Knowledge Integration**

It is necessary to prioritise and improve the awareness of the project's members on the benefits of tacit knowledge and how its integration will lead to improve the project's process and performance. Generally, members of construction organisations are aware of the importance of tacit knowledge and its key role in solving problems that occur in the construction project lifecycle. However, the awareness of the importance of TKI, in terms of transferring the captured tacit knowledge, in a traditional construction project is low. This is due to the separation of the design and construction team. In this type of procurement system there is a lack of awareness on how using the captured tacit knowledge could impact project and save cost and time, and lack of related facilities for utilising TKI in terms of capturing, sharing, and transferring knowledge. However, the separation of the design and construction team raises the issue of having the liability of captured tacit knowledge.

### **V2. Lack of Participation in Knowledge Integration**

The participation in KI depends on being well incentivised and informed about the importance of KI. This lack of participation leads to not capturing and documenting the project's members' knowledge properly in the first place and transferring it to the next phase or project. Participants believed that the project members mostly do not participate in sharing activities between the project phases because they are not well incentivised and informed about the liability of the shared knowledge. Their role and participation in the process of sharing knowledge between project phases should be elaborated in their contract due to the separation of the design and construction phase within a traditional construction project.

### **V3. Lack of Time**

The participants believed that allocating time is one factor that enables project members to participate in the KI process in construction projects. Project members are always under time-pressure to reach the deadlines and complete their tasks. Additionally, they will be recruited in another project once the current is completed. Therefore, project members suffer from allocating time to participate in capturing, sharing, and transferring knowledge.



#### **V4. Lack of Information and Knowledge Integration**

The participants highlighted that there were no guidelines in their organisation for integrating knowledge in terms of capturing, sharing, and transferring. They believed that information and knowledge were not documented properly from the previous phase, and if they were captured, documented, and existed, it was difficult for them to find the relevant knowledge. This means that the traditional construction project suffers from lack of information and KI between its phases. In other words, there is a lack of shared knowledge between the design and construction phase which is due to the fragmentation nature of the TPS. This lack of KI will result in spending more time, incurring greater costs and increasing the possibility of “Reinventing the Wheel”.

#### **V5. KM System (policies and strategies)**

The poor management of knowledge between project phases leads to considerable amount of knowledge loss. This is more common in construction projects undertaken through the TPS due to the fragmentation nature of this system where the design team is separated from construction team. This fragmentation means different teams and organisations which come together during a project run and maintain their own KM systems and processes and then they disperse after project taking with them their acquired knowledge from the completed project. Therefore, their knowledge would not be available and accessible when it is needed in other projects or at other phases. Respondents highlighted that their communications with other teams were only based on their contract and they were not incentivised and informed properly to share their experiences between project phases. Additionally, some participants highlighted that their organisation identified the lessons learned from previous project and recruited experts who left the organisation before, for their current project. However, other participants stated that their organisation has not made any effort to keep experts. All agreed that there were no guidelines for integrating knowledge. Thus, the KM system was poor which means using less and inappropriate techniques, policies and strategies for capturing, sharing and transferring project knowledge.

#### **V6. Lack of Incentives**

The motivation plays a key role in communication with project members. Project leaders need to be incentivised to participate in the KI process in terms of capturing, sharing, and transferring knowledge. Participants highlighted that they were not open and incentivised to

share their experiences and ideas between project phases and, furthermore, their contract clarified the way in which to communicate with other project members in different phases. Additionally, there is no ethos of collaboration and participation in sharing knowledge in the TPS due to the separation nature of this system. Therefore, lack of incentives should be tackled through conducting a comprehensive contract and implementing appropriate KM strategies.

#### **V7. Lack of Proper use of Knowledge Integration Techniques**

The participants highlighted that they have difficulty in finding relevant knowledge, capturing, and documenting their experience properly, allocating time to participate in shared activities between project phases, and not being well aware of the importance of knowledge transfer. Therefore, the KI techniques in terms of capturing, sharing, and transferring knowledge were not properly applied and used. However, this issue could be tackled by adopting an appropriate KM system that improves the awareness of project members on the importance of TKI and incentivise them to participate in the KI process.

#### **V8. Lack of Trust**

Having an open environment to communicate and share ideas depends on having a mutual trust between project members at different phases. Participants stated that they had open environment and shared their ideas within their teams but had difficulty in communicating and sharing their experiences with members of other teams because they had to communicate and share information and experiences between different project phases according to their contract. Additionally, they mentioned that project members also were reluctant to participate in knowledge sharing process between project phases because they did not know whether they were liable to share their experience and information because their knowledge is a proprietary asset of their organisation. However, improving trust depends on the culture of organisations and the KM policies that are adopted by the project manager and stakeholders in order to encourage and motivate project members to participate in the KI process. In the TPS, lack of trust is significant as the nature of this system is based on the separation of the design and construction team.

#### **V9. Culture of Organisations**

As mentioned in Sections 4.4.3 and 4.6, the organisational culture is the most important factor that affects the process of capturing, sharing, and transferring knowledge. It depends on the

attitudes of the knowledge manager to incentivise project members and to participate in the KI process by using various appropriate techniques and technologies. This means adopting an appropriate KM system depends on having a supporting organisational culture. Participants highlighted that the organisational culture should prioritise and increase the awareness level of project members on the importance of KI in terms of capturing, sharing, and transferring knowledge. In other words, an organisation must encourage trust and provide incentives for its project members in order to implement appropriate KM strategies (including the consideration of approaches that increase the awareness of project members on the importance of TKI, and proper techniques for integrating tacit knowledge).

#### **V10. Contractual Boundaries**

The nature of the TPS is based on the fragmentation rather than integration. This means the design team is separated from the construction team in a traditional construction project, and their communication is highly dependent on the provisions of their contract. Participants stated that it is the terms of the contract that dictates what type of knowledge and how to communicate and share information and experiences. In other words, it is the provisions of contract that affects the flow of information and knowledge between the design and construction phase of projects. This means that the KM policies of organisations in terms of sharing information and knowledge between project phases in the TPS depends on the provisions of their contract with the client. This issue has a significant role in the process of KI in terms of sharing knowledge between different project phases.

#### **5.5.7 Techniques**

Respondents, from CS1 and CS2 agreed that they mostly used monthly meetings, emails, face-to-face dialog, CoPs, and workshops for communication and sharing their experiences with project members at different project phases (Concept 1112). Additionally, they stated that they discussed lessons learned in their monthly meetings and meeting minutes were recorded in the project's file. Although the meeting minutes and lessons learned were recorded and documented in the project's file, respondents stated that it was difficult to find the relevant and required knowledge when it is needed (Concepts 1116 and 2202). Furthermore, they stated that there were no guidelines to review the project's file of similar project, which was already completed, in order to minimise the probability of same problems occurrence

(Concepts 1111 and 2201). They indicated that communication and sharing knowledge between the different phases of the project only depended on their contract (Concept 1106 and 2206). Participants highlighted that meetings are valuable because of bringing people around the table to share their information and knowledge. Emails were used for communication between project members within each the project's phases because it is quick to distribute information to different people and very easy to use. The drawback to this is that there will be tens of thousands of emails from the beginning to the end. As a result there is a need to effectively manage them in order to minimise the lack of traceability and auditability of the emails. Interviewees stated that there are benefits in using COBie and IFC file for sharing and transferring information and knowledge. There is also a plan by the government for implementing BIM level 3 in all construction projects by 2025.

*"I think it is very important to always ensure as soon as you finish the project to actually identify the lessons learnt and what works well and what didn't work well. We usually do it in our monthly meeting.....We get things, like meeting minutes, documented and keep things in files.....Apart from our monthly meetings, we mostly communicate through email in our department to share files and our ideas and also arrange for the meetings....Our organisation provides communities of practices for its members in order to improve and share their skills and knowledge..... We didn't use BIM in this specific type of project, but we used it before and it was really helpful in terms of exchanging information through COBie files..... Regarding to the BIM technology, I have to say it will dominate the whole industry, as it is started and there is a plan to implement BIM level 3(including the IFC files) in all construction projects by 2025 ..... I think one problem that leads to designing clashes is using different software by sub-contractors that cannot be synched"*

### **5.5.8 Critical Success Factors (CSFs)**

This section presents the data analysis in relation to the CSFs of TKI in the traditional construction projects that were highlighted by interviewees in CS1 and CS2. Figure 5.8 shows the themes that emerged from the analysis of the semi-structured interviews on the CSFs. These themes are further discussed.

Critical Success Factors			
Name	Sources	References	
[-] Critical Success Factors	0	0	
[-] Contractual Boundaries	0	0	
[-] Clear liability of project members for sharing knowledge at different phases of project	7	15	
[-] Culture of Organisation	0	0	
[-] Open Environment	7	13	
[-] KM System (policies and strategies)	0	0	
[-] Adopting proper tools for TKI	7	15	
[-] Adopting two-stage process traditional procurement	7	13	
[-] Building Trust	7	12	
[-] Designing sub-contractors use software that can be synchronised	7	12	
[-] Having Clear definition of objectives	7	11	
[-] Improving awareness on the importance of TKI	7	15	
[-] Incentivise project members for participation in TKI	7	15	

Figure 5.8 – Screenshot Showing Nodes on CSFs of Tacit Knowledge Integration

### **Culture of Organisation**

The organisational culture is one of the important factors that affect the process of integrating tacit knowledge. Effective organisational culture depends on having an open environment to communicate and share individual ideas and experiences. An open environment means providing a trusted working environment where project members dedicate enough time to share their knowledge with each other.

*“We have friendly environment. Internally, within the department our team members easily approach each other. We are working together as a one team. I think this is because we trust each other. The project managers creates this environment and gave us this feeling.....within each team, I know exactly who I’m going to share my knowledge with and they are willing to share their knowledge with me”*

Participants believed that project members should dedicate enough time to do lessons learned and that it should be done as soon as each task is completed. The lessons learned could be achieved through the meetings with contractors and consultants and between contractors.

*“I think it is very important to always ensure as soon as you finish the project to actually identify what works well and what doesn’t. We always had problem in arranging meetings with contractors and consultants to document the problems and how they*

*were solved after each phase of project, because contractors and consultants are recruited to another project whilst one is finished ..... I think the first is the reflection; we need to dedicate enough time to reflect and identify what went wrong”*

### **Contractual Boundaries**

In the TPS, contractual boundaries play a significant role in sharing knowledge between project phases because it is the provisions of the contract that dictates the amount of knowledge and the liability of project member for sharing knowledge with other contractors.

*“It was clearly mentioned in our contract how to communicate and respond to ‘3Styles Group’. In the traditional, because we are liability for the design, we are responsible for the type of information and knowledge to share with ‘Balbo Ltd’.....In the traditional, the ethos of sharing knowledge is not there, and it depends on the contracts how much knowledge you shared.”*

Participants believed that the liability of project members on sharing information and knowledge at different project phases should be clarified in the contract. Furthermore, this clarification will enable both the project and knowledge manager to adopt appropriate policies and strategies for managing knowledge.

*“As I explained earlier, we communicate with ‘3Styles Group’ according to our contract. It is mentioned in the contract that I, as a project manager, should respond to enquiries that comes from them in a short time.....Although their communication is according to their contract, but it takes time, as they have to send their request through email with full details of issue and asking for meeting, then we will arrange a date to discuss about the issue and resolve it”*

### **KM System (policies and strategies)**

The importance of KM lies in the fact that knowledge if managed properly is a valuable, competitive asset for organisations. It is more significant in construction projects undertaken through the TPS due to the fragmentation nature of this system where the design team is separated from construction team. Therefore, it is important for organisations to adopt

appropriate policies and strategies for managing knowledge in this type of project. The KM system includes how to integrate knowledge in terms of capturing, sharing, and transferring.

Participants believed that effective the KM system in organisation should initially improve the awareness of project members of the importance of TKI in all its categories: capturing, sharing, and transferring.

*“I think everybody knows the value of knowledge and their experience, but the idea of integrating knowledge needs a bit more exploration, specifically in this type of procurement. The issue is in sharing and transferring part, in our organisation I am willing to share my experiences with colleagues, but in this type of procurement, we have to share and collaborate with other organisations, that’s where people have doubts. In terms of transferring, I think it is a good idea and needs a good strategy and plan from the beginning of project to prevent similar problem occurrence.”*

*“Not in this particular project, in another project when it was over budget the client suggested having a meeting with contractors and consultants to identify what went wrong and where the problems was. Things like that are very helpful to make sure in the next time doing a project with a same and similar nature you won’t do the mistakes twice”*

This improvement requires adopting the proper tools in techniques and technologies for TKI and having a clear definition of objectives. Most of interviewees highlighted that an effective KM system should build trust between project members and incentivise them to participate in TKI.

*“I think the first is the reflection; we need to dedicate enough time to reflect and identify what went wrong. Two, now when we identify what went wrong, when we are working on second project, how clear are objectives, and how maybe some kind of methods statement or some kind of procedures which uses what we have learnt and how that is going to achieve our next objective. However, we also need to use the best tools for both achieving objectives and recording the lessons learned. When there is clear objectives, it is easy to identify what you are trying to achieve and by then it is easy to actually see what works and what being used then in project”*

*“We have friendly environment. Internally, within the department our team members easily approach each other. We are working together as a one team. I think this is because we trust each other, the project managers creates this environment and gave us this feeling”*

*“I think KM and specifically TKI will achieve greater success if there is good support from management and team leaders. People should be incentivised to participate in recording their experiences, sharing them with their colleagues and reusing their lessons learned. This motivation from leadership has a positive influence on team performance.”*

However, in terms of sharing knowledge between different phases of the project, participants believed that construction team can be involved a bit earlier (ahead of completion of the design) in the TPS in order to improve the team-work, advice on best practise and decrease the possibility of ‘reinventing the wheel’ by sharing their knowledge and experiences. This requires improvement in the awareness of the client on the importance of appointing the contractors earlier (two-stage tendering traditional project). Furthermore, interviewees stated that the use of the BIM technology can facilitate the project’s performance. They reported that sub-contractors at the design phase use the different designing software that leads to designing clashes: therefore, it is required to use software that can be synchronised to improve the communication of information. In this regard, participants noted that implementing BIM technology would minimise the occurrence of designing clashes and could improve the project performance.

*“I think one problem that leads to designing clashes is using different software by sub-contractors that cannot synchronised. It depends on the policy of organisation to use what type of software. We didn’t use BIM in this specific type of project, but we used it before. Although this technology is more used in other types of procurement, but I think it is applicable in the traditional procurement. “*

*“I think team-working and collaboration are important in this type of procurement, the early you can appoint and import contractors, more knowledge will be shared, and the less likely the common mistakes occur. As I mentioned before, this project is based on*



*two-stage traditional project and we really benefit from having construction team earlier in terms of saving time and preventing designing clashes”*

The mentioned CSFs are further discussed in the next chapter (Section 6.2) based on the classification of challenges after implementing the ISM approach (Section 5.6).

## 5.6 ISM and MICMAC Analysis – Classification of Challenges

As mentioned in Section 3.9.2.1 (Chapter 3), the ISM-based approach can be used to identify and summarise the relationships among specific variables which define an issue or a problem. The ISM approach has various steps which were thoroughly explained in Section 4.5 (Chapter 4). Therefore, the SSIM, Reachability Matrix, Final Reachability matrix, and Partitioning of variables are presented in Tables 5.3, 5.4, 5.5, and 5.6, respectively, before presenting the ISM-based model.

The SSIM is a contextual relationships among the identified variables from the analysis of the findings of CS1 and C2 interviews. The rules for developing SSIM are stated in Section 4.5.1. This contextual relationships is presented in Table 5.4.

Table 5.4 – Self-Structured Interaction Matrix

Variable	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10
V1		V	V	V	A	O	V	O	A	O
V2			A	V	A	A	A	X	A	A
V3				V	A	A	A	X	A	A
V4					A	A	A	A	A	A
V5						V	V	V	A	A
V6							V	X	O	O
V7								X	A	A
V8									A	O
V9										O
V10										

The SSIM is transformed into a binary matrix by substituting symbols V, A, X and O to 1 or 0. The rules for this substitution are explained in Section 4.5.2. The initial and final reachability matrix is presented in Table 5.5 and 5.6.

Table 5.5 – Initial Reachability Matrix

Variable	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10
V1	1	1	1	1	0	0	1	0	0	0
V2	0	1	0	1	0	0	0	1	0	0
V3	0	1	1	1	0	0	0	1	0	0
V4	0	0	0	1	0	0	0	0	0	0
V5	1	1	1	1	1	1	1	1	0	0
V6	0	1	1	1	0	1	1	1	0	0
V7	0	1	1	1	0	0	1	1	0	0
V8	0	1	1	1	0	1	1	1	0	0
V9	1	1	1	1	1	0	1	1	1	0
V10	0	1	1	1	1	0	1	0	0	1

The final reachability matrix is developed by considering the concept of transitivity, which was explained in Section 4.5. The final reachability matrix along with the dependence and driving power is presented in Table 5.5. The driving and dependence power will be used in the MICMAC analysis (Section 5.6.2). Table 5.5 will be used to develop the structural model in the next section.

Table 5.6 – Final Reachability Matrix

Variable	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	Driving Power
V1	1	1	1	1	0	0	1	1*	0	0	6
V2	0	1	1*	1	0	1*	1*	1	0	0	6
V3	0	1	1	1	0	1*	1*	1	0	0	6
V4	0	0	0	1	0	0	0	0	0	0	1
V5	1	1	1	1	1	1	1	1	0	0	8
V6	0	1	1	1	0	1	1	1	0	0	6
V7	0	1	1	1	0	1*	1	1	0	0	6
V8	0	1	1	1	0	1	1	1	0	0	6
V9	1	1	1	1	1	1*	1	1	1	0	9
V10	1*	1	1	1	1	1*	1	1*	0	1	9
Dependence Power	4	9	9	10	3	8	9	9	1	1	

### 5.6.1 Formation of ISM-based Model

The final reachability matrix will be used to derive the reachability and antecedent set which are required in developing the table of partitioning of variables, which include ‘reachability set’, ‘antecedent set’, ‘intersection’, and ‘participation level’ (Table 5.7). The rules for developing this table were explained in Section 4.5.3.

Table 5.7 – Partitioning of Variables

Variable	Reachability set	Antecedent set	Intersection	Level
V1	1,2,3,4,7,8	1,5,9,10	1	III
V2	2,3,4,6,7,8	1,2,3,5,6,7,8,9,10	2,3,6,7,8	II
V3	2,3,4,6,7,8	1,2,3,5,6,7,8,9,10	2,3,6,7,8	II
V4	4	1,2,3,4,5,6,7,8,9,10	4	I
V5	1,2,3,4,5,6,7,8	5,9,10	5	IV
V6	2,3,4,6,7,8	2,3,5,6,7,8,9,10	2,3,6,7,8	II
V7	2,3,4,6,7,8	1,2,3,5,6,7,8,9,10	2,3,6,7,8	II
V8	2,3,4,6,7,8	1,2,3,5,6,7,8,9,10	2,3,6,7,8	II
V9	1,2,3,4,5,6,7,8,9	9	9	V
V10	1,2,3,4,5,6,7,8,10	10	10	V

According to this table, V4 should be positioned at top level and V9 and V10 at the bottom level of ISM hierarchy (Figure 5.9).

Figure 5.9 illustrates that ‘Contractual Boundaries’ and ‘Culture of Organisations’ along with ‘KM System (policies and strategies)’ are significant challenges in integrating knowledge in the TPS because they come at the bottom level of the ISM hierarchy (level V and IV). These challenges affect all other challenges positioned above their level, and together will lead to the variable at the top level which is ‘Lack of Information, and Knowledge Integration’. It should mention that variables positioned at level II have the same impact on each other. However, the ‘Lack of Awareness of the importance of Tacit Knowledge Integration’ (V1) only affects three challenges at level II and other challenges V6 and V8 are affected by the ‘KM System (policies and strategies)’ (V5).

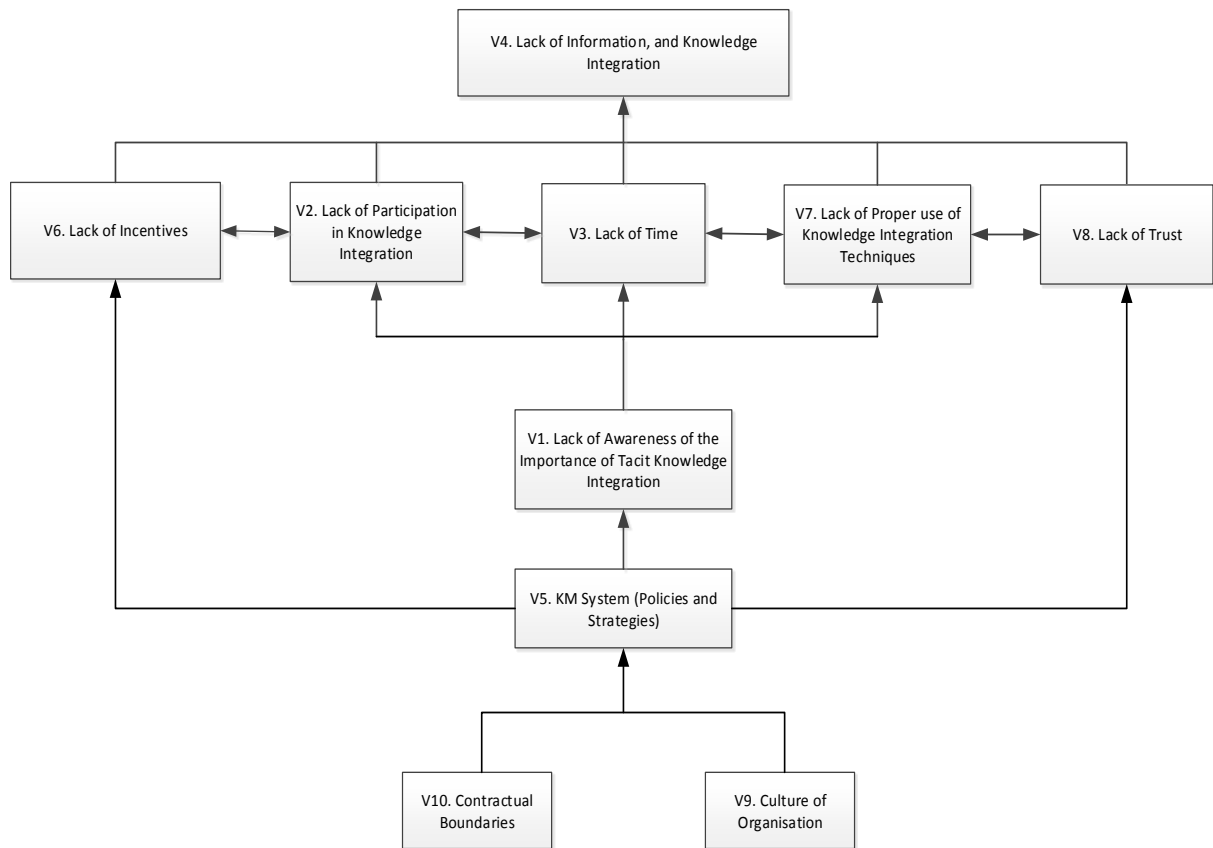


Figure 5.9 – ISM based model of Knowledge Integration Challenges in the Traditional Procurement System

### 5.6.2 MICMAC Analysis

The MICMAC analysis is used to analyse the driving and dependence power of variables which were identified in the final reachability matrix (Table 5.6). The variables are categorised into four clusters according to their driving and dependence power: *Autonomous*, *Independent*, *Linkage* and *Dependent*. The driving and dependence power diagram is presented in Table 5.8.

The first cluster consists of *autonomous* variables that have little dependence and driving power. In other words, the autonomous variables are relatively disconnected from the system. Table 5.8 illustrates that no variables are laid in autonomous cluster. This means that all variables influence the integration of knowledge in the TPS.

The second cluster consists of *dependent* variables that have high dependence power and low driving power. Variable 4 (Lack of Information and Knowledge Integration) has the highest dependent power and minimum driving power and comes at the top level of ISM model.

Table 5.8 – Clusters of Variables of Knowledge Integration Challenges in the Traditional Procurement System

Driving Power	10										
	9	V10, V9	INDEPENDENT				LINKAGE				
	8		V5								
	7										
	6			V1			V6	V2,V3, V7,V8			
	5										
	4										
	3		AUTONOMUS				DEPENDENT				
	2										
	1									V4	
		1	2	3	4	5	6	7	8	9	10
		Dependence Power									

The third cluster includes *linkage* variables that have high dependence power and strong driving power. This means that any action on these variables will influence other variables in this cluster and also feedback effect on themselves. Five variables lie in this cluster:

- Lack of Participation in Knowledge Integration
- Lack of Time
- Lack of Incentives
- Lack of Proper use of Knowledge Integration Techniques
- Lack of Trust

The fourth cluster consists of independent variables that have low dependence power and strong driving power. This means that the positioning in this cluster play significant role in integrating knowledge in the TPS and will be placed at the bottom level of the ISM hierarchy. Therefore, they need to be prioritised and analysed by managers. In this case, four variables lie in this cluster: KM System, Culture of Organisations, Contractual Boundaries, and Lack of Awareness of the Importance of TKI. Although the last variable (V1) is positioning in this cluster, but based on Figure 5.9, its positioning level in the ISM hierarchy is above other variables and directly affected by ‘KM System (policies and strategies)’.

## **5.7 Summary**

This chapter has presented information on CS1 and CS2 and data from semi-structured interviews in the exploratory phase of this research, which was conducted with two case studies in the UK construction industry with the aim of identifying challenges, techniques, and CSFs of TKI in the traditional construction project. The ISM approach was used to summarise the relationships between identified challenges from CS1 and CS2. The findings show that the main challenges are: culture of organisation, contractual boundaries, and the KM system (policies and strategies). The next chapter presents the discussion on the challenges, techniques, CSFs, and development of the framework for the TKI in the TPS.

# Chapter 6 – Discussion – Development and Validation of the Framework

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## 6.1 Introduction

In Chapter 4 and 5, findings from the experts' survey and case studies on the challenges, techniques, and CSFs of integrating tacit knowledge in the TPS were discussed. This chapter presents the overall results on the triangulation of data analysis covered in Chapters 2, 4 and 5. The discussion in this chapter provides the final framework of TKI within the TPS. Afterwards, the process of the framework development, and its validation are presented.

## 6.2 Discussion

Carrillo et al. (2000) stated that one of the main challenges that confront KM in construction industry is 'Tacit dimension of project knowledge' (Chapter 2, Section 2.8.2). Regarding this, Aziz et al. (2014) said that this issue is more common in integrating tacit knowledge in construction projects undertaken through the TPS due to the nature of this system which is based on fragmentation rather than integration (Chapter 2, Section 2.10). In other words, knowledge is not properly integrated in this system in terms of capturing, sharing, and transferring because the design and construction team are separated and project members are recruited in another project ahead of the completion of the current project.

The aim of conducting a case study as part of the research strategy was to explore TKI within the traditional construction project in order to identify existing challenges and approaches that organisations have for integrating tacit knowledge (Chapter 3, Section 3.6.3). In this regard, two cases (CS1 and CS2) were selected with having the same designing organisation, one completed and one ongoing. The purpose was to analyse, compare and evaluate the process of TKI within projects that have been designed by the same organisation. The findings revealed that the TKI was not properly and completely implemented by the designing organisation. The synthesis of CS1 and CS2 identifies a set of challenges that exist in the TPS (Section 5.5.5, Table 5.2) which are:

- Lack of Awareness of the Importance of Tacit Knowledge Integration
- Lack of Participation in Knowledge Integration
- Lack of Time
- Lack of Information and Knowledge Integration
- KM System (policies and strategies)



- Lack of Incentives
- Lack of Proper use of Knowledge Integration Techniques
- Lack of Trust
- Culture of Organisations
- Contractual Boundaries

Comparing these findings with findings from the experts' survey (Chapter 4, Section 4.4, and Table 4.2) reveals that most of them are similar and one of them is new. The 'Contractual Boundaries' is identified as a new variable that affects the TKI in the TPS. An ISM approach is used to identify the relationships and hierarchy among the identified challenges (Chapter 5, Figure 5.9). The ISM model analyses the interaction between the identified variables which represent strategic information to project managers and supports their decisions in the TKI process. The relations between variables in Figure 5.8 are shown with an arrow and all variables at level-two of hierarchy (V6, V2, V3, V7 and V8) have impact on each other. Comparing this model with the ISM-based model identified in the experts' survey (Section 4.5.4, Figure 4.4) reveals a bit of change in the position level of some variables. Variables like 'Culture of Organisations' and 'KM Systems' are positioned at the bottom-level of ISM hierarchy along with the new variable 'Contractual Boundaries'. This means that these variables are the root of other variables that finally lead to lack of information and KI, which is positioned at the top-level of ISM hierarchy. In this regard, the MICMAC analysis (Chapter 5, Table 5.7) shows that these variables are allocated in the 'Independent' cluster which means they are a driver to other variables. Therefore, these variables are significant and play a key role in integrating tacit knowledge and can be considered as the main challenges of TKI in the TPS. Project managers should consider these challenges and investigate them in order to effectively integrate tacit knowledge. The rest of variables are mainly affected by these challenges. Figure 6.1 illustrates the challenges that were identified from the synthesis of findings in the experts' survey and case studies.

Kamara et al. (2002) stated that transferring knowledge between different organisations involved in a project highly depends on the type of contract and contractual clauses. The 'Contractual Boundaries' plays a significant role in bidirectional flow of knowledge between the design and the construction phase of a project because it is the contract that dictates the

way of communication of project members at different phases. In this regards, participants in CS1 and CS2 clearly stated that they had to follow their contract in order to communicate with project members at different project phases (Concepts 1103, 1106 and 2206). Additionally, positioning this challenge below of 'KM Systems' means the KM policies and strategies that are adopted by organisations for sharing knowledge between project phases in the TPS depends on the provisions of the contract. One of the respondents in the experts' survey (Chapter 4, Section 4.3.2) mentioned that employing different techniques for sharing knowledge between different phases of traditional project depends on the contractual mechanisms and boundaries.

In order to tackle this challenge, it is suggested to thoroughly consider and improve the communication and collaboration of the design and construction team in the provisions of their contract. This requires clarification of the liability of project members on sharing knowledge at different phase of project. Additionally, the awareness of the client and his consultants should be improved on the importance of TKI and the benefits of importing contractors before completing the designing phase in the project (two-stage tendering traditional procurement). According to Masterman (2000), the involvement of contractors ahead of completion of the designing phase means more collaboration and sharing of knowledge with the designing team on best practises and lessons learned, which will lead to saving time, cost, and minimising the designing and buildability issues. In other words, this would improve the project performance and decrease the possibility of reinventing the wheel. Participants in CS2 stated that when they were assigned to a project they had meetings with the client's consultants and discussed the benefits of importing the construction's contractors before completion of the designing phase. Therefore, the procurement type of CS2 became 'two-stage traditional project'.

Hari et al. (2005) and Bessick and Naicker (2013) highlighted 'organisational culture' as the most important challenge in integrating knowledge in construction projects (Chapter 2, Section 2.11). The synthesis of CS1 and CS2 highlights the 'Culture of Organisations' as another main challenge of TKI within the traditional construction project. Existence of the supporting culture in organisations is required for having an efficient collaboration between project members in capturing, sharing and transferring tacit knowledge within the traditional construction project (Chapter 2, Section 2.11 and 2.12.3). This supporting culture means

having an open environment in which project members are incentivised to work and communicate with each other (Concepts 1104, 1105, 2209, 2210). Additionally, participants highlighted that it depends on the culture of the organisation to adopt an appropriate KM strategy that prioritises and incentivises project members to participate in integrating tacit knowledge.

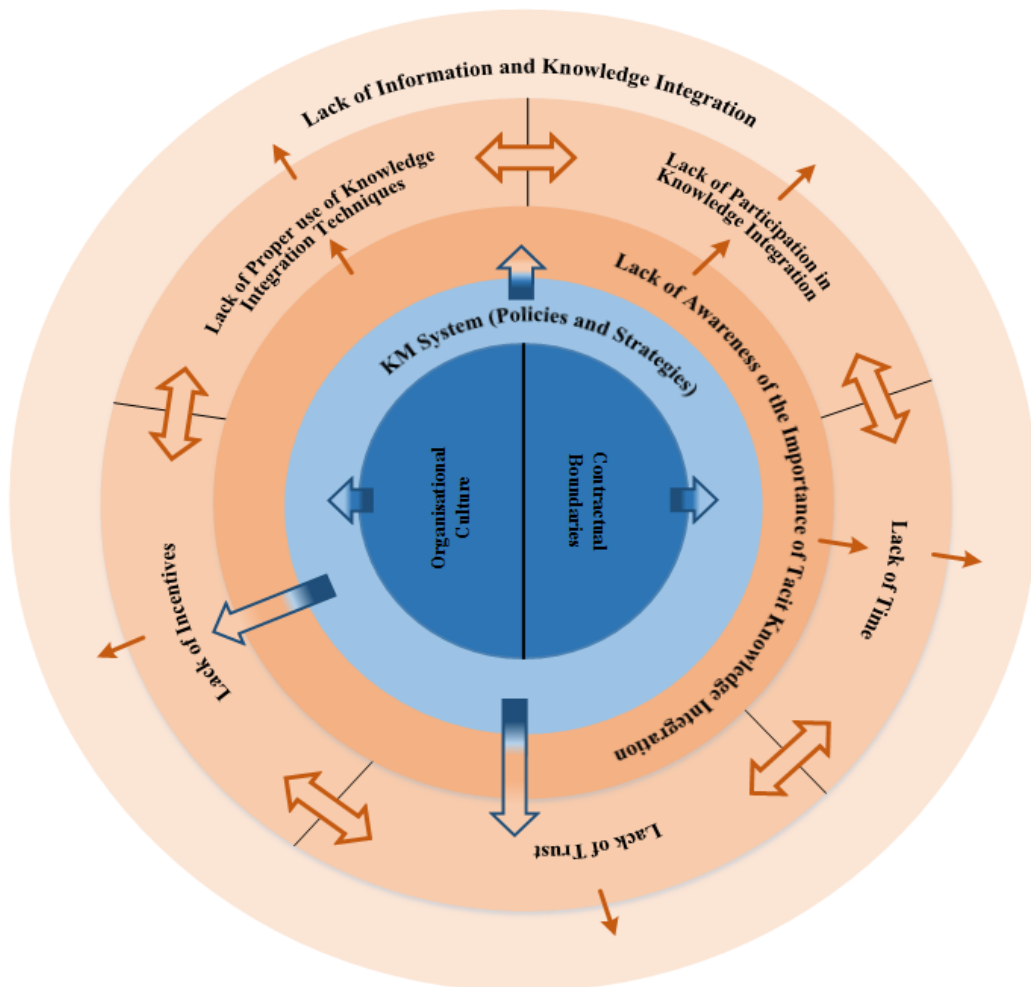


Figure 6.1 – Challenges of Tacit Knowledge Integration within Traditional Procurement System

The key to this challenge is having an open environment (supporting culture) which improves the awareness of the project manager in the importance of TKI. In this regard, Kwawu et al. (2010) stated that the organisational culture should be supportive in terms of improving awareness and willingness to participate in the KI process (Chapter 2, Section 2.12). This will lead to adopting an effective KM system that uses the appropriate tools and techniques to build trust, increase awareness of project members on the importance of TKI and encourage

them to participate in TKI process, specifically in capturing and using lessons learned. This is also in line with findings in the experts' survey (Chapter 4, Sections 4.3 and 4.4).

The 'KM System (policies and strategies)' along with variables 9 and 10 are at the bottom levels of the ISM model (Chapter 5, Figure 5.8), and are considered to be the main challenges in the TPS. Participants stated that motivation and collaboration between different project phases was not efficient enough and only based on their contract's clauses (Concepts 1104, 1105, 1106, 1108). This means that 'Contractual Boundaries' play a significant role in adopting an effective KM system for collaboration and sharing knowledge between the design and construction phase in the TPS. Additionally, participants explained that even though their organisation identified the lessons learned after each project but they still had difficulty in finding the relevant knowledge (Concepts 1116 and 2217). Fong and Chu (2006) stated that this difficulty is caused by lack of proactive management strategies in organisation (Chapter 2, Section 2.12). This means the KM strategy and policies that are adopted by organisations were not effective for capturing and retrieving tacit knowledge in the traditional construction project. This requires proper guidelines and techniques for capturing knowledge that should be considered by project manager when determining the KM policies and strategies of projects.

It is clearly stated by participants that they only captured and shared their experiences and were not aware of the importance of transferring their experiences to another project in this type of procurement system (Concepts 2202, 2203 and 2213). This means there were no guidelines provided by their organisation to integrate tacit knowledge (Concepts 1111 and 2201), and the adopted KM system by organisations did not improve the awareness of the importance of transferring knowledge between projects. Furthermore, recruiting experts is an effective strategy for keeping the knowledge inside organisations. Some participants stated that their organisations had this strategy and recruited experts, who left the organisation before and then returned for the current project. Other participants stated that their organisation did not adopt effective a KM system and easily let experts leave their organisation (Concepts 1113, 1115, 2215 and 2216). This means that their organisation was not aware of the importance of keeping their experts' knowledge, which is a competitive asset for an organisation. The above factors are in line with the challenges and CSFs that were

discussed in Chapter 2, Section 2.12. Therefore, the CSFs for tackling this challenge is for the project managers to adopt an effective KM system (policies and strategies) that covers:

- Considering contractual boundaries (what type of knowledge and who is liable to share that knowledge) in implementing appropriate tools (techniques and technologies) for collaboration and sharing knowledge between the design and construction team
- Clarifying objectives of a project
- Improve the awareness of project members on the importance of TKI
- Freeing up time, building trust, and incentivising project members in order to create an open environment and to participate in TKI process
- Implementing appropriate tools and techniques for identifying lessons learned and for capturing, sharing, and transferring tacit knowledge
- Using synchronised software by designing sub-contractors at designing phase in order to reduce designing clashes and save time and cost
- Adopting two-stage tendering TPS

The effective KM system will increase the awareness of project members on the importance of knowledge capturing and their willingness in sharing their knowledge during the project life cycle (Pan & Flynn, 2003; Carillo et al., 2004; Lin, 2007).

The 'Lack of Awareness of the Importance of Tacit Knowledge Integration' is positioned at the third level in ISM hierarchy (Chapter 5, Figure 5.9), which is comparing the developed ISM model from the experts' survey (Section 4.5.4, Figure 4.4) and is dropped one level down. The ISM model (Chapter 5, Figure 5.9) depicts this variable having no direct influence on the two specific challenges at the second level of the ISM hierarchy. They are 'Lack of Incentives' and 'Lack of Trust', because they are directly influenced by 'KM System (policies and strategies)'. Additionally, this challenge is changed from 'Lack of Awareness of the Importance of Tacit Knowledge and its Integration' to 'Lack of Awareness of the Importance of Tacit Knowledge Integration' because findings revealed that most of the people and organisations involved in the construction projects are aware of the importance to their experiences and skills but they are not aware of its importance of the process of TKI in terms of transferring knowledge to the next project (Concepts 2202 and 2203).

In terms of KI approaches and techniques that were identified in CS1 and CS2 (Section 5.5.7), it was found that organisations used these techniques mostly for communication and sharing information and knowledge. The identified techniques are lessons learned, post project reviews, regular meetings, face-to-face dialog and CoPs. These techniques are in line with the findings from both literature review (Chapter 2, Section 2.10) and the experts' survey (Chapter 4, Section 4.3.2). Kamara et al. (2002) and Anumba et al. (2005) stated that PPR can be used as a means for capturing lessons learned and best practices. Furthermore, Fong and Chu (2006) and Cheng (2009) state that meetings, project reviews and face-to-face dialog are means of sharing and transferring knowledge.

Participants said that they neither use any techniques for transferring knowledge nor are they aware of the importance of knowledge transfer (Concepts 2202 and 2203). This happens due to the lack of the appropriate KM strategies and policies which should consider the importance of transferring knowledge from previous projects and implementing appropriate techniques and technologies for doing it. In this regard, the participants in CS1 mentioned that they had difficulty in finding and retrieving captured knowledge (Concepts 1116 and 1117).

Furthermore, the participants were asked about the use of BIM technology for capturing knowledge in this type of procurement system and most of them agreed that it could be used as a repository and facilitate the TKI process. In this regard, the respondents in the experts' survey (Chapter 4, Section 4.3.2) stated that BIM technology (having the view of using IFC file at BIM level 3), could be used for capturing and saving knowledge, and improving project's performance. They also stated that using this technology has its own challenges in the TPS like the fear of adopting new technology and the accessibility of the knowledge repository. Hari et al. (2005) stated that project members have fear of problem occurrence and the negative impact of admitting mistakes among their team members when using the new technology (Chapter 2, Section 2.11). In probing analysis of CS1 and CS2, interviewees stated that the liability of holding this repository is a major issue in the TPS due to the separation of organisations that are involved at different project phases in this system. As most of the problem occurrence is during the project life cycle and related to the designing phase, it is suggested that the designing organisation have the liability of the knowledge repository. Furthermore, interviewees stated that using the BIM technology (in terms of using COBie and IFC file for sharing and transferring knowledge) will reduce the occurrence of designing clashes

between sub-contractors involved at design phase, and it is important that all sub-contractors implement synchronised designing software (Chapter 5, Section 5.5.7).

## **6.3 Framework Development**

The considering above factors lead the conceptual framework (Chapter 2, Section 2.14) to be revised, which is discussed and presented in this section.

### **6.3.1 Conceptual Framework**

In Section 2.14.1 in Figure 2.14, the conceptual framework for describing TKI within the traditional construction project has been developed based on the literature review. It is derived from a theoretical KM framework (Section 2.8.2, Figure 2.7) which was developed by Carrillo et al. (2000). The KM framework has three main components; challenges, means and process, which are the fundamentals for integrating knowledge. Therefore, they are interlinked together for the purpose of this research. The three components are further investigated in terms of identifying challenges, techniques, technologies and CSFs that affect the TKI process within the context of the TPS. This conceptual framework was further revised during the process of data collection and analysis.

The development of the framework is based on the literature review, qualitative data collected through semi-structured interviews in the experts' opinion survey, case studies, and a questionnaire survey. As mentioned in Chapter 3 Section 3.10, the literature review is used to collect data through a documentary survey in order to form the research background for the research topic. The conceptual framework is developed based on the documentary survey. The experts' opinion survey (Chapter 4) is used to collect more data on the three components of conceptual framework from experts in academia and industry in order to be more familiar with the research topic. The findings are further taken to a real life situation for more exploration through case studies (Chapter 5). The collected data from the case studies are analysed (Chapter 5, Sections 5.5 and 5.6) and triangulated with the findings from both documentary and experts' opinion survey (Section 6.2). This triangulation leads to refining the conceptual framework which is presented in the next section. The revised framework is further validated through an online questionnaire survey (Section 6.4).

## 6.3.2 Revised Framework

Figure 6.2 presents the final framework of TKI within the traditional construction project. This framework has three main components which are interlinked together: KI Challenges, KI Means, and TKI process. As discussed in Section 6.2, the BIM technology is suggested for use in the TPS as a technology that can be used as a knowledge repository and facilitate the process of TKI. Therefore, the proposed framework is based on considering using the BIM technology by construction organisations.

### 6.3.2.1 Knowledge Integration Challenges

According to the findings in Chapter 5 (Section 5.5.6), 11 factors are identified as challenges of TKI within the TPS. These factors are explained in detail in Chapter 5 (Section 5.5.6) and further discussed in Section 6.2. It is concluded that three of them are the main challenges that affect the process of TKI. The three main challenges are *Culture of Organisation*, *Contractual Boundaries*, and *KM System (policies and strategies)*. The relationship between these challenges is identified through ISM approach (Chapter 5, Section 5.6) and it is concluded that 'KM System' is affected by 'Culture of Organisation' and 'Contractual Boundaries'.

To successfully implement TKI within the traditional construction project, the project manager should consider the mentioned challenges and solve them by considering the CSFs. The CSFs for tackling these challenges are identified in Chapter 5 (Section 5.5.8) and further explained in the discussion section (Section 6.2). These challenges and CSFs affect the TKI process and should be considered by the project manager when establishing strategy and objectives for integrating knowledge. Furthermore, considering these challenges will enable project managers to choose an appropriate means for integrating tacit knowledge within the traditional construction project. In other words, resolving issues like

- having an open environment for integrating knowledge (Culture of Organisation)
- having a clarification on the liability of project members for sharing knowledge between contractors (Contractual Boundaries)
- adopting proper policies and strategies for KM (Knowledge Management System)



will influence the choice and usage of techniques and technologies which will further impact the TKI process.

### **6.3.2.2 Knowledge Integration Means**

KI means handle the content and richness of knowledge. Thus, it is important to choose appropriate techniques and technologies for integrating knowledge. Therefore, 'Knowledge Integration Means' directly prompts the TKI process forward. Project managers need to adopt appropriate means (techniques and technologies) for integrating knowledge. This is highly dependent on considering the challenges within the TPS due to the separation of the designing and construction phase in this system. The techniques and technologies for facilitating the process of TKI are identified and discussed in previous sections (Section 5.5.7 and 6.2).

### **6.3.2.3 Tacit Knowledge Integration Process**

As explained in Chapter 2 (Section 2.7.4), KI consists of three processes: capturing, sharing and transferring. The TKI process within the traditional construction project should mainly be implemented by the designing team because most of the problems occur during the project lifecycle are related to designing. This process includes some stages which are explained below.

#### **Stage One: Project Inception**

To successfully integrate tacit knowledge in the traditional construction project, the project manager in the designing team must thoroughly understand and research the project in order to identify whether there has been a similar project run by their organisation in the past or not. If so, initially the related strategy for transferring knowledge should be established to retrieve the related project knowledge from the knowledge repository (refer to stages two, five and eight). Then the project manager should establish strategy and objectives for the knowledge capturing and sharing process (with respect to stage two).

#### **Stage Two: Establishing a strategy and objectives for TKI**

Establishing a strategy for TKI is significantly influenced by KI challenges that enable the project members at designing phase to exploit their knowledge and learning capabilities. It includes the extent to which the project members are

- working in an open environment in terms of willingness to share knowledge, having mutual trust, and enough time to participate in TKI
- aware of the importance of TKI
- having a clear definition on their objectives

Furthermore, the project manager must have a clear view on the contract's clauses in terms of knowing the liability of the project members for sharing knowledge at the different phases of project. In other words, the project manager must know what type of knowledge and to what extent the knowledge can be shared between contractors. This will enable the project manager to select and use proper means for TKI in terms of capturing, sharing, and transferring knowledge.

### **Stage Three: Implement appropriate means (techniques and technologies) for TKI - Capturing**

There are different ways to integrate knowledge (tacit and explicit). Project members need to be incentivised to participate in the TKI process. The project manager can elicit tacit knowledge from project members in the form of lessons learned, best practice, communities of practices, post project review (PPR), and regular meetings. Furthermore, technology has a direct impact on the TKI process, specifically in capturing process. ICT (Information and Communication Technology) like E-mail, video conferencing, and internet can be used by project members for not only capturing knowledge but also for sharing knowledge during the project lifecycle. In the TPS, the BIM technology can be used by the project manager at the designing phase, in order to enhance the TKI process.

### **Stage Four: Filter Knowledge**

Each project creates new knowledge and project members can achieve new knowledge during a project lifecycle. Once it is captured, the knowledge repository tends to grow. When using the BIM technology as a repository, the captured knowledge (in form of either COBie or IFC files) is subject to review and value adding processes of filtering like indexing, abstracting, integrating, labelling and sorting. This filtering should be done by experts before adding the captured knowledge to the knowledge repository. In the TPS, the knowledge that is captured from the construction team also needs to go through filtering process.

### **Stage Five: Knowledge Repository**

The BIM technology can be used as a knowledge repository within the TPS. Due to the nature of this system, it is suggested that the designing organisation holds the liability of this repository. This repository is a database that includes designing team information, project information, the knowledge that is gained from reports and meeting' minutes during designing phase, and the COBle and IFC files that are used by designing contractors.

### **Stage Six: Knowledge Sharing**

As knowledge equals to power, if it is shared it will be multiplied. Therefore, the project manager should consider the power of knowledge sharing and incentivise project members to share their experiences and knowledge. With respect to stage two and three, once a strategy and objectives are established for the KI, the proper means can be used for sharing knowledge by project members at the designing phase. In the TPS, knowledge sharing should happen between the designing and construction phase. The knowledge sharing process can be facilitated by using a knowledge repository.

### **Stage Seven: Knowledge Update**

Once the knowledge is shared, new knowledge will be created and project members can update their knowledge. This new knowledge can also be created and gained through the knowledge sharing process between the designing and construction phase. The new knowledge, with respect to stage four, is required to be reviewed and validated by experts before being put in the knowledge repository.

### **Stage Eight: Knowledge Transfer**

With respect to stage one and two, if the designing organisation has done the similar project in the past, then the project manager should retrieve the related project knowledge from the knowledge repository. With respect to stage three and stage five, the BIM technology is suggested to be used as the knowledge repository. Therefore, the retrieval of the related project knowledge from repository means acquiring the related BIM model and then using and modifying it for the current project. The knowledge transfer process facilitates the project in terms of minimising the number of designing errors which will result in reducing the cost and time.

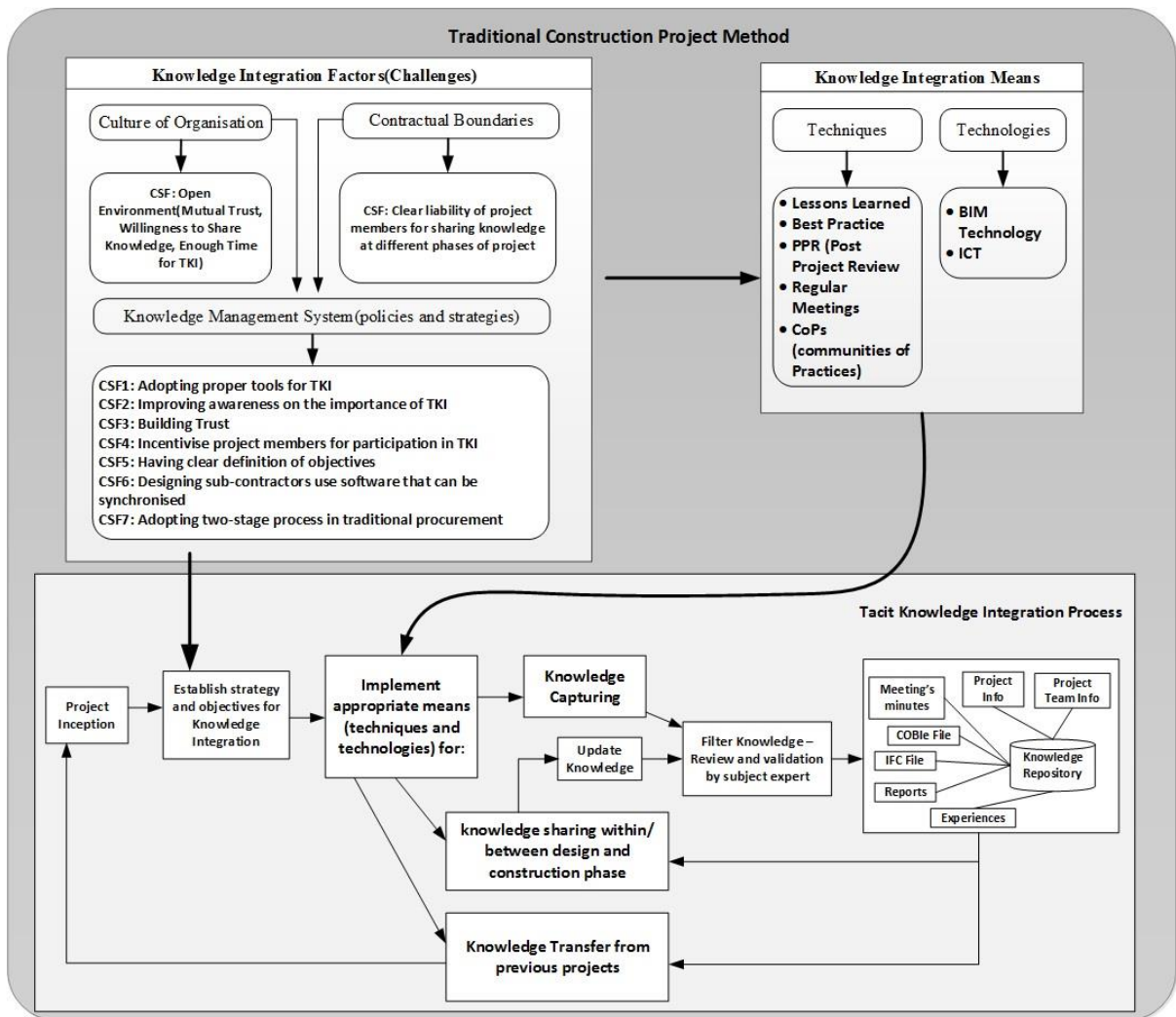


Figure 6.2 – Revised Tacit Knowledge Integration Framework

## 6.4 Framework Validation

This section focuses on the validation of the framework. The revised framework is a result of research data analysis process which still needs to be validated. This research adopted the use of an experts' questionnaire survey as its validation method to obtain feedback and comments on the developed framework.

The survey was conducted through use of an online open-ended questionnaire distributed to experts who were selected from a member database of professional bodies like RICS and CIOB. The invitation email was sent to 180 experts but only 16 experts responded to the questionnaire. Table 6.1 indicates the respondents involved in the validation process.

Table 6.1 – Validation Questionnaire Respondents

Respondents	No
Project Manager	6
Site Manager	4
MEP Designer	3
Architect	3

The validation questionnaire asked respondents to review the developed framework. Each expert received a summary of research project through an invitation email. The framework was fully explained in the questionnaire and the experts were asked to identify their job title, years of experience, and to give their opinion and comments on the framework in terms of:

- applicability of ‘TKI Process’ phase
- further clarification on any section or point of the framework
- any modification in each section

The number of years that the respondents had work experience in the construction industry is illustrated in Figure 6.3.

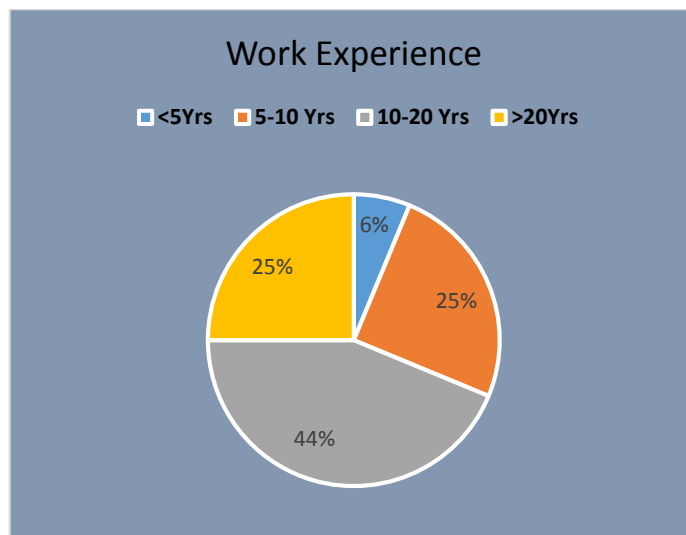


Figure 6.3 – Validation Questionnaire Respondents’ Work Experience

The survey responses were analysed to incorporate their suggestions and comments for the improvement of the framework. The feedback received from the respondents was positive and they all agreed on the applicability of the framework. However, they offered to clarify the

'TKI Process' section by providing a guideline to improve and increase the understanding of the framework for project managers.

### **The applicability of 'TKI process' phase**

87 percent of respondents were totally agreed on the applicability of TKI process stage and only 2 respondents were slightly considering the applicability of TKI process at the construction phase of project for construction organisations.

*"In general, the process is presented simple and understandable, but as a site manager this is more applicable and useful for designers, which is quite acceptable in this type of procurement. What about the construction organisations? How can it be useful for them?"*

### **Further clarification on any section or point of the framework**

Although most of the respondents agreed with the applicability of the framework, they indicated that the 'TKI process' requires a guidelines in terms of explaining the integration process step-by-step which will help the project manager to understand the process effectively.

*"The process is simple and easy to understand. However, the start and end point is not clear. As a project manager I would prefer more clarification on knowledge capturing, sharing, and transferring sections, and how this framework can help me when an issue occurs. The framework is suggesting using BIM in this type of procurement and I would like to see its procedure in the TKI process."*

### **Any modification in each section**

All of the respondents were agreed that there is no need to modify any section in the framework because they are simple and understandable. As mentioned above, they only concerned about the clarification of TKI process.

*"The good thing about this framework is its simplicity. Each section talks itself and well presented. The challenges are well addressed, their relationship and CSFs are all make sense for me. As a project manager, the means are presented properly and each of*

*them can be used whenever it is needed to. The interesting part for me is the use of BIM in this type of procurement, which I prefer to see when and how it is applied because it is not clear in the integration process.”*

Based on the validation analysis and overview of the findings, no elimination of the concepts or sections occurred in the framework and only the ‘TKI Process’ guidelines were added which is described in the next section (Figure 6.4).

### **6.4.1 Framework Guidelines**

Based on the feedback of the experts’ opinion on the validation of the framework, a guideline was developed for the ‘TKI Process’. Figure 6.4 illustrates the TKI framework guidelines for the construction project undertaken through the TPS. The guidelines consists of two main sections which are described below:

#### **Brief and Design**

1. Start
2. Select a Project
3. Create a KI Project File
4. Elaborating the Project
5. Has there been a similar project in the past?
  - 5.1. Yes: Identify Activity for KT (Knowledge Transfer)
    - 5.1.1. Retrieve Related Project Knowledge from Knowledge Repository
    - 5.1.2. Identify Activity for KC and KS (Knowledge Capturing and Knowledge Sharing)
    - 5.1.3. Use/Modify the repository BIM models
  - 5.2. No: Identify Activity for KC and KS
    - 5.2.1. Confirm the BIM Technology for KC and KS
    - 5.2.2. Create a BIM model/COBle File

#### **Design and Construction**

6. Is there a New KI Topic?
  - 6.1. Yes: Set up the KI Topic on Project File
  - 6.2. No: Go to 7

- 7.** Does it Need Construction Team Involvement?
  - 7.1.** Yes: Meeting with Construction Team
    - 7.1.1.** Attach Files with Issues in the Information
  - 7.2.** No: Edit Response on the Topic
- 8.** Review and Validate Established Topic
- 9.** Bank Knowledge
- 10.** Is there another Issue?
  - 10.1.** Yes: Go to 6
  - 10.2.** No: Go to 11
- 11.** End



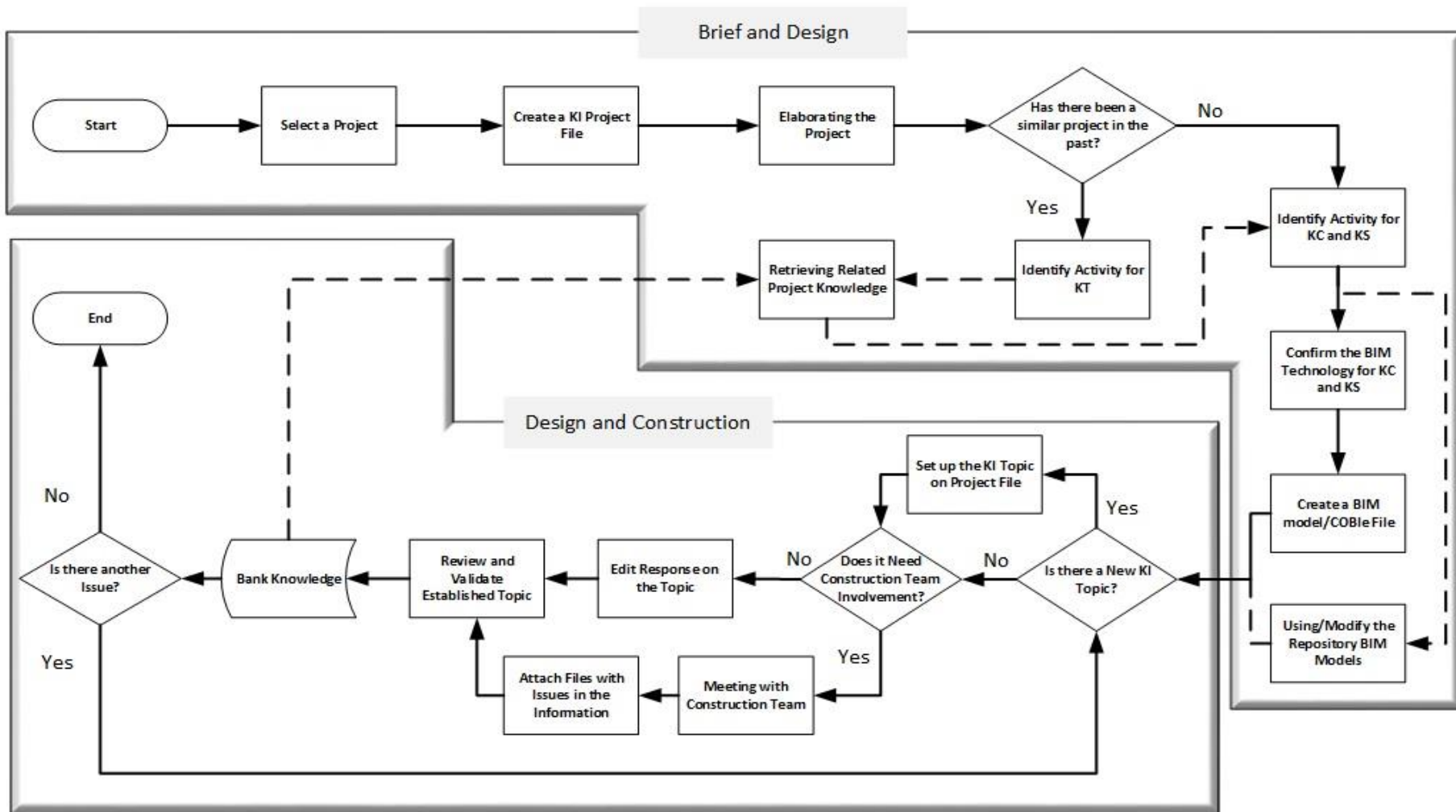


Figure 6.4 – Tacit Knowledge Integration Framework Guidelines

## **6.5 Summary**

This chapter presented the discussion on the findings from the data analysis process which was about identifying the challenges, techniques and CSFs on integrating tacit knowledge within the TPS. This discussion led to developing the TKI framework. The process of this development and each section of the framework were presented. Furthermore, the framework was validated through the experts' questionnaire survey which led to development of guidelines for TKI framework.

The next chapter will be the final chapter of the research, which is the conclusion and recommendations. It will revisit and discuss the summary of this research including research aim, objectives, presenting conclusions derived from the research, highlighting the contributions to knowledge, limitations for this research, and suggesting recommendations for further study.

# Chapter 7 – Conclusions and Recommendations

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## 7.1 Introduction

The aim of this research was to develop a framework on how to integrate tacit knowledge, in terms of capturing, sharing, and transferring, within a construction project context undertaken through the TPS, in the UK. This chapter revisits the research process from the synthesis of the literature review, research methodology, and results of analysing the collected data through semi-structured interviews and experts' survey questionnaire. The research aim and objectives are also summarised. Furthermore, the contribution of this research to knowledge is highlighted as well as the limitations of conducting this research. Finally, the areas for further research are recommended.

## 7.2 Revisiting the Research Process

This research was conducted by reviewing and synthesising the literature sources. Initially, the research problem, aim and objectives were identified (Chapter 1).

**Chapter 2** presents the literature discussed on the typologies of knowledge, general areas of KM, and KM and its challenges in construction. The operational definition of KI was presented as a subcategory of KM, and its process including capturing, sharing, and transferring were thoroughly discussed. The aim of this research was to develop a framework on how to integrate tacit knowledge in terms of capturing, sharing, and transferring, within a construction project undertaken through the TPS. Thus, it was required to identify the approaches, techniques, challenges and CSFs of each sub-process of TKI. Identifying these factors helped to develop the conceptual framework of KI within a traditional construction project.

**Chapter 3** gives an outline for the methodology adopted to achieve the aim and objectives of this research and also meet the requirements of the research questions. The philosophical approach, including epistemology, ontology and axiology, taken for this research was; interpretivism, subjectivism and value laden. In addition, the abductive research approach and multi-mono method were adopted. The case study and survey were selected as the research strategy for conducting this research. The data collection method adopted for conducting this research was semi-structured interviews through the experts' survey and case studies. Four experts, from both academia and industry, were selected for conducting the experts' survey

(Chapter 4). Two case studies, one completed and one on-going, were selected including eight semi-structured interviews with project members at both the design and construction phases (Chapter 5). The collected data were analysed through content analysis with the aid of computer software, NVivo 10. The ISM approach was used to identify and summarise the relationship between identified themes. Furthermore, an online experts' questionnaire survey was used to validate the developed framework (Chapter 6). The questionnaire was distributed to 180 experts in the industry and only 16 replies received.

**Chapter 4** presents findings from the experts' survey through semi-structured interviews with four experts from both academia and industry. The findings were analysed contently, with the aid of computer NVivo software, in order to find the challenges, approaches and techniques of TKI within the TPS. Furthermore, the findings were used in structuring the interview questions in the exploratory phase of research, the case studies.

**Chapter 5** highlights the findings of case studies and synthesis them in order to identify the challenges, techniques, and CSFs of TKI. These findings were further discussed in chapter 6 in the form of comparing the findings from document and the experts' survey. The ISM approach was used to identify and summarise relationships between the identified challenges.

**Chapter 6** presents the discussion on findings from the document survey, the expert's survey and case studies. The final challenges of TKI were identified and presented with the CSFs. The development process of TKI framework was presented. The final framework consists of three main sections which were KI Challenges, KI Means and KI Process. Further, the framework validation process was discussed. The validation of TKI framework was through an expert's survey by an online open-ended questionnaire. The feedback from the experts' survey led to the development of a guideline framework.

### **7.3 The Research Conclusions**

This section presents conclusion of this research through reviewing the research aim and objectives, (Chapter 1, Section 1.4) and how they have been achieved.

### 7.3.1 Research Aim

The aim of this research was to develop a framework on how to integrate tacit knowledge, in terms of capturing, sharing, and transferring, within a construction project context undertaken through the TPS in the UK. The framework was developed, (Chapter 6, Section 6.3) through the findings from the analysis of data collected from the documentary survey and qualitative data collected from the semi-structured interviews and experts' survey questionnaire. The framework was presented with the guidelines (Chapter 6, Section 6.4.1) that together provided a set of useful and practical actions that can help to improve the awareness and understanding at the individual and organisational level about TKI and also help project managers at the designing phase to improve the TKI practices within the TPS.

### 7.3.2 Research Objectives

The main conclusions of this research are presented according to the highlighted following objectives:

- **To establish and document the specific areas of tacit knowledge integration within construction project context**

This was addressed through conducting a document survey with an in-depth review of existing literature on the concept of TKI within the construction project context. In this regard, relevant areas were investigated which are typologies of knowledge and KM in terms of capturing, sharing, and transferring due to the operational definition of KI. The literature revealed that knowledge is personalised and it should be accurately captured, shared, and transferred in order to be useful and interpretable by receivers (Chapter 2). Having investigated the different typologies and perspectives of knowledge enabled the researcher to have a better understanding of KM, which was a wide concept and consists of various processes. However, KI was a sub-category of KM that included processes of capturing, sharing and transferring (Chapter 2). Therefore, the areas of KM and KI in construction were investigated. The literature review highlighted that KM requires more exploration in the construction industry in terms of how to manage knowledge across projects, which aligns with the operational definition of KI. Furthermore, the area of construction project in terms of the TPS was also investigated. The literature review also discussed the characteristics of

construction projects which are temporary organised teams, unpredictable working schemes, and unique project designs. These characteristics had a direct impact on integrating knowledge in the construction industry, specifically in construction projects undertaken through the TPS because the nature of this procurement system was based on the separation of design and construction phase (Chapter 2).

- **To investigate different approaches and techniques that are currently used in construction projects with respect to knowledge integration**

This objective was explored in the literature review. It was identified that KM approaches are classified into two categories; process and object approach. However, the researcher investigated the SECI model as another approach for KM (Chapter 2). In the construction industry, project knowledge is created through actions of individuals, construction organisations, project teams, and interaction of different types of knowledge (tacit and explicit) between the different phases of the project lifecycle. The SECI model was based on the theory of knowledge creation (Chapter 2). Within this in mind and also considering the KI as a sub-category of KM, the SECI model was adopted as the KI approach in this research.

According to the operational definition of KI which included three processes: capturing, sharing, and transferring knowledge, the researcher investigated the different techniques of each process. The literature review revealed that the identified techniques were in line with the adopted KI approach, SECI model. The identified techniques addressed the socialisation, externalisation and internalisation mode of interaction which enables knowledge to transform from tacit to tacit, tacit to explicit and explicit to tacit in order to facilitate the KI process (Chapter 2).

Furthermore, the identified techniques in the literature review were considered through the semi-structured interviews within the experts' opinion survey in order to find out which one was more used within the TPS (Chapter 4). These findings were further considered through the semi-structured interviews during the collecting of data through case studies (Chapter 5). The identified techniques from case studies were further analysed and compared with the findings in the literature review, which enabled the researcher to propose the appropriate techniques and technologies for

integrating knowledge within a construction project undertaken through the TPS (Chapter 6). The identified techniques and technologies for the KI were Lessons learned, Best practice, PPR, Regular meetings, CoPs, BIM technology and ICT. The BIM technology was suggested to be used as a knowledge repository to enhance the process of TKI.

- **To explore key challenges of knowledge integration process within construction project context, undertaken through the traditional procurement system**

Addressing this objective required to, initially, investigate the literature review on challenges of KM in construction. The literature review identified that KM challenges can be classified into two categories: identification of existing challenges in project environment that affects KM and identification of the means of implementing, exploiting, and sharing knowledge of individuals and the project. However, tacit dimension of the project knowledge was identified to be one of the four main challenges that confront KM in the construction industry. The literature review further explored the challenges of each sub-process of KI. Culture of organisation was identified as one of the main challenges in all of the sub-processes of KI (Chapter 2). These findings were further used during the experts' survey and case studies in order to find the challenges of KI within the TPS. Eleven factors were identified as challenges of KI in the TPS (Chapter 4, Section 4.4.3). An ISM approach was used to identify the relationships between these factors and it was identified that 'Culture of Organisation' and 'Lack of KM System (Policies and Strategies)' were the two main challenges that lead to the other nine challenges (Chapter 4). As discussed in Chapter 6, the findings from the case studies and experts' survey were merged and compared with the literature review. Ten factors were identified as challenges of KI among which, by implementing an ISM approach and MICMAC analysis, three of them were identified as the main challenges: 'Organisational Culture', 'Contractual Boundaries' and 'KM System (Policies and Strategies)' (Chapter 5). The remaining challenges are mainly affected by the main one which are located at the bottom of hierarchy. These challenges were

- Lack of Awareness of the Importance of TKI



- Lack of Trust
  - Lack of Incentives
  - Lack of Participation in KI
  - Lack of Time
  - Lack of Proper use of KI Techniques
  - Lack of Information, and KI
- **To critically analyse the success factors for tacit KI within construction project context, undertaken through the traditional procurement system**

The literature review identified the CSFs (Chapter 2) of TKI in terms of its sub-processes which are capturing, sharing and transferring. The main TKI CSFs that were highlighted in the analysis of the semi-structured interviews, in both the experts' survey and case studies, are classified according to the three main challenges (Chapter 6).

- Clear liability of project members for sharing knowledge at different phases of project
- Open Environment
- Adopting proper tools for TKI
- Improving awareness on the importance of TKI
- Building Trust
- Incentivise project members for participation in TKI
- Having clear definition of objectives
- Designing sub-contractors use software that can be synchronised
- Adopting two-stage process in the TPS

The results from the research suggested that having an 'Open Environment' (supporting culture) in terms of mutual trust, willingness to share knowledge, and enough time for TKI, along with 'clear liability of project members in sharing knowledge across project phases' were two CSFs that should be considered by project managers in order to tackle the main two challenges of TKI which were 'Culture of Organisation' and 'Contractual Boundaries'. These CSFs would enable the project manager to adopt an effective KM system for enhancing the TKI process in terms of using appropriate

tools and techniques to build trust, increase awareness of project members on the importance of TKI and encourage them to participate in TKI process, specifically in capturing and using lessons learned. Furthermore, using synchronised software by the designing sub-contractors at the designing phase will lead to the minimisation of designing issues and save time and cost. This could be enhanced by implementing BIM technology. The project manager also should improve the awareness of the client and consultants of the importance of TKI and the benefits for adopting two-stage tendering traditional procurement (Chapter 6).

- **To develop and validate a framework on how to integrate tacit knowledge within a construction project undertaken through the traditional procurement system**

As discussed in Chapter 6, the analysis of the findings led to the revision of the conceptual framework and development of the TKI framework, which includes three main sections: KI Factors (Challenges), KI Means, and TKI Process. The KI Factors (Challenges) presents three main challenges with related CSFs for tackling them. The 'KI Means' included techniques and technologies that can be used for enhancing the TKI Process. The TKI Process presented the process of capturing, sharing, and transferring knowledge within the traditional construction project. Further, the experts' questionnaire survey was conducted in order to validate the developed framework (Chapter 6). The findings from the experts' questionnaire survey led to developing a guideline for the TKI Process that helps the project manager at the design phase to better understand the TKI Process and improve TKI practices within the TPS.

Throughout this research, all the research objectives were satisfied and achieved. The literature review established that many research have been done on KM-related issues within construction industry, including knowledge accumulation, capturing, sharing, translating and so on, but less attention has been paid on the best ways of managing knowledge and its process within TPS. It is concluded that there were three main challenges that hinder TKI process within the TPS in terms of capturing and sharing knowledge within a project and transfer it to the next project. These challenges were 'Organisational Culture', 'Contractual Boundaries', and 'KM System (Policies and Strategies)'. Furthermore, BIM technology was suggested to be used as a knowledge repository to enhance the process of TKI. As the nature of TPS is based on the

separation of the design and construction team, and most of the design errors occur at the construction phase, it was suggested that the design team have the control of this repository which would enhance the TKI process in terms of transferring knowledge between projects. Findings revealed that adopting two-stage process in the TPS would led to more collaboration and sharing of knowledge with the designing team on best practises and lessons learned. This would improve the project performance and decrease the possibility of reinventing the wheel.

## **7.4 Research Contributions**

### **7.4.1 Contribution to Academia**

Extension studies have been conducted in the area KM. However, studies integrating tacit knowledge in terms of capturing, sharing, and transferring within a construction project undertaken through the TPS are rare. Hence, one of the main contribution of this study is to develop a framework that bridge s this gap. Secondly, it creates an awareness on the importance of TKI within construction project undertaken through TPS. Thirdly, this study extends previous research on TKI by looking at the way in which different challenges and means of capturing, sharing, and transferring knowledge as perceived to affect the process of KI within the traditional construction project. Fourthly, it extends the body of knowledge on CSFs of TKI within TPS.

### **7.4.2 Contribution to Practice**

This research offered a framework, with a guideline, on how to integrate tacit knowledge in terms of capturing, sharing, and transferring within the traditional-based construction project. Furthermore, construction practitioners would benefit from the output of this research which will

- improve the awareness and better understanding of the process of TKI in terms of; capturing, sharing and transferring in a construction project undertaken through the TPS
- extend the body of knowledge on the challenges of TKI, and their relationships, within the TPS
- highlights the CSFs that will assist practitioners to integrate TK within construction projects undertaken through the TPS

- provide a framework that covers the social dimension of knowledge in managing and integrating tacit knowledge in the construction industry

This research would enable stakeholders to be aware of the key challenges and techniques of capturing and sharing knowledge in same project and transferring it across projects within the TPS. It is expected that this framework and guidelines will help construction organisations to integrate tacit knowledge within the TPS and also to improve the awareness and understanding of individuals and organisations about KI and the use of BIM technology as a knowledge repository and its process. In turn, the practical application of this framework is expected to improve the efficiency of project delivery and the competitiveness of the organisation.

## **7.5 Research Limitations**

Although the research aim and objectives were achieved, there were some unavoidable limitations. The following limitations were encountered during this research.

1. The study is restricted to the UK construction sector; therefore, it cannot be generalised to other countries unless more research is conducted in other countries.
2. There are only limited sources of appropriate literature relevant to the research scope mainly in integrating tacit knowledge within the TPS. Therefore, the researcher investigated 'capturing, sharing and transferring knowledge' separately under the context of KM in the construction industry in order to integrate them. This research has made a positive contribution to the current literature context.
3. This framework is for TKI within a construction project undertaken through the TPS. However, it will need some customisation to be implemented in other types of construction procurement system.
4. For the experts' survey questionnaire, 180 experts were asked to participate in the validation process. However, the number of respondents was restricted to 16 and it was expected to receive more replies.

## **7.6 Recommendation for Practitioners**

The research recommendations on how organisations and project managers can benefit from implementing TKI within the construction projects undertaken through the TPS are presented below.

1. Investment in training and improving the awareness of project members about the importance of TKI.
2. KI is a team effort which requires a trust between all team members. There is the need for project teams to support and enhance good working relationships between all team members. This leads to improve perceptions of trustworthiness.
3. Building trust networks and effective motivation strategies (open environment) between project members in order to incentivise them to participate in the TKI process openly.
4. Project managers need to clarify the liability of members for sharing knowledge at different phases of project.
5. Project managers need to consider designing software that can be synchronised with the software that are used by other sub-contractors involved in project. This will lead to save time, minimisation of the designing issues and improve the project efficiency.
6. Investment in the BIM technology by the designing organisations, to aid KI process in terms of capturing and sharing knowledge within a project and transferring it to the next project.
7. Project managers need to promote the awareness of the client and consultants on the importance of TKI and the benefits for adopting two-stage tendering traditional procurement.

## **7.7 Directions for Future Research**

This research has developed a framework for a process to integrate tacit knowledge, in terms of capturing, sharing, and transferring within a construction project undertaken through TPS. However, there are several areas of future research that can be pursued by considering this research as a starting point. The recommendations for future research are:

1. Further research to investigate the challenges, CSFs, and means of KI within the same context in another country.
2. Investigate whether the findings of this research are supported by a wider survey sample and to explore the relative impact of CSFs on KI within the TPS.
3. In terms of the knowledge repository, further research can be done to explore the use of the BIM technology in action as a knowledge repository within the TPS.
4. A need exists to further investigate the applicability of this framework both in other procurement systems and other industries.
5. Investigate the knowledge capturing process in client briefing within construction projects undertaken through the TPS.

## **7.8 Summary**

This chapter summarised the conclusion and recommendations of the research findings. It highlighted the purpose of this research following its objectives. Further, the contribution of this research to knowledge in terms of both academics and practitioners were presented. Finally, the limitations that were encountered during conducting this research and recommendations for future investigations by researchers were presented.

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# Appendices

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# Appendix I – Research Ethical Approval

Academic Audit and Governance Committee

College of Science and Technology Research Ethics Panel  
(CST)

University of  
**Salford**  
MANCHESTER

To Mohammad TAKHTRAVANCHI (and Dr Chaminda Pathirage)

cc: Professor Hisham Elkadi, Head of School of SOBE

From Nathalie Audren Howarth, College Research Support Officer

University of  
**Salford**  
MANCHESTER

Date 5/01/2015

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**Subject:** Approval of your Project by CST

**Project Title:** Tacit Knowledge Integration within Construction Projects for Better Performance

**REP Reference:** CST 14/61

Following your responses to the Panel's queries, based on the information you provided, I can confirm that they have no objections on ethical grounds to your project.

If there are any changes to the project and/or its methodology, please inform the Panel as soon as possible.

Regards,



Nathalie Audren Howarth  
College Research Support Officer

## Appendix II – List of Publications

- Takhtravanchi, M. (2014), Understanding Knowledge Boundaries in the Construction Industry: A Critical Review, Unpublished poster presentation at: 50<sup>th</sup> Annual International Conference for the Associated Schools of Construction, March 26 – 28, 2014, Washington DC, United States.
- Takhtravanchi, M. and Pathirage, C.P. (2015), *The Importance of Tacit Knowledge Integration within Traditional Project Environment: A Critical Review*, 12<sup>th</sup> International Post-Graduate Research Conference 2015(IPGRC2015), Salford, UK.
- Takhtravanchi, M. and Pathirage, C.P. (2016), *Knowledge Management Challenges within Traditional Procurement System*, 18<sup>th</sup> International Conference on Software, Knowledge, Information Management and Applications, December 15-16 2016, Sydney, Australia.

## **Appendix III – Research Invitation Letter**

### **Introductory Email (Interview)**

To the kind attention of (----)

I am a PhD Student in the School of the Built Environment, at the University of Salford. My research aim is to develop a framework on how to integrate tacit knowledge, in terms of capturing, sharing and transferring, within a construction project context, in the UK. It is expected that this framework would help to improve the awareness and understanding of individuals and organisational level about knowledge integration and its impact on project performance. The research will focus on construction projects undertaken by traditional procurement system, compared to projects undertaken through other procurement system, as it shows many challenges in terms of cost and time performance. This research is supervised by Dr. Chaminda Pathirage and he can be contacted via [c.p.pathirage@salford.ac.uk](mailto:c.p.pathirage@salford.ac.uk). I am therefore sending you this email since I feel your contribution to the study would be of significant value, given your relevant involvement within the topic area.

The contribution would only involve a short interview discussion, which would be strictly anonymous, which will be arranged and held at the most suitable time and date for you.

Please let me know if this is of interest to you, in which case, I will send additional information on the participation, including a Participant Consent Form and Information Sheet, as well as a Draft Interview Guide.

Should you wish to formally accept the collaboration, what I will kindly ask you to do is to let me know by replying to this email. Then I will send you the consent form and participant information sheet. After this, an interview will be arranged at your convenience.

I look forward to hearing from you, and thank you for your consideration.

Kind Regards,

Mohammad Takhtravanchi

PhD Research student

School of the Built Environment | Maxwell Building | Salford | M5 4WT

# Appendix IV – Research Participation Information Sheet

## Participant Information Sheet

### **Title of the Research Study:**

Tacit Knowledge Integration within Traditional Construction Project

### **Additional Information:**

PhD research at the University of Salford

### **By:**

Mohammad Takhtravanchi

### **Supervisor:**

Dr. Chaminda Pathirage

### **Invitation Paragraph:**

You are being invited to take part in a research study as part of a doctoral research project. The present information sheet is for you to have additional information on the project and is aimed to help you decide whether or not you would like to take part in the research. There would be no payment for your participation in this research.

### **Aim of the study:**

The aim of this research is to develop a framework on how to integrate tacit knowledge, in terms of capturing, sharing and transferring, within a construction project context in the UK

### **Why have I been chosen?**

Given your academic/professional background in construction, I strongly believe you would be able to provide fundamental value to the present research. This would form the first phase of the study and would be followed by the main study, which will address knowledge integration strategies, thus involving further relevant persons in the chosen projects. Please note that, should you decide not to participate, you do not have to necessarily reply to this request.

### **Should I decide to take part, what happens next?**

If you decide to take part, I will explain in more detail, what the research is about by providing you with a draft interview guide, and I will also be available to answer any questions you might have. After this, we can arrange a meeting at a suitable time and location, which will be both safe and confidential.

### **What am I supposed to do if I become involved in the project?**

Your involvement in the study would be to take part in an interview where your role in the field and concerning perspectives on the subject will be discussed. The interview will take approximately 1 hour and I will audio-record it with your permission. If you are happy to

participate in this research, you will be required to read this information sheet, sign the consent form and return it to me.

**Will my taking part in this study be kept confidential?**

All information provided by you will be kept confidentially and locked out securely (in password protected computers and locked drawer) and your responses made anonymous. No personal information of participants will be used other than codes and numbers as required to guarantee safety and untraceable track to participants. Interview data would be anonymously transcribed and also saved in a password protected computer which would only be accessed by the researcher alone. The collected data will be part of the researcher thesis and publications, and also will be available for the supervisory team and names will be kept anonymous. All collected data would be securely stored for up to 6 years in accordance with University of Salford's data retention requirements and thereafter be destroyed months after final submission of thesis, and certificate awarded by the University of Salford.

**What if I don't/won't to continue with the interview?**

You are entitled to withdraw the interview anytime during or after the interview without giving any reason. If you decided to do so all the information (both written and recorded) will be destroyed immediately and no information will be taken in any research and publication.

**What are the potential benefits of participating?**

You have been chosen because of your relevant role in the field; hence the information you provide would be able to contribute to the future development of the knowledge integration and reuse framework.

**What will happen to the results of the research study?**

The results of the study will be used in my PhD thesis and will be presented at seminars, conferences and academic journals. Anonymity and confidentiality will be maintained even when the findings are shared with other researchers and practitioners in the field.

I hope you will decide to contribute to the project; however, in all cases, I thank you in advance for your time and consideration.

Kind Regards,

Mohammad Takhravanchi

[m.takhravanchi@edu.salford.ac.uk](mailto:m.takhravanchi@edu.salford.ac.uk)

PhD Research student

School of the Built Environment | Maxwell Building | Salford | M5 4WT



# Appendix V – Research Participation Consent Form

## Participant Consent Form

### Title of the Research Study:

Tacit Knowledge Integration within Traditional Construction Projects

### Additional Information:

PhD research at the University of Salford

### By:

---

### Supervisor:

---

Please tick the appropriate boxes

Y N

### 1 - Taking Part

I have read and understood the Project Information Sheet.

I agree to take part in the project. Taking part in the project will include being interviewed and audio-recorded.

I understand that I take part as a volunteer: hence, I can withdraw from the study at any time and I do not have to give any reasons for why I no longer want to be involved.

### 2 - Use of data in the project

I understand that my personal details will not be revealed to people outside the project, and my name kept anonymous.

I understand that my words may be quoted in publications, reports, web pages, and other research outputs.

\_\_\_\_\_  
Name of participant [printed] Signature \_\_\_\_\_ Date \_\_\_\_\_

\_Mohammad Takhtravanchi\_  
Researcher [printed] Signature \_\_\_\_\_ Date \_\_\_\_\_

[m.takhtravanchi@edu.salford.ac.uk](mailto:m.takhtravanchi@edu.salford.ac.uk)

PhD Research student

School of the Built Environment | Maxwell Building | Salford | M5 4WT

# Appendix VI – Semi-Structured Interview Questions – Experts’ Survey

## Interview Questions

### Title of the Research Study:

Tacit Knowledge Integration within Traditional Construction Projects

### Additional Information:

- The aim of this research is to develop a framework on how to integrate tacit knowledge, in terms of capturing, sharing and transferring, within a construction project context, undertaken by traditional procurement system, in the UK
- PhD research at the University of Salford

### By:

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### Supervisor:

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### Aim

- To investigate different approaches and techniques that are currently used in construction projects with respect to knowledge integration
- To explore key challenges and barriers of knowledge integration within construction project environment, undertaken through traditional procurement route
- Do you think managing knowledge is important within construction projects?
  - Knowledge means the kind of good practices, lesson learned, the way of doing things
- Do you think the tacit knowledge is important within construction project environment?
  - To what extent do you think it is important?
  - Do you think it is important as explicit knowledge, which is a documented knowledge? / Do you think the knowledge recites within workers, industry, construction projects is much more important into that kind of aspect?
- Do you think it is important for us to integrate that tacit knowledge within construction projects, especially within traditional projects, because in traditional projects people are different, organisations are different and separated?

- I myself define knowledge integration as: capturing & sharing knowledge within a project and transfer it into another project
- Why do you think managing knowledge (tacit) is important in traditional project environment comparing to other types of procurement?
- Why do you think it needs more attention in terms of managing and integrating tacit knowledge within the traditional project environment?
- Do you think the extent of managing this tacit knowledge is more crucial within the design phase or within the construction phase?
  - Why do you think like that, is it because the design phase or construction phase is where a lot of problem/mistakes happen or because in the design phase there is a little of professional involved?
- Within the industry, how do they manage knowledge?
  - Do you think there are best way of capturing knowledge than sharing knowledge?
  - Do you think there are best techniques to use for capturing knowledge than sharing knowledge?
- Do you think there are barriers and challenges in terms of knowledge integration in traditional project and what are those in your views?
  - The literature has come across organisational culture as the main challenge/barrier, do you think it is a kind of barrier, because when it comes to, especially, traditional project environment, there are so many different organisations/ companies, so many people coming and joining the projects, so do you think it is a barrier?
- Do you think there are better ways/techniques of capturing knowledge rather than sharing and transferring?
- What are the barriers within traditional project environment regarding to knowledge integration?

# Appendix VII – Semi-Structured Interview Questions – Case Studies

## Interview Questions

On commencing the interview:

- Explain the purpose of the interview
- Express the importance of their views and experience
- Give an assurance of confidentiality
- Ask the interviewee's permission to record the interview if appropriate
- Explain about the Tacit knowledge and Tacit knowledge integration

### General Questions

- Would you please briefly explain about this project and your contribution?
- To what extent human knowledge and its integration contribute in improving the performance of project?

### Knowledge Capturing

1. Why do you think it is important to store or record your experience and project knowledge?  
(Awareness)
2. Does your department encourage you to capture your experience and project's knowledge?  
How? (Motivation/ Awareness)
3. Does your department inform you about the benefits of recording human knowledge?  
(Motivation/ Awareness/ Culture)
4. Is there any system, routine or guidelines for capturing your experiences and project knowledge in your department? Please explain briefly (Technique)
5. How is knowledge stored and recorded within your department? (Culture/ Technique)
6. What are the biggest challenges from your perspective in capturing project knowledge in design phase?
7. Where do you face problems in capturing knowledge in your department/ during design phase? (Challenges)
8. In your opinion, what are the critical success factors for capturing experiences effectively in your department? How do you think the knowledge capturing could be improved in design phase?

### Knowledge Sharing

1. Does your department encourage knowledge sharing and its benefits? How? (Motivation)
2. Does your department have any knowledge sharing systems, routines or guidelines? (how is it shared within your department?) Please explain briefly (Techniques)

3. Do you expect anything in return when sharing knowledge? (Motivation/Incentive)
4. In your experience, does the knowledge sharing differ from person to person in your department? Which one is easier to share, with someone speaking the same language or different language than your mother tongue? (Culture: Communication)
5. Do you feel threatened by sharing knowledge/ Do you fear to share your knowledge? (Trust)
6. What are the biggest challenges from your perspective in sharing knowledge in your department and with construction department?
7. Where do you face problems in sharing knowledge in your department/ during design phase? (Challenges)
8. In your opinion, what are the critical success factors for sharing experiences effectively in your department?

### **Knowledge Transfer**

1. In your opinion, how do you think experience and knowledge of previous projects could be useful and improve the project's performance? (Awareness)
2. Does your department encourage you to use experience of previous projects in order to solve problems that occur in current project? (Motivation, Culture)
3. How often do you use knowledge and experiences of previous projects? (Culture, Awareness)
4. In your department, is there any routine or guidelines to use previous project's knowledge?  
Please describe
5. In your department, how do you get access to the previous projects' knowledge? (Culture, Technique)
6. What are the biggest challenges from your perspective in sharing knowledge in your department and with construction department?
7. Where do you face problems in using experiences and knowledge of previous projects during design phase? (Challenges)
8. How do you think knowledge should be transferred from one project to another?
9. In your opinion, what are the critical success factors for transferring or using previous projects' knowledge and experiences effectively in your department?

### **Sum up**

- To conclude, do you think your department is successful in capturing, sharing and transferring knowledge and experience?

## Appendix VIII – Questionnaire Survey

### Introductory Email (Questionnaire)

To the kind attention of ( )

My name is Mohammad a PhD (research) student at the School of Built Environment, University of Salford, Greater Manchester.

As part of my PhD thesis, I am in the process of collecting data to validate my framework on 'Tacit Knowledge Integration within Traditional Construction Project'. I am therefore sending you this email since I feel your contribution to the study would be of significant value, given your relevant involvement within the topic area. The contribution would only involve filling a questionnaire, which would be strictly anonymous. This survey will only take about 8-10mins of your time and will help me complete my research. I have obtained ethical approval from my University which allows me to proceed with data collection accordingly. Find included the survey link;

<https://www.surveymonkey.co.uk/r/XZKLYWD>

Please find included my supervisor's details if in doubt of the authenticity of this email.

**Name: Dr Chaminda Pathirage**

**School: School of the built environment, University of Salford, Greater Manchester.**

**Email: c.p.pathirage@salford.ac.uk**

If you like to discuss further on the prospect of this research, please find included my details below.

Kind regards,

Mohammad Takhtravanchi

PhD Research student

School of the Built Environment | Maxwell Building | Salford | M5 4WT

## Questionnaire – Framework Validation

This questionnaire is designed to elicit responses on issues to the knowledge integration within traditional construction project. It is mainly an instrument for gathering data for PhD research on ‘Tacit knowledge integration within construction projects for better performance’ through the School of Built Environment, University of Salford. Please kindly tick the most appropriate answer in the boxes provided based on your perception and experiences of knowledge integration within construction projects in relation to the questions asked. Under the guidance and accreditation of the university, the researcher has obtained ethical approval by the university to carry out the necessary data collection for this research. Every data collected will be treated with ultimate confidentiality and anonymity. Please be aware that you are allowed to withdraw from this study at any time without any prior notice or reason for why you no longer wish to be involved. Please "click next" if you are happy to proceed with this survey.

Section 1: General Information				
<b>What is your job title?</b>	Project manager			
	Site manager			
	MEP Designer			
	Architect			
	Other(Please specify)			
<b>Work Experience</b>				
	<5 years	5-10 years	10-20 years	>20 years
<b>How many years have you worked in construction industry?</b>				
<b>How many years have you worked in designing company?</b>				
<b>How many years have you worked in construction company?</b>				

### Section 2 - Tacit Knowledge Integration Process

Tacit knowledge (human knowledge) is defined as know-how embedded within individuals, in other words, it is the experience that individuals gained during project life cycle. Tacit Knowledge Integration (TKI) in construction projects undertaken through traditional procurement route consists of three phases; capturing and sharing knowledge at different phases of project, and transferring the captured knowledge to the next project. Based on the findings from literature review and qualitative data analysis below framework is designed. The TKI process is affected by both knowledge integration challenges and means.

At initial stage (Project Inception) of TKI process, the knowledge/ project manager should identify whether the project is new or it is similar to previous designed projects by their company. The next stage is establishing a strategy and objectives for TKI. It is significantly influenced by knowledge integration challenges which are organisational culture, contractual boundaries and knowledge management system of organisation.

If the project is new then knowledge capturing strategy and objectives should be established in order to capture tacit knowledge at design phase of project. For doing this, appropriate techniques and technologies must be implemented. Before adding to knowledge repository, the captured knowledge is subject to review and value-adding processes of filtering and refining by subject expert, such as cleansing, labelling, indexing, sorting, standardising and recategorising. In order to share the captured knowledge within design phase or between design and construction phase, appropriate techniques and technologies should be implemented. This requires establishing a strategy and objectives for sharing knowledge and updating the knowledge repository, because once the captured knowledge is shared, new knowledge could be created which requires to be captured again, and filtered by subject expert before storing in knowledge repository. If the project is similar to previous designed projects then knowledge transfer strategy should be established to retrieve the captured knowledge from knowledge repository by applying appropriate techniques and technologies.

If this proposed TKI framework be applied to traditional construction project, it can reduce the possibility of occurring similar designing problems and improve the project performance.

#### Section 4: Tacit Knowledge Integration Process

Based on your experience please give your views about application of this framework.

<b>Please give your comments on the applicability of TKI process stage of framework?</b>	
<b>Which stage or point in this framework you disagree?</b>	
<b>On which stage or point you would like to have further clarification?</b>	
<b>In your opinion what stage of this framework can be applied in other industry/s?</b>	
<b>In your opinion does each section require any modification?</b>	



