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Evaluation of Tacit Knowledge Elicitation in Construction Consultant Firms

Master's Thesis in Design and Construction Project Management

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ABSTRACT

Construction consultants as knowledge based organizations (KBOs) have been moving towards considering their intangible assets known as knowledge. The economy and competition has led these companies towards thinking about ways to retain knowledge in their organizations, which is available in the form of tacit or explicit. Tacit knowledge identified as experts' valuable knowledge can be elicited and stored as explicit forms of knowledge. This process known as knowledge elicitation (KE) is the most difficult part of knowledge management (KM) within the organizations since the nature of tacit knowledge is personal, unarticulated and hard to be communicated. Construction consultants suffer from more difficulties since they deliver complex problem-solving services performed with non-standardized processes due to high level of creativity.

The purpose of this study is to compare the common techniques used for eliciting experts' tacit knowledge among construction consultant firms. Furthermore, this research intends to find the existing pitfalls and recommend possible solutions to improve KE processes in construction consultant firms. An evaluation framework was also chosen to guide the path of the investigations. Two similar construction consultants in terms of work context, size and number of employees were chosen for investigations on how these organizations utilize KE techniques to capture experts' tacit knowledge. In order to have a better understanding of the environment, semi-structured interviews were conducted with both senior managers and experts in the companies. The results showed that chosen construction consultants mainly use task analysis, interviews and group decision making as their main methods from gaining knowledge from their experts. However, they had no plans to store elicited knowledge in the form of written documents. Evaluation of KE strategies implemented in both case organizations showed that they could facilitate their KE process by applying a formal procedure for KE, having a role as a knowledge engineer in companies as responsible for KE, using incentives to motivate the experts, improving their IT infrastructure for live capturing of knowledge, providing a strategy for balancing time, cost, effort and knowledge yield.

Key words: knowledge elicitation, knowledge management, tacit knowledge, explicit knowledge, construction consultants

Contents

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1 Introduction

Construction is known as a major industry in the world due to its sizable proportion in most countries' gross domestic product (GDP). Construction industry plays an important role in economic development. The importance of this industry is because of its fundamental role in creating facilities for all other industries. This industry comprises various sectors with different roles from designing projects to delivering to end users. Consultants, contractors, suppliers, real estate agencies all and all are classified under the title of construction sector (Carrillo et al., 2004, Crosthwaite, 2000).

Amongst all firms involved in this sector, consultant firms are named as service-oriented knowledge-intensive organizations where the final products are intangible. This kind of organization consists of complex problem- solving services performed with non-standardized processes due to a high level of creativity needed to solve the problems in this business. Projects designed in construction consultant organizations could be residential building, educational centres, hospitals, roads, tunnels, railways, airports, power plants, etc. Designing such projects from architectural and structural point of view is highly dependent on team work and knowledge sharing between experts involved in the projects (Apostolou and Mentzas, 1999)

Since performing projects in construction consultant firms is highly dependent on experts who work as a team, the expertise of the consultant employees must be taken into account. In other words, the nature of construction consultant firms is team-based and project-focused. In accordance with the nature of engineering design, creative and innovative employees shape the majority of experts working in construction consultant firms. Therefore, a huge amount of knowledge, as an intangible asset, flows in these organizations that need to be managed in a proper way (Apostolou and Mentzas, 1999).

Hence, considering the importance of knowledge in construction consultant firms as knowledge based organizations (KBOs), the necessity of shifting from concentration on tangible assets (e.g. financial oriented issues) to intangible assets (e.g. organizational knowledge) is significantly perceived (Kululanga and McCaffer, 2001). By focusing on organizational knowledge, which is the basis of a concept called knowledge management (KM), a strong methodology was provided in order to strengthen the construction consultant firms to survive in a dynamic and competitive economical market. The process of KM is described in the following section (Section 1.1) in accordance with the importance of skilled employees' knowledge in construction consultant firms and the necessity of capturing and retaining it as an organizational asset.

1.1 Background

Construction organizations could acquire knowledge from different sources both internally and externally. The internal source of knowledge in this industry refers to experts working in the organization while the external source is related to acquiring knowledge from other involved sectors such as contractors, suppliers, etc. In both

cases, there should be a robust KM strategy to manage the flow of knowledge (Kululanga and McCaffer, 2001). The following definition of KM could encompass involved issues in the process of managing knowledge.

> *"Knowledge management is a discipline that seeks to improve the performance of individuals and organizations by maintaining and leveraging the present and future value of knowledge assets. Knowledge management systems encompass both human and automated activities and their associated artefacts"* (Newman and Conrad, 1999)

The process of KM contains four main steps: knowledge acquisition, sharing, reusing and maintenance. The first step (knowledge acquisition) includes capturing, representing, storing and validating knowledge. Capturing (eliciting) knowledge is considered as the most difficult part of KM (Tan et al., 2007). Knowledge is basically divided into two main categories: tacit and explicit knowledge. Tacit knowledge is individually developed from experience and it is hard to convert into explicit. However, explicit knowledge refers to written documents of the organization, which is publically available to all employees. Although knowledge splits into tacit and explicit, they are compared with an iceberg. The visible part represents explicit knowledge while the larger and invisible part shows tacit knowledge (Pathirage et al., 2007).

Continuously interchanging tacit and explicit knowledge could lead to creating knowledge within the organization, which is counted as a vital factor for aiding the organization to overcome its competitors (Nonaka et al., 1994). In other words, tacit knowledge is known as a crucial factor that can raise organizational performance and ability to remain competitive in an economically dynamic market if it is elicited from individuals and exposed to all employees. The purpose is not only eliciting experts' tacit knowledge, but storing the elicited knowledge within the organization for reusing in the future. Furthermore, eliciting experts' tacit knowledge leads to reduction of rework resulting from decreased errors and quick response to clients (Kivrak et al., 2008, Pathirage et al., 2007).

Additionally, the importance of organizational knowledge is also considerable from an economic point of view. When new employees are recruited, much of the skills and knowledge that they need for performing their duties can be picked up during the job. This would be one of the problems that organizations face since it simultaneously reduces the efficiency and increases the cost. The useful solution to overcome or at least reduce this problem is to exploit the organizational knowledge captured from skilled employees to train newcomers. In this case, employees could learn before doing rather than learning by doing (Wong and Radcliffe, 2000).

Lack of appropriate KM strategy for transforming experts' tacit knowledge into an organizational asset could also hamper the performance of the organization when skilled employees are retired. It is because the valuable knowledge gained from several years of experience would simply leave the organization. This challenge could be very risky when the employee has a key role in the organization (Hoffman et al., 1995).

Construction consultant firms with several unique characteristics are concerned about all mentioned barriers related to KM and especially knowledge elicitation (KE) as the most difficult step. The nature of complex and unique tasks with high level of creativity that should be performed in these organizations leads construction consultant firms to a field known as professional organizations. Therefore, capturing and retaining experts' tacit knowledge in construction consultant firms should be a vital approach for these organizations if they want to survive in the competitive market (Pathirage et al., 2007).

Considering the global expansion of many organizations such as construction consultants, geographically dispersion of skilled employees could make the process of KE more difficult. To overcome this problem, larger construction consultant firms with great number of employees need a more specific and formalized strategy for knowledge management especially KE (Carrillo et al., 2004). The major challenges to implement KE strategies existing in many organizations are counted as lack of standard processes, insufficient time, continuous change in the nature of information, lack of methods on eliciting useful knowledge, organizational culture, insufficient funding, employee resistance, and poor information technology infrastructure. (Kivrak et al., 2008, Tang et al., 2007).

The main reason for unsuccessful knowledge elicitation in the construction sector including consultants is due to lack of formal strategy in KM. Although the general concept of KM is not new, the implementation of knowledge management in construction consultant firms is still vague since there is no formal methodology for implanting KM in this industry (Kululanga and McCaffer, 2001). The importance of KE in construction consultant firms and its unsuccessful implementation due to lack of formal methodology motivated the authors of this study to investigate this subject. The purpose of this study is formulated in Section 1.2.

1.2 Purpose of the study

The purpose of this research is to compare commonly used techniques for KE from skilled experts within the construction consultant firms. This research intends to find how to convert experts' tacit knowledge into explicit knowledge in order to store it as an organizational asset.

Furthermore, this study attempts to find the existing pitfalls and recommend possible solutions to improve the process of knowledge elicitation from internal sources (experts) in construction consultant firms. In order to get accurate outcomes, the viewpoints of both senior managers as decision makers in KE strategy and experts whose knowledge should be elicited were considered in this study. The following are four research questions of this study.

- What are different techniques for elicitation of experts' tacit knowledge?
- What are strengths and weaknesses of those elicitation techniques?
- How is the KE process carried out in construction consultant firms?
- What are the probable reasons of unsuccessful implementation of knowledge elicitation in construction consultant firms?

1.3 Limitations of the study

The present study has some limitations that should be taken into account when considering its outcomes. One major limitation of this study was to find the interested construction consultants for the empirical study due to time limitation of senior managers. Since the purpose of study was to evaluate the process of KE in construction consultant, senior managers as decision makers on KE strategies should be interviewed while most of them did not have enough time. This circumstance not only reduced the number of senior managers, but also reduced the number of consultants as the case organizations.

The third constraint of this study was to investigate only the Swedish construction consultants due to time limitation of performing the study. Therefore, the outcomes of this research might be valid only in Sweden because of different organizational cultures between countries. The language barriers could be named as another limitation. Since all interviews were conducted in English (due to lack of Swedish knowledge of the authors), it could affect the quality of interview findings due to misunderstandings. However, all interviews were recorded and fully transcribed to avoid missing any important point. In order to reduce the risk of misunderstanding and overcome the language barriers, a terminology list attached with interview questions were also sent to all interviewees in advance.

1.4 Overview

The present thesis report is divided into six chapters. Every chapter has a short overview at the beginning to show what is discussed in it. Chapter 1 provides a general introduction to the research. This chapter has a view on the importance of KM in the construction industry especially consultant firms. The background is followed by the aim of the study including the research questions. In addition, the limitations of the study are described in order to inform the reader of study about validity domain of the present research.

In the second chapter, the literature review on the study topic is presented. This chapter comprises the definition of tacit and explicit knowledge and tries to clarify their characteristics. The importance of tacit knowledge in construction consultant firms and the source of knowledge in these firms are also described in this chapter. Afterward, Nonaka's theory of knowledge creation followed by the characteristics of different actors in the process of KE is introduced. Considering the first and second research questions of this study, ten most common elicitation techniques and their weaknesses and strengths are explained. Finally, the chapter ends with the barriers of KE and comes up with possible solutions to overcome them.

The applied framework for evaluating KE process in chosen construction consultant firms is expounded in Chapter 3. Additionally, the process of designing questions and conducting interviews in two selected case organizations is thoroughly explained. This part comprises how the interview questions were brought up and categorized, how many employees were interviewed and how the interviews were conducted in order to acquire required information. The interview questions and terminology list given to all interviewees are also available in the Appendix of this report.

Chapter 4 comprises the findings gained from interviews with senior managers and experts in case organizations. This chapter attempts to cover the third and forth research questions of this study. This chapter starts with general backgrounds of construction consultants chosen for evaluating their KE strategies. The empirical data acquired from the interviews presented in this chapter are divided into two main categories: the senior mangers' perspective and experts' perspective. Senior managers' perspective begins with the senior managers' background. The information acquired from interviews with senior managers is divided into four sections; companies' strategies for KE, different tools for KE, performance measurement and KM awareness/commitment.

The findings from interviewed experts begin with describing experts' backgrounds. This section is followed by experts' perspective on KE strategies and implementation of applied strategies in their organizations. The findings from companies are compared in each section of chapter 4 in order to aid the reader for better understanding of efforts currently applied in construction consultant firms for KE.

In Chapter 5 (Discussion), the interview findings are compared with the theoretical contexts described in the second chapter. The aim of this part is to compare the industrial context of KE with its academic concepts in order to find existing challenges and recommend the possible improvements. This goal is followed by evaluating the process of KE in accordance with the research framework described in Chapter 3. The last chapter of this study (Chapter 6) attempts to conclude the mentioned concepts in the discussion part and comes up with several hints as recommendations.

2 Theoretical framework

This chapter includes the review of literatures relevant to the concept of eliciting tacit knowledge. First, the history of tacit knowledge theory followed by different characteristics of tacit and explicit knowledge is described. Afterwards, tacit knowledge in construction consultant firms and the source of knowledge domains in these firms are deeply explained. The process of KE supported by Nonaka's theory and different actors involved in this process are two important concepts separately explained in this chapter. Thereafter, the ten most common elicitation techniques and their weaknesses and strengths are explained. According to some limitations of KE in construction consultant firms, some improvements are brought up in order to overcome these constraints.

2.1 Tacit and explicit knowledge

Michael Polanyi (1891-1976) was the pioneer of tacit knowledge theory which he proposed in 1966. His basic fact for propounding this theory was related to "*we can know more that we can tell*". Tacit knowledge is frequently called *knowledge of experience* since it is closely related to individuals' skills. Polanyi believed that tacit and explicit knowledge are mutually constituted, so they cannot be considered as two separate kinds of knowledge. Afterwards, this principle was applied as the basis of the theory of knowledge creation within the organization through frequent transformation of tacit and explicit knowledge to each other (Polanyi, 1966, Stenmark, 2000).

Tacit knowledge has two main properties called proximal and distal terms. Polanyi explained that proximal part is closer to us while the distal part is far away. As an example of proximal and distal parts of tacit knowledge, he pointed out the simulation of photo-fit picture by a witness in order to identify a suspect. The first image of features (e.g. nose, eyes, etc) that witness could remember refers to proximal tacit knowledge. The next images he/she could recall are respectively more distal. Polanyi also believed that language is not a sufficient tool to share tacit knowledge, no matter it is proximal or distal. Therefore, in accordance with the face description example, he believed that tacit knowledge could be easily communicated through documents (Polanyi, 1966).

After proposing tacit knowledge theory by Polanyi in 1966, different researches came up with various characteristics for tacit and explicit knowledge. According to Nonaka et al. (1994), tacit knowledge is highly *personal* and *hard to formalize and communicate*. Tacit knowledge is also *practical* and it is acquired on the *job or in the situation that is acquired*. Furthermore, tacit knowledge is known as *implicit*, *unarticulated* or *procedural* knowledge (Ambrosini and Bowman, 2001). Considering all mentioned characteristics of tacit knowledge, the hypotheses behind such conclusion are described as follows.

In accordance to the personal nature of tacit knowledge, it should be mentioned that tacit knowledge is classified into technical and cognitive dimensions. The technical dimension refers to information and expertise in relation to "know-how" while the cognitive dimension encompasses mental models, beliefs and values. Since the tacit

knowledge has a cognitive dimension, everybody follows a certain mental model in certain situations in order to make decision on a specific task. This hypothesis is the basis of knowing tacit knowledge as *personal* (Ambrosini and Bowman, 2001, Pathirage et al., 2007).

In order to clarify *practical* characteristics of tacit knowledge, two concepts must be distinguished; resources and capabilities. Resources imply inputs into the production process while capabilities are processes by which resources are used. Ambrosini and Bowman (2001) mentioned that capabilities which could be named as "know-how" refer to tacit knowledge. However, tacitness is not only associated with "know-how" but also with "what", "where", "when", "who" and "which". Consequently, as tacit knowledge is about "action and doing" rather than "knowing about", it is considered as practical. In addition, inability to writing down, formalizing and articulation of tacit knowledge make it *hard to be communicated* (Carrillo et al., 2004, Wong and Radcliffe, 2000).

So far the characteristics of tacit knowledge have been discussed. Although knowledge is divided into tacit and explicit, it is rarely completely tacit or explicit. In fact, the organizational knowledge is a combination of both tacit and explicit knowledge that could be placed in a spectrum. As shown in Figure 1, the knowledge could be only tacit or explicit at the both extremes, which is infrequently found in organizations (Wong and Radcliffe, 2000).

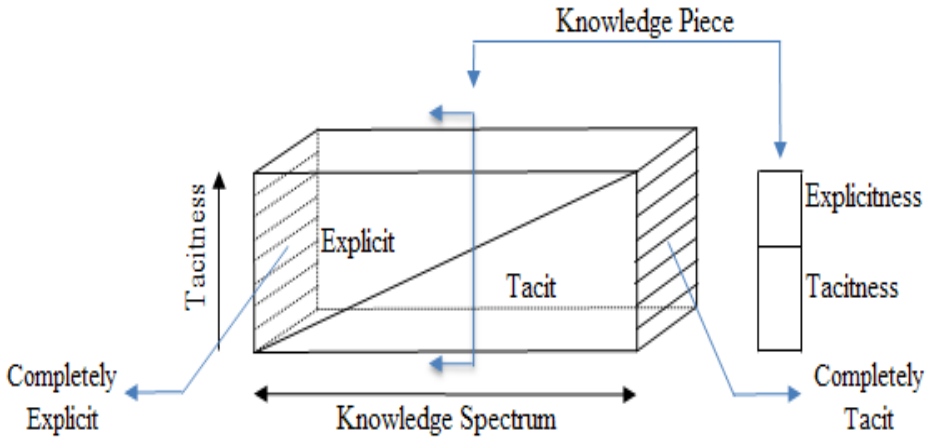

Figure 1 Spectrum of tacitness/explicitness of knowledge (Wong and Radcliffe, 2000)

Since the organizational knowledge exists as a combination of tacit and explicit, attempts should be made to transform tacit knowledge into explicit. It is discussed that, the difficulty of tacit knowledge to be communicated depends on *the degree of tacitness*. The degree of tacitness classifies into four levels respectively from high tacitness to low tacitness; 1) deeply integrated tacit skills, 2) tacit skills that can be imperfectly articulated, 3) tacit skills that could be articulated, 4) explicit skills (Ambrosini and Bowman, 2001).

The degree of tacitness should be taken into account when eliciting experts' tacit knowledge, since most of the human expertise embedded in the experience has the characteristics of tacit knowledge. This kind of expertise gathered during years of working in the specific domain of knowledge is called *heuristic* knowledge. When experts become less and less aware of the act that they are performing to solve the specific problem during passing years, it would make the process of elicitation more difficult. In fact, the repetition and routine processes that have shaped their expertise leads to raising their level of tacitness (Schreiber, 2000).

Conversely, explicit knowledge is systematic and formal, so it can be easily communicated and shared in the form of for example words and numbers. This kind of knowledge has the potentiality of being shared in various ways such as manuals, product specification, etc. Additionally, explicit knowledge can be easily transmitted between individuals systematically and formally by IT tools such as email. This kind of knowledge can be also stored in databases since it can be transmitted electronically (Carrillo et al., 2004, Desouza, 2003).

Consequently, the organizational knowledge is in the form of a combination of tacit and explicit knowledge. In accordance with the importance of tacit knowledge in all organizations, it should be attempted to transform the tacit knowledge into explicit knowledge to be publically available. Although the process of KE is hard to implement because of the nature of tacit knowledge, the organization needs to make proper strategies in order to overcome the challenges.

2.2 Knowledge in construction consultant firms

Construction consultants are known as knowledge-intensive project-focused organizations and they are highly dependent on the team working and the expertise of skilled employees. Construction projects as assignments in consulting firms are unique, complex and custom-built based on clients' interests. In accordance with these characteristics of a construction projects, the high level of creativity must be considered when designing construction projects from a structural and architectural point of view (Apostolou and Mentzas, 1999).

Considering the tasks that should be performed in construction consultant firms, these firms are divided into architectural and engineering firms. Architectural firms are considered as service based, professional and creative organizations. They are service organizations since they offer services to the clients in the form of knowledge. The delivered services in construction consultant firms are intangible since they are in the form of the valuable knowledge of skilled employees (Winch and Schneider, 1993).

Furthermore, professional characteristics of architectural consultants are because of their skilled employees working in these organizations. The term *architect* refers to a skilled and experienced person who is responsible for supervision of architectural design. Furthermore, the creative nature of architectural consultants refers to the purpose of clients to hire them. In fact, they are hired by clients to provide a novel solution to a complex problem. Therefore, they need to be creative and innovative to be able to solve perfectly the problems that they are confronted with (Winch and Schneider, 1993).

In order to understand how the knowledge is shared and transformed in construction consultant firms, the investigation of performing assignments in these firms would be useful. In general, construction projects are divided into several stages shown in the form of a project life cycle. These phases could be named as conceptual and planning, design and engineering, bidding, construction, commissioning and closeout. Construction consultant firms basically focus on the two first phases of project life cycle (conceptual/planning and design/engineering). The feasibility of a project is analyzed in the conceptual and planning step. This analysis is performed on the basis of economic conditions, risk assessment, timeframe and client's budget. In this case, considering the complexity and uniqueness of construction projects, the highly skilled experts should perform the assignments as a team. Knowledge is the valuable issue continuously shared and transformed in this kind of team working to perform the assignments (Rasli, 2006).

The second phase that construction consultant firms are responsible for is design and engineering. This stage comprises two main phases: designing the task from an architectural point of view and detail engineering to designing the elements from a structural point of view based on regulations and standards. In the conceptual and planning phase, the cost and time of project are roughly estimated while they could be accurately estimated in design and engineering stage after clarifying project details. In this phase, drawings and specifications of projects are prepared by skilled engineers and architects for bidding and construction phases. It is important to mention that all tasks involved in two first phases of project life cycle are performed by team work. Therefore, the knowledge flow must be properly managed in construction consultant firms since it affects the quality of projects delivered to the clients (Rasli, 2006).

Since delivering knowledge to clients in construction consultant firms such as architectural firms is considered as an intangible service, it is important to distinguish the tacit knowledge from explicit knowledge in the delivered knowledge. It could help construction consultant firms to properly elicit their employees' tacit knowledge in order to make it as an organizational asset. It is also important to know what the sources of knowledge are in construction consultant firms to be able to make proper strategies for capturing knowledge from them. These two important issues are described in the following section.

2.2.1 Tacit knowledge in construction consultant firms

According to the knowledge spectrum shown in Figure 1, the knowledge in most cases is a combination of both tacit and explicit. Therefore, the knowledge required for performing engineering design in the construction consultant firms should be distinguished in terms of tacit and explicit. This kind of distinction could help the construction organizations to understand what part of their knowledge is tacit. In this case, they could make the appropriate strategy to transform tacit knowledge into explicit. Knowledge schema in engineering design shown in Table 1 would be an appropriate model that indicates different categories involved in the design process (Wong and Radcliffe, 2000).

Table 1 Knowledge schema in engineering design (Wong and Radcliffe, 2000)

	Knowledge types	Description
Explicit	Linguistic	The knowledge of a language. Non-verbal body language could be also named as a channel for communication
	Formal	The knowledge acquired from all formal education steps
	Professional	The knowledge acquired through doing the tasks in the organization
	Societal	The knowledge of some factors such as safety requirement that must be met in order to accept an engineering design by the market
Tacit	Know-x	The knowledge that an engineer needs to know what to do, when to do and how to do

The first four categories represent explicit domain of full knowledge spectrum shown in Figure 1. On the other hand, the "know-x" is classified as tacit knowledge. The "x" refers to "what", "when", "where", "why" and "how. In other words, the designers must know "what" knowledge to be used, "when" and "where" it is used, "why" the specific information/knowledge is applied and "how" it should be applied (Wong and Radcliffe, 2000). Therefore, construction consultant firms should just focus on "know-x" part of their knowledge when they are making strategies for KE.

2.2.2 Knowledge domains/sources in construction consultant firms

Distinguishing the knowledge domains in construction consultant firms enables them to choose appropriate techniques for capturing knowledge. In addition, sources of knowledge could be considered as an important issue when acquiring knowledge since it helps them find the spots that should be focused on. These two significant issues that should be considered by construction consultant firms in the process of KE are described in this section as follows.

In order to distinguish knowledge domain in construction consultant firms, design processes as the core business of these firms should be deeply considered. The process of architectural and structural design is broken into three main phases. The first phase is the decision phase where the designer evaluates different elements concerning the final product. The next step is concerned with designing tasks that are mainly focused on the product and its features. Construction consultants usually go through the process of goal elaboration, which is the conceptualization and finalization of the goals related to the design. The design generation concerning the details of the design and criteria is needed for meeting the goals discussed earlier in the team (Magee, 1987).

According to Magee (1987), these processes are not always followed in the same order and in many cases other stakeholders get involved as one of the elements that affect the design process. The final stage is the design process at the project level, whereas two main attributes of this stage are counted as the

information/communication flow and the inter-link between power and authority with information.

Definitely, the knowledge domain is an important issue when discussing KE. This concept refers to the domain of expertise that an engineer or architect uses in order to design an engineering task. Knowledge domains are basically divided into four categories: declarative, procedural, situational and strategic. The declarative, procedural, situational and strategic knowledge domain respectively refer to "knowing what", "knowing how", "knowing when and where" and "knowing why" (Wong and Radcliffe, 2000).

On the other hand, knowledge sources in construction consultant firms have been identified and classified into external and internal sources, where external sources are comprised of stakeholders (e.g. clients), academic reports, university studies, knowledge brokers, etc. The internal sources of knowledge are considered as organizations' documentations, project meetings, intranet, etc. Beside all mentioned knowledge sources, it is also mentioned that organizational knowledge as an internal source is shaped by the skills, experiences, and cross organizational knowledge of employees. Knowledge sources in construction consultant firms are shown in Table 2 (Kivrak et al., 2008, Kululanga and McCaffer, 2001).

Table 2 Sources for acquiring knowledge in construction consultant firms

	Sources
Internal acquisition	• Internal staff • Internal benchmarking • Learning from experience
External acquisition	• Staff from other organizations • External benchmarking • Collaboration with other organization • Reviewing innovation in the business environment • Attending conference on new development

Considering the knowledge domains described in this section and knowledge schema in construction consultant firms (Section 2.2.1), it is concluded that these organizations could capture and retain their declarative, procedural, situational and strategic knowledge as an organizational asset. These parts of knowledge domain, which are the combination of tacit and explicit knowledge, could be acquired from different sources mentioned in Table 2. According to the purpose of this study, which is to focus on internal acquisition (internal staff), and knowledge domains in construction consultant firms, elicitation of tacit knowledge from experts working in these firms is described in Section 2.3.

2.3 Knowledge elicitation

Knowledge elicitation (KE) is the process of converting tacit knowledge into explicit knowledge. Considering the degree of tacitness described in Section 2.1, KE focuses only on the second and third stages (tacit skills that can be imperfectly articulated and tacit skills that could be articulated) (Ambrosini and Bowman, 2001). The conversion of knowledge is divided into four main modes called SECI (socialization, externalization, combination and internalization). The second mode (externalization) refers to KE since it is related to transformation of tacit to explicit knowledge. Four modes of SECI are clearly described as follows and shown in Figure 2 (Nonaka et al., 2000).

- *Socialization*: tacit knowledge is converted to the new tacit knowledge through shared experience individually. This could be done through spending time together.

- *Externalization*: is done through articulation of tacit knowledge to explicit knowledge. In this mode, tacit knowledge is elicited into written documents like manuals, reports, etc. According to Schreiber (2000), the process of knowledge elicitation comprises a set of techniques and methods applied to elicit knowledge from a domain specialist through interacting with experts.

- *Combination*: is a process of converting explicit knowledge into more complex and systematic explicit knowledge. This process is conducted through collecting the explicit knowledge (written documents) from inside or outside the organization. Afterwards, the collected knowledge is combined and edited in order to create a new knowledge.

- *Internalization*: is the conversion of explicit knowledge to tacit knowledge by individuals. This concept is close to learning by doing. Transferring knowledge via reading written documents of the company is a clear example of this mode.

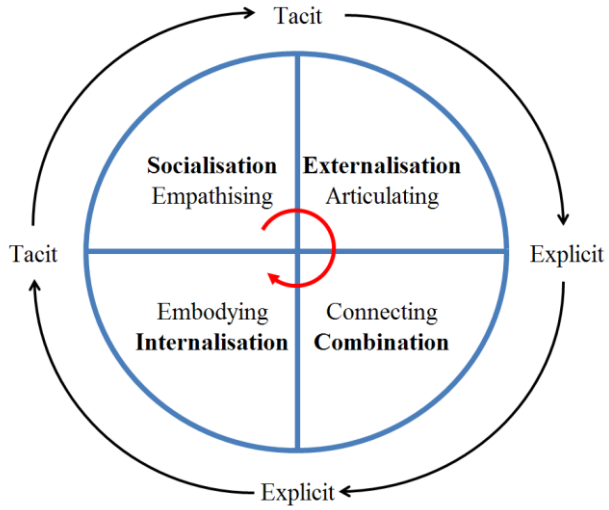

Figure 2 The SECI process (Nonaka et al., 2000)

In KE process (externalization mode of SECI process), tacit knowledge must be firstly elicited into models, words or numbers in order to facilitate the process of transmission. This conversion could be conducted through using IT tools such as electronic networks. In this case, individuals are able to exchange their tacit knowledge via email, chats, and online discussion. Furthermore, people-centred approach would be another alternative for eliciting tacit knowledge into explicit. Face-to-face dialogue is the most common technique between employees working in the organization. The communication between employees could be performed in the form of cross-functional team meetings (Desouza, 2003).

Thus, the process of knowledge elicitation (externalisation) could be performed through either IT-centred or people-centred approach. Whether IT tools or face-to-face dialogues are exploited for eliciting experts' tacit knowledge, involved actors in KE process could be divided into two groups as described in Section 2.4.

2.4 Actors in the process of knowledge elicitation

The first group is *knowledge engineers* who are responsible for eliciting experts' tacit knowledge. *Experts* whose knowledge should be elicited for reusing in the future form the second group. Knowledge engineers (also called knowledge activists) facilitate the process of elicitation in the organization. They are a link between the experts and the organization in order to collect experts' knowledge. Knowledge engineers are not controllers rather they are enablers and facilitators for the enhancement of the level of knowledge elicitation (Von Krogh et al., 1997).

The educational background of the knowledge engineer could be either as the same as the expert's background or not. Furthermore, the ability to measure the quality and quantity of elicited knowledge is also of importance to knowledge engineers. They would also be cautious to differentiate experts based on their expertise before starting to elicit their knowledge. This kind of separation helps the knowledge engineer use the appropriate technique for eliciting experts' knowledge based on their different level of expertise (Schreiber, 2000, Shadbolt and Burton, 1989).

The definition of expertise must be considered in order to find what expertise really means. According to Hoffman et al. (1995), the experts are chosen on the basis of years of experience and professional criteria such as level of education, training experience, publication records, etc. Therefore, the criteria for selecting the experts would be based on the experimental, social, cognitive and performance-related issues. Considering mentioned criteria, the level of expertise is classified into seven different categories: naiveté, novice, initiate, apprentice, journeyman, expert and master. The characteristics of the expert are described as follows (Hoffman et al., 1995).

> "*The distinguished and brilliant journeyman, highly regarded by peers, whose judgments are uncommonly accurate and reliable, whose performance shows consummate skill and economy of effort, and who can deal effectively with rare or tough cases. Also, an expert is one who has special skills or knowledge derived from extensive experience with sub-domains.*"

Schreiber (2000) proposed another categorization of experts in accordance with knowledge domain, experts' action to solve the problems, the approach towards solving problems in the working environment and their level of responsibilities. This kind of categorization divides the experts into three different categories as follows.

- *Academicians*: they are very organized and close to the theory. Their main attempt is to implement theories into practice.

- *Practitioners*: these people are closer to the reality of day-to-day problems and problem solving. Their solutions are mainly dependant on the limitation imposed through resource and time constraints. Their distance from academic theories is more evident.

- *Samurais*: they are pure performance experts. Their main intention is to optimize the processes and respond to problems without spending time for thinking. They independently act and their knowledge is expressed through verbal communications.

Overall, the necessity of assigning a position by the name of knowledge engineer is perceived in the organization in order to facilitate the process of elicitation. One of the main responsibilities of knowledge engineers is to apply appropriate elicitation techniques in accordance with the categorization of experts. The most common elicitation techniques that could be applied by a knowledge engineer are described in Section 2.5.

2.5 Knowledge elicitation techniques and classification

This section includes two main parts. The first part contains the description of the 10 most common elicitation techniques and discusses about how to implement these methods. In the second part, various classifications for elicitation techniques are described since most researchers diversely classified these techniques in accordance with the application of the techniques, the methods of implementation, the elicited knowledge, etc.

2.5.1 Knowledge elicitation techniques

Task analysis

This technique requires a special task to be reviewed by experts. Thereafter, the result is presented in a written document by the knowledge engineer for analysis. The task can come from different sources like test cases with different degrees of toughness. Test cases could be either taken from archived data existing in the organization or generated by other experts who are familiar with the task. Considering the toughness of the test cases, research shows that the elicited knowledge from tough cases is more reliable than observing the experts solving common problems. This technique can describe jobs and identify existing sub-tasks in an appropriate manner. In addition, it is a preferable method for eliciting knowledge regarding manufacturing and process

control procedures, equipment design and yielding job specifications (Hoffman et al., 1995).

Protocol analysis (think aloud problem-solving)

Protocol analysis is "*based on a transcribed interview, but attempts to structure the process, and procedure more meaningful results*" (Hart, 1985). This technique is interesting since experts prefer to talk about specific examples in their problems compared to brief description of their thoughts. In this technique, experts could take project histories or documents and think aloud when trying to solve the problem at hand.

Like task the analysis technique, protocol analysis is also a problem-solving method for eliciting tacit knowledge. This technique needs a specific task for reviewing by experts. The think aloud procedure generates a protocol, which is a recording of transcribed and analyzed deliberation for propositional content. The verbalization process of this technique could lead to formation of the reasoning sequence of experts' problem-solving and reveals how the experts' thinking procedure is performed (Hoffman et al., 1995).

In a protocol analysis session, the knowledge engineer observes the experts' reactions to the problem through recoding it either by audio-taping or videotaping. Two methods are suggested for KE via protocol analysis: *offline* and *online*. Offline alternative refers to cases where the knowledge engineer comments and analyzes the elicited knowledge after reviewing the recorded conversation. On the other hand, in an online mode, the knowledge engineer simultaneously comments on the experts' talks while being recorded. *Self report* or *think aloud* is a method that is considered as an online mode of knowledge elicitation. Therefore, this method could be done either by the knowledge engineer or the expert himself. The last phase of protocol analysis is to analyze the transcript of the knowledge that has been elicited (Schreiber, 2000).

Unstructured interview

The interview technique is the most common method to elicit tacit knowledge. This is an open-dialogue interview including open-ended questions in order to elicit expert's tacit knowledge and reasoning. However, unstructured interview is not a disorganized technique. Recording the interview is strongly recommended since it can ease the process of analyzing. In order to check the accuracy of elicited knowledge, knowledge engineer must analyze the findings of interview away from the experts and present his thoughts to interviewed experts for rechecking (Hart, 1985, Hoffman et al., 1995).

Unstructured interviews are mainly used as a tool to identify the knowledge domain. In order to get better quality of interview results in terms of accuracy, it is suggested to move towards structured interviews. In fact, applying structured interview could significantly fill the gaps of missing pieces in the knowledge domain, which is elicited through conducting unstructured interview (Schreiber, 2000).

Structured interview

Structured interview is designed and planned in advance with the predefined roles and clear purpose of each session. Structured interview is conducted through *domain-specific probe question* and *generic probe question*. When domain-specific probe questions are applied, the knowledge engineer prepares a fixed set of questions that should cover a broad range of particular subjects within the domain. Although questions are predefined in advance when generic probe questions are used, the order of questions is not predetermined and it might change during the interview session (Hoffman et al., 1995).

Since predefined questions are asked during structured interviews, this limits the expert to talk about the specific task in the knowledge domain. Therefore, this kind of interview could properly avoid broad and disorganized talking. After transcribing the interview, it would be suggested that the transcript is presented to the expert in order to make sure that the elicited knowledge is in accordance with their expression of the knowledge domain (Schreiber, 2000). Wong and Radcliffe (2000) came up with different questions shown in Table 3 referred as "know-x" part of knowledge schema shown in Table 1. These questions are useful for the process of eliciting experts' tacit knowledge in construction consultant firms.

Table 3 Sample questionsused for elicitng designers' tacit knowledge ("know-x")

Know-x	The questions of "know-x"
What	What information is required?
	What additional factor needed?
	What equipment is required?
	What are the effects of designing this particular task on systems?
Where	Where should be the information applied?
	Where can be the information acquired?
	Where is the design task to be carried out?
When	When is the design task to be carried out?
	When should use the particular information/ techniques?
Why	Why do we need to carry out the design task?
	Why is the particular knowledge/information applicable?
Who	Who will be the most appropriate person to conduct the task?
	Who should be contacted for knowledge/information required?
	Who is going to use the result of design?
Which	Which route should be chosen?
	Which knowledge/information should be used?
	Which equipment/document is required for conducting the task?
	Which format is used to present the result?
How	How to conduct the design task?
	How can the knowledge/technique be applied?
	How can the acquired data and present the result?

Narrative interview

According to Kwong and Lee (2009), narrative interview is the most recent type of interviews compared to structured and unstructured interviews. This technique refers to describing the story of the situations and characters considering a timeline. In other words, it represents telling of events that led to an outcome which would be valuable for certain audiences. The first step of narrative interview is to clearly explain the purpose of interview to experts in order to minimize possible misunderstandings.

Thereafter, the expert must be required to freely talk about specific subjects. Recording and transcribing the interview would be a useful technique to prevent missing information. The next step is to extract the learning point of the interview by carefully reviewing the transcript and separating important phrases by "/". The last step of the narrative interview technique is to classify the learning points gained from the experts under three headings including failure, investigation and solution (Kwong and Lee, 2009).

Although conducting the narrative interview allows free flow of information, there should be a set of open-ended questions in hand for guiding the interviewee to talk about his/her experience. It is important that the knowledge engineer does not interrupt the expert during interview session since it can destroy the original idea of the interviewee (Kwong and Lee, 2009).

Decision analysis

This technique is started by an event and its probability of occurrence. Then the expert is asked to make decisions on the existing problem (event). The output of this technique could be used to build a mathematical model for reasoning such as a decision tree. This technique is conducted by a knowledge engineer (Bradshaw et al., 1991). Decision analysis technique is a formal procedure to find how the steps of decision making are delivered. This could be done through a sequence of steps led to make a decision. Different issues affect the process of making decision could be named as the component of the problems, the relationship between components, various kinds of problems encountered, the characteristics of each problem and the judgment of problem solvers (Hoffman et al., 1995).

Group decision making

This technique includes three alternatives that could lead to making decisions on a specific task. In the first alternative, KE is done through brainstorming *in a small group* of experts. Experts involved in a group are challenged to generate creative decisions. The second alternative is named *consensus decision making*. In this case, the group's goal is to find the best decision on the basis of existing strengths and weaknesses of available options. The third alternative is *nominal group decision making*. In this alternative, the experts involved in a group are given a list of solutions in order to independently perform a rating of advantages and disadvantages of each alternative. The knowledge engineer is responsible for analyzing the elicited knowledge (Hoffman et al., 1995).

Rating and sorting tasks

A familiar task is given to the expert in order to judge and rank the priority of different issues involved. The process of judgment is conducted through a think aloud procedure. An example of rating and sorting is to judge about particular road's aesthetic value by highway engineers in order to predict the road's accident and estimation of road capacity. The information required for experts must be available either on slide show views or a bar graph (Hoffman et al., 1995). This is an attempt to identify the view point of the expert through relating the concepts represented in that knowledge domain. The concept sorting is performed through repeating the same actions in sorting out the similar definitions to find the similarities and differences from an expert's point of view (Schreiber, 2000).

Cognitive (causal) mapping

The origin of cognitive mapping comes from graph theory formulated by Euler in 1736 and developed by Axelord in 1976. Among different techniques of KE, cognitive mapping still is powerful. Cognitive mapping is an appropriate technique used for representing experts' views on reality. In fact, this method is applicable when individuals are supposed to explain the world around them. Cognitive mapping can represent both experts' personal knowledge and experience about a specific task (Ambrosini and Bowman, 2001, Kwong and Lee, 2009).

There are various types of cognitive maps in order to elicit experts' tacit knowledge. *Causal mapping* as one of cognitive mapping techniques is more applicable since it is simple to conduct and the outcome is fairly acceptable. Causal mapping could be defined as "*a form of cognitive map that incorporates concepts tied together by causality relations*" (Ambrosini and Bowman, 2001). It is a form of graphic representation including different nodes linked by arrows. Nodes in causal mapping method represent the constructs that an expert believes they are important and the arrows refer to the relationship between nodes (Figure 4). Causal mapping allows knowledge engineers to focus on actions.

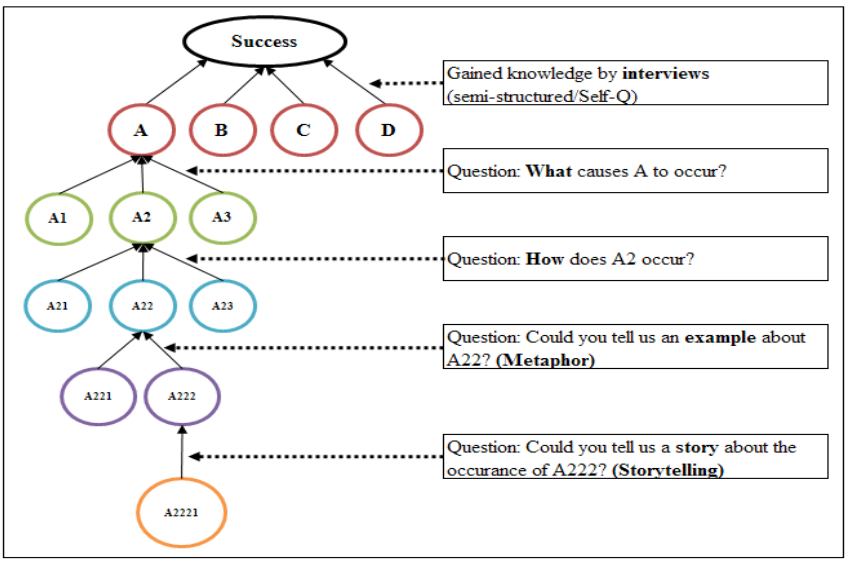

Figure 3 The process of causal mapping (Ambrosini and Bowman, 2001)

Causal mapping starts with asking broad questions (e.g. what causes success in the project?). Having a preliminary interview could help the knowledge engineer to elicit the constructs that might be used as a basis for mapping. In order to elicit those constructs, each expert must be interviewed only once. There are three techniques that can help knowledge engineers to elicit experts' tacit knowledge about a specific subject: semi-structured interview, self-Q technique and metaphors (Ambrosini and Bowman, 2001).

- *Self-Q interview*: is a non-directive mapping and self-interviewing technique. In this alternative, experts interview themselves by formulating questions based on their own personal knowledge and their thinking about the specific task. Events, concepts and objects can be used in order to bring the questions up.

- *Semi-structured interview*: is conducted through storytelling approach. This alternative is used in order to uncover constructs. As storytelling is the basis of this technique, the experts must be encouraged to tell their experience about a specific subject like the story. In fact, stories are known as one of the forms of implicit communication that could be used. Applying storytelling approach enables knowledge engineers to elicit experts' tacit knowledge since interviewees can manage the collective memory of the organization through storytelling. During semi-structured interview techniques conducted for causal mapping, experts are asked to tell two stories regarding past experience in the project or organization; one positive led to project/organizational successes and one negative causing project/ organizational failure.

- *Metaphors*: can be applied by asking experts to express a metaphor for their explanation on specific subjects. In this case, the expert tries to come up an example in order to clarify what he/she has already explained.

According to Ambrosini and Bowman (2001), after acquiring experts' knowledge on a specific task, the causal map should be drawn. The map is started with "success" or other revealed factor already gained through self-Q technique, semi-structured interview and metaphors. The purpose of preparing such map is to find the reasons for success. Causal mapping process could be conducted through asking different questions mentioned in Figure 3. The end point of the map is where the expert cannot reveal more factors. In this stage, the mapping process will stop.

Log-in systems

This technique is used via a computer interface within the organization. In this technique, every expert has a personal username and password to log in to the system. The expert is responsible to fill the blank boxes by him/herself. There is no knowledge engineer for eliciting knowledge in this technique. However, knowledge engineers are responsible to validate the shared knowledge in the system before reuse (Tan et al., 2007).

As described in this section, there are many techniques that could be used to elicit experts' tacit knowledge. Some techniques named in this section need a computer interface while some of them are manually conducted. The role of knowledge

engineer is obvious in some techniques while some of them can be applied by experts themselves. Considering the common characteristics between mentioned techniques, researchers came up with the classification of elicitation techniques explained in Section 2.5.2.

2.5.2 The classification of KE techniques

Magee (1987) classified the elicitation techniques into two main categories; *manual vs. automated*. Thereafter, Dhaliwal and Benbasat (1990), Burge (1998) and Gardner et al. (1998) used different classifications of KE techniques. They categorized KE techniques into *direct vs. indirect* and *specific vs. general*. Wilson and Corllet (1995), Hoffman et al. (1995) and Schreiber (2000) divided techniques used for eliciting tacit knowledge into *contrived vs. non-contrived*. Considering different classifications of KE techniques, the methods described in Section 2.5.1 are classified in Table 4 and described as follows.

- *Manual vs. automated*: manual techniques are those where the knowledge engineers produce a report of the expert's knowledge after the process of elicitation. However, automated techniques refer to ones in which experts are encountered with a computer interface in order to individually add their knowledge into the database. Log-in systems technique including a software platform in which the experts could log in and fill the blank boxes can be named as automated technique. On the other side, other techniques such as protocol analysis, cognitive (causal) mapping and interviews are classified as manual techniques. These techniques are either descriptive or observational (Dhaliwal and Benbasat, 1990, Magee, 1987).

- *Direct vs. indirect*: direct techniques are those where the knowledge is directly gained from experts. In fact, the knowledge can directly be obtained from asking direct questions or through observation. Conversely, the knowledge cannot be directly gained from the experts when indirect techniques are applied. In this case, the knowledge is captured by analyzing the elicitation sessions in order to capture required knowledge. Simple observations and protocol analysis are classified as direct techniques (Burge, 1998, Magee, 1987).

- *Specific vs. general*: some techniques focus on specific tasks or problem solving while some other techniques emphasize on general tasks. Diagnosis, debugging, repair, scheduling and design could be named as general tasks while heuristic problems are considered as specific tasks. In other words, the elicitation techniques in which experts are asked to share their knowledge on a specific task can be classified as specific methods (e.g. task analysis, protocol analysis, etc). On the other hand, those techniques that reveal the general aspect of a task are categorized as general techniques (e.g. structured interview, unstructured interview, etc) (Dhaliwal and Benbasat, 1990).

- *Contrived vs. non-contrived*: contrived techniques are those that are able to reveal the process of thinking and reasoning of the expert. Decision analysis, group decision making, rating and sorting can be counted as contrived

techniques. This is while those techniques in which the sequence of experts' thinking is not revealed are known as non-contrived techniques (Hoffman et al., 1995).

Table 4 Classification of different techniques used for eliciting tacit knwoledge

Elicitation techniques	Manual *vs.* Automated[1]	Direct *vs.* Indirect[2]	Specific *vs.* General[2]	Contrived *vs.* Non-contrived[3]
Task analysis	Manual	Indirect	Specific	Non-contrived
Protocol analysis	Manual	Direct	Specific	Non-contrived
Unstructured interview	Manual	Direct	General	Non-contrived
Structured interview	Manual	Direct	General	Non-contrived
Narrative interview	Manual	Direct	Specific	Non-contrived
Decision analysis	Manual	Direct	Specific	Non-contrived
Group decision making	Manual	Direct	Specific	Non-contrived
Rating & Sorting tasks	Manual	Indirect	Specific	Contrived
Cognitive (causal) mapping	Manual	Indirect	Specific	Contrived
Log-in system	Automated	Indirect	General	Non-contrived

[1](Magee, 1987)
[2](Burge, 1998, Dhaliwal and Benbasat, 1990, Gardner et al., 1998)
[3](Schreiber, 2000, Wilson and Corllet, 1995)

The classification of KE techniques could help decision makers and knowledge engineers apply appropriate techniques that are most compatible with the organizational knowledge domains in the organizations. The classifications mentioned in Table 4 consider different aspects that could lead to successful implementation of KE strategies since the abilities and requirements of each technique are identified. However, the weaknesses and strengths of each technique should be considered before applying it.

2.6 Weaknesses and strengths of KE techniques

Every elicitation technique has some limitations beside strengths that should be considered before applying KE techniques. In accordance with weaknesses of each technique, it is suggested to use a combination of techniques when eliciting experts' tacit knowledge. In this case, the limitations of a technique could be amended by other methods (Hoffman et al., 1995, Hart, 1985). Weaknesses and strengths of all

elicitation techniques mentioned in Section 2.5.1 are separately described in this section and summarized in Table 5.

2.6.1 Task analysis

Task analysis is an instructive method for system developers. It is very useful for comprehensive exploration of experts' tacit knowledge when performing a task, which is a basis for development of knowledge management process. Furthermore, this technique is able to appropriately reveal what the experts do. However, this technique could not properly reveal the thinking process of expert when performing a task. Therefore, it is not a strong method to reveal what the experts know. In addition, task analysis technique is time consuming (Hoffman et al., 1995).

2.6.2 Protocol analysis

This technique could not always be an appropriate technique to be applied in different situations. It is a useful method when documents and histories of cases are available for review (Hart, 1985). Furthermore, conducting a full protocol analysis including transcribing and functional coding of audio-taped statements is time consuming and effortful while it has a low efficiency yield. On the other hand, protocol analysis is instructive to system developers and it can reveal what the experts do. However, it cannot reveal what the expert knows (like task analysis technique) (Hoffman et al., 1995).

2.6.3 Interviews

Since interview techniques including unstructured, structured and narrative interviews are very common KE techniques in organizations, various researchers focused on these techniques to find their strengths and limitations. Magee (1987) counted the flexibility of all interview techniques as the main strengths. In this case, an experienced knowledge engineer has the ability and latitude to make sure that the expert does understand the questions.

On the other hand, interview techniques have also some weaknesses. The expert (interviewee) does not have the replies at their fingertips during interview session. Neither the knowledge engineer nor the expert knows which parts of their conversation during an interview session are important. However, interview recording and producing transcripts would be an appropriate strategy to overcome these limitations (Hart, 1985).

Additionally, experts' tacit knowledge may not be totally elicited via interview techniques since the expert might assume that the knowledge engineer is already familiar with the subject of discussion. This is because of the level of information that the knowledge engineer has about the specific topic that must be discussed. This challenge could also be named as a weakness of narrative interview (Hart, 1985, Jovchelovitch and Bauer, 2005).

In fact, if the knowledge engineer is a highly knowledgeable or experienced person, that might make the expert feel uncomfortable since he/she might dislike his/her knowledge to be judged. On the other hand, if the knowledge engineer does not have a minimum knowledge regarding the specific topic, that might make the experts uncomfortable since they prefer to share their knowledge with someone who can understand what they are talking about (Hoffman et al., 1995, Jovchelovitch and Bauer, 2005).

In particular, the unstructured interview is useful when users' needs should be determined. In addition, both structured and unstructured interview can give the information about reasons of performing tasks. However, structured interview is more efficient and productive than unstructured interview (Hoffman et al., 1995). Unstructured interviews are counted to make a good relationship between the expert and the knowledge engineer before getting further into discussion. In fact, unstructured interview is a useful technique for social facilitation. It could significantly reduce the stress felt by experts. However, a structured interview has an advantage over the unstructured interview and that is the ability of the knowledge engineer to analyze the data extracted from experts in an easier manner (Hoffman et al., 1995, Schreiber, 2000).

The analysis of the result gained from unstructured interview is difficult due to the existing bulk of disorganized information in the transcript. This problem could be counted as a weakness for narrative interview since a broad knowledge is elicited during this interview that might not be relevant to the specific task. In other words, the unstructured and narrative interview is also counted to be inefficient due to lack of structure (Hoffman et al., 1995, Jovchelovitch and Bauer, 2005). Unstructured and narrative interviews are both time consuming methods for eliciting tacit knowledge. However, structured interview takes less time to be conducted when compared to unstructured and narrative interview (Hoffman et al., 1995, Schreiber, 2000).

The likelihood of imposing knowledge engineer's ideas and thoughts on the expert is counted as a weakness of structured interviews. This bias could be created by only a change of intonation or other obvious factors. The expert may not be easily integrated with the process since they might find it hard to express their opinion. Secondly, the expert may find it hard to admit to decisions that he thinks might jeopardize their credibility and experience. In addition, experts could mislead the knowledge engineer as a result of their unawareness of their actual decision making. Therefore, it could be possible that they act differently while they believe the contrary (Magee, 1987). Potential shortcomings of interviews are concerning the fact that experts usually do not talk about professional matters that they cannot verbalize. Another problem could be due to vague answers that do not specify any particular path of problem solving (Schreiber, 2000).

2.6.4 Decision analysis

Conducting decision analysis techniques for eliciting experts' tacit knowledge takes about 10 hours per case. Therefore, decision analysis technique is also time consuming and effortful like protocol analysis and other various interview techniques. Experts feel uncomfortable with this technique since they are suffering from having to

explain their decisions. On the other hand, this technique is very useful for eliciting the reasoning procedures or strategies (Hoffman et al., 2002).

2.6.5 Group decision making

Group decision making as a contrived technique has also both advantages and disadvantages. This technique (like decision analysis) can appropriately reveal the reasoning of what the experts do. However, they might feel uncomfortable when this technique is applied for eliciting their knowledge. Since the expert must explain their decisions in the group, he/she may fear of revealing the knowledge in front of his/her colleagues (Hoffman et al., 1995).

2.6.6 Rating and sorting tasks

As already discussed in Section 2.5.2, rating and sorting method is categorized as a contrived technique. Therefore, like other contrived techniques (decision analysis, group decision making), rating and sorting can properly reveal the reasoning of tasks performed by experts. However, experts might feel uncomfortable when this technique is applied for eliciting their knowledge (Hoffman et al., 1995).

2.6.7 Cognitive (causal) mapping

As mentioned in Section 2.5.1, Self-Q interviews and metaphors are named as two important methods that could help knowledge engineers to elicit experts' tacit knowledge when cognitive mapping technique is applied. Strengths of using this alternative to facilitate KE processes are described as follows.

Self-Q interview can minimize the influence of knowledge engineers on the quality of elicited knowledge. This technique has the lower employees' resistance since experts do not find themselves against pre-defined questions. Furthermore, applying this technique reduces the problems in the production of constructs by knowledge engineers due to their lack of knowledge about the process or organization under observation (Ambrosini and Bowman, 2001).

Metaphors can also help state the meaning where no explicit language is available. Furthermore, using metaphors enables the experts to think in different ways and to explain most complex organizational phenomena. Metaphors "*transmit an entire story visually using one image*" (Ambrosini and Bowman, 2001). Therefore, they could be used as a means of capturing the flow of experts' experience, which is available in the form of tacit knowledge. However, some experts may not be able to use metaphors for their statements. This can be considered as a constraint of using metaphors.

Generally, the strengths of cognitive (causal) mapping techniques are that they show the relationship between variables that could be defined and described by experts rather than by knowledge engineers. Furthermore, cognitive map helps structure and analyze the captured knowledge in a better form. This technique is formed from a

series of psychological transformations helping the individuals to acquire code, store, recall and decode information. Cognitive (causal) mapping can also lead to evaluation of the reasoning of people while they prevent the unnecessary simplification of complex situations (Kwong and Lee, 2009).

In addition, the graphical feature of cognitive mapping techniques enables the people willing to use the elicited knowledge for better understanding since it is easier for them to feel the meaning when the elicited knowledge is presented in a visual format. This technique has the strength of supporting the expert for laying out the model of his/her tasks. In other words, cognitive mapping helps the organization to generate a model of the domain knowledge (Hoffman et al., 2002, Kwong and Lee, 2009).

2.6.8 Log-in systems

Considering the classification of elicitation techniques described in Section 2.5.2, log-in systems are classified as automated techniques, which are more efficient compared to manual methods. It is mentioned that automated techniques can yield more valid knowledge since the experts are required to decompose their domain into elements. Furthermore, the elicited knowledge from automated techniques is ready to be implemented in a prototype. When log-in system is applied as an elicitation technique, a group of experts is needed to validate shared knowledge before storing it in the repository (Hoffman et al., 1995, Tan et al., 2007).

Overall, as discussed in this section, elicitation techniques have some limitations that could affect the quality of elicited knowledge. Therefore, decision makers and knowledge engineers must be aware of all aspects of elicitation techniques before applying them in organizations. In order to overcome the limitations inherent in KE techniques, using a combination of elicitation methods could be a useful solution.

Table 5 Summary of strengths and weaknesses of KE techniques

Techniques	Strengths	Weaknesses
Task analysis	• Instructive method to system developers • Reveal what the experts do	• Not useful to reveal what the experts know • Time consuming
Protocol analysis	• Instructive method to system developers • Reveal what the experts do	• Not applicable for all cases • Time consuming • Effortful • Low efficiency yield • Cannot reveal what the expert knows
Unstructured interview	• Ability to social facilitation in order to establishment of a good relationship between the expert and the knowledge engineer • Ability to clarify vague points to experts (interviewee) • Ability to determine users' needs • Reveal reasoning of doing task	• Experts may not have the replies at their fingertips • Inability to understand the important parts of interview • Inability to totally elicit tacit knowledge • Difficulties in analyzing gained result • Inefficiency due to lack of structure • Time consuming • Experts may not reveal everything due to jeopardizing their credibility and experience • Inability of experts to talk about professions that they cannot verbalize
Structured interview	• Easiness of analyzing captured knowledge • Ability to clarify vague points to experts (interviewee) • Reveal reasoning of doing task • Less time consuming	• Experts may not have the replies at their fingertips • Inability to understand the important parts of interview • Inability to totally elicit tacit knowledge • The risk of imposing the knowledge engineer's ideas and thoughts to the expert • Experts may not reveal everything due to jeopardizing their credibility and experience • Inability of experts to talk about professions that they cannot verbalize

Table 5 (Continue) Summary of strengths and weaknesses of KE techniques

Techniques	Strengths	Weaknesses
Narrative interview	• Ability to clarify vague points to experts (interviewee)	• Experts may not have the replies at their fingertips • Inability to understand the important parts of interview • Inability to totally elicit tacit • Difficulties in analyzing gained result • Inefficiency due to lack of structure • Time consuming • Experts may not reveal everything due to jeopardizing their credibility and experience • Inability of some experts to verbalize their professions
Decision analysis	• Reveal reasoning of doing task	• Time consuming • Effortful • Experts feel uncomfortable
Group decision making	• Reveal reasoning of doing task	• Experts might fear to reveal the knowledge in front of their colleagues
Rating & Sorting tasks	• Reveal reasoning of doing task	• Experts feel uncomfortable
Cognitive (causal) mapping	• Minimizing the influence of knowledge engineer by Self-Q interview technique • Lower employees' resistance • The benefit of using metaphors • The benefit of graphical form for better analyzing • Reveal reasoning while preventing the unnecessary simplification of complex situations • Not very time consuming	• Inability of some experts to use metaphors for their statements
Log-in systems	• Most efficient method • Yielding more valid knowledge	• Needs a group of experts to validate shared knowledge

2.7 Inherent barriers to knowledge elicitation

Considering the barriers to implementation of KE strategies, it is concluded that some problems are related to the nature of tacit knowledge, which is inherently hard to elicit. On the other side, some obstacles are related to the nature of construction consultant firms that make KE processes difficult to implement. These two groups of barriers in the process of knowledge elicitation are described as follows.

As to barriers related to the nature of tacit knowledge, it should be mentioned that most of the problems in implementing KE processes is related to psychological issues. This challenge refers to the inability of experts to describe how they view specific problems. This is because of the inability of some people to distinguish between beliefs, facts and the factors that can influence the process of their decision making (Hart, 1985).

This argument is strongly linked with Michael Polanyi's belief that "*we can know more that we can tell*" mentioned in Section 2.1. It clearly shows the inherent difficulty of eliciting tacit knowledge. Two main issues could be counted as the reason of such conclusion. First is the matter of awareness and consciousness. It is mentioned that there is a set of rules that have to be observed before we can perform an act. This set of rules is not always clear to the human expert. Experts might follow a set of rules but are not necessarily aware of the rules they follow (Gertler, 2003). Therefore, it might make the process of elicitation difficult to implement. The second explanation is of communication problems and the inability to verbalize all the knowledge that is embedded in human experts' minds. This could be due to the shortcomings related to language barriers (Chervinskaya and Wasserman, 2000, Gertler, 2003).

According to Chervinskaya and Wasserman (2000), another main reason that extracting tacit knowledge seems to be problematic is related to the fact that many knowledge engineers neglect or underestimate numerous elements influencing the decision making process. For instance, Gertler (2003) pointed out measuring the knowledge as a dilemma for implementing a knowledge elicitation process. Although it would be an obstacle for both explicit and tacit knowledge, the latter is more difficult since tacit knowledge is more intangible. In addition, solving problems in the presence of short-term memory, incorrect use of some methods for eliciting knowledge and employee resistance could also be named as general dilemmas for KE.

Experts' time is another limitation for knowledge elicitation processes. Since the experts' working hours are costly and usually the process of knowledge elicitation takes a long time, the organizations' cost increases. In other words, the cost and risk of KE techniques is too high for the organization. The process is time consuming including too much uncertainty (Turner, 1990). Furthermore, knowledge sharing is never obligatory, it is only volunteered. Nobody can be obliged to share his/her knowledge. Therefore, employees could easily reject contributing in KE processes unless they have sufficient motivation such as financial bonuses (Kwong and Lee, 2009).

In construction consultant firms, lack of standard work processes, lack of time, poor organizational culture, budget limitation, employee resistance and poor IT infrastructure could be named as other barriers to successful implementation of KE strategies. Lack of standard work processes is the most important challenge in many construction consultant firms. Furthermore, time limitation in construction consultant firms would be an important dilemma since they should deliver projects on schedule. Therefore, most experts do not have enough time to contribute to the process of knowledge elicitation (Carrillo et al., 2004).

The organizational culture is also an important barrier to successful KE processes since some construction consultants have hierarchical structure where there is less communication between different units. Budget limitation for launching and maintaining IT systems could be a challenge for these organizations. As many organizations, construction consultants suffer from employee resistance in implementing KE strategies. This is because of employees' time limitation of, personal characteristics issues, lack of sufficient incentives, etc (Carrillo et al., 2004).

Tan et al. (2007) counted another three barriers to KE in the construction industry including consultants. These are the loss of knowledge due to the time lapse in capturing the knowledge, high rate of staff turnover and reassignment of personnel. However, conducting live knowledge elicitation could significantly overcome mentioned limitations. According to Pathirage et al. (2007), most of the construction knowledge exists in the mind of individuals working within the domain. Therefore, when the skilled individuals who have the valuable knowledge about the project leave the organization, most of the knowledge goes out with them.

Altogether, the implementation of KE strategies in construction consultant firms has some challenges, which is the result of both inherent barriers to tacit knowledge in general and the nature of these firms. As a summary, the psychological characteristics of experts as granters of knowledge, lack of standard KE strategy, employee resistance and time limitation could be counted as some of the most important challenges. Possible solutions for facilitating a KE process are described in Section 2.8 in accordance with the challenges mentioned in this section and weaknesses and strengths of each technique mentioned in Section 2.6.

2.8 Possible improvements for knowledge elicitation

As mentioned in Section 2.6, the combination of KE techniques could appropriately cover the weaknesses of each technique. Therefore, it is suggested to start with some sort of task analysis followed by structured interview and end up with contrived techniques such as cognitive (causal) mapping. In this way, the thinking process of experts can be revealed at the beginning and then asking pre-defined questions could lead to better understanding of vague information. At last, applying contrived techniques helps knowledge engineers to find how the expert makes decision on a specific task (Hoffman, 1989).

In order to facilitate KE processes according to the limitations created by the hierarchical structures, matrix organizational structures are recommended. Furthermore, mentoring and tutoring scheme and technical networks could be useful

strategies since they can make a proper atmosphere to ease the communication flow. In addition, assigning a knowledge engineer (knowledge manager) could help facilitate the implementation of KE strategies (Carrillo et al., 2004, Tan et al., 2007).

Considering employee resistance in KE processes, it is suggested to have incentive programs as part of an organizational culture in order to encourage employees to contribute. However, implementation of reward scheme is extremely difficult in construction consultant firms since it depends on teamwork and it is hard to distinguish between involved employees' contribution even if there is a performance appraisal (Carrillo et al., 2004).

A possible solution for enhancement of tacit knowledge sharing and elicitation could be investment on individuals in the shape of education and training. In fact, the creation of a common social, organizational and cultural context could facilitate the process of knowledge elicitation since employees (experts and knowledge engineers) have similar interests and can talk with the same language (Gertler, 2003).

To reduce the cost of implementing KE strategies, it is suggested to develop a methodology based on the existing practices that employees already carry out (e.g. interview, meeting, etc). According to the importance of accuracy level of elicited knowledge, construction organizations could form a panel of experts to review the captured knowledge before storing it in the company's database for reuse. In this case, not only more valid knowledge is reused in future, but also knowledge granter's workload is reduced (Tan et al., 2007).

According to Tan et al. (2007), live capture of knowledge in the construction industry would be an appropriate solution to overcome some barriers created by time lapse. Live capture strategy refers to "integrate learning within day-to-day work processes". The advantages of live capture of knowledge are to facilitate reuse of knowledge, management of project phases in a proper time and prevention of knowledge loss. According to the methodology for live capture, the knowledge could be elicited through frequent meetings and the project must be reviewed at the end of each phase. Having post project reviews is also highly recommended. Project meetings could be held either with the group of people or with an individual through conducting problem solving techniques.

As a summary, the possible solutions for facilitating KE processes mentioned in this section could be named as a combination of different KE techniques, flat organizational structure, mentorship and networking programs, assigning knowledge managers, application of incentive programs, development of training programs, consideration of organizational culture when making KE strategies and live knowledge capture.

3 Methodology

This chapter includes two main subjects. First, the research framework used in this study to evaluate knowledge elicitation (KE) processes in chosen organizations. Afterwards, the process of designing interview questions and conducting all interviews are explained.

According to the general purpose of this study, which is evaluation of KE in construction consultant firms, qualitative research was conducted via two approaches: literature review (e.g. scientific journal articles and books) and interviews. In order to answer the first research question mentioned in Section 1.2, broad academic literature related to the concept of knowledge acquisition (KA) was selected. Reviewing such a broad range of literature that not only focused on knowledge elicitation, but also comprised other steps of knowledge acquisition gave the authors the opportunity of having an overview on the entire KA process. However, the literature review was gradually narrowed down into specific literature related to KE.

Considering the first research question, focus was put on academic literature that proposed common techniques for eliciting tacit knowledge in general instead of those only applied in construction consultant firms. In this case, the possibility of evaluating the implementation of those techniques that have not been applied in construction consultant firms was created. Therefore, 10 most common KE techniques were finally selected.

In order to cover the second research question of this study focused on the weaknesses and strengths of 10 selected elicitation techniques (Section 2.5), only the academic literature was used. However, the interviewees were also required to point out the weaknesses and strengths of KE techniques from an industrial point of view.

In accordance with the third research question, which is to explore current processes of KE in construction consultant firms, two Swedish construction consultants (Sweco Infrastructure and White Arkitekter AB) were chosen for investigation. Therefore, four senior managers and two experts in both companies were contacted for interview. Senior managers represent those who are decision or strategy makers for KE while experts are employees whose valuable tacit knowledge could be elicited. Conducting interviews with both senior managers and experts was in accordance with the investigation of KE strategies in two selected consultants from both sides; this included decision makers' perspective and employees' perspective exposed to the strategies made by senior managers.

As mentioned in Section 1.2, the goal of the fourth research question of this study was to find the probable reasons of unsuccessful implementation of KE strategies in construction consultant firms. Therefore, the necessity of a comprehensive framework was perceived in order to have a robust evaluation. The purpose of such framework was to highlight the major dimensions, providing a scheme for comparing/integrating the findings and making common languages for talking about critical issues. In other words, this kind of framework could help evaluate the implementation of KE strategies. Finally, the following framework shown in Figure 4 was chosen for

evaluating strategies of the case organizations. The components of this framework are described in Section 3.1.

3.1 Applied framework for evaluating KE strategies

The framework shown in Figure 4 was the basis for designing interview questions to get senior managers' and experts' perspectives towards KE strategies in two selected consultants. This framework was proposed by Dhaliwal and Benbasat in 1990. Although the applied framework is relatively old, it was chosen since most of the elicitation techniques considered in this study was brought up in the same period of time. Additionally, this framework attempts to generally evaluate the process of knowledge elicitation in the organizations. Therefore, application of a general framework was useful in this study since it has a holistic view on the implementation of KE strategies. As mentioned in Section 1.3, there was a time limitation to perform this study. Therefore, it was impossible to deeply focus on applied strategies of organizations towards knowledge elicitation since various aspects should have been investigated from psychological perspectives of organizational behaviours.

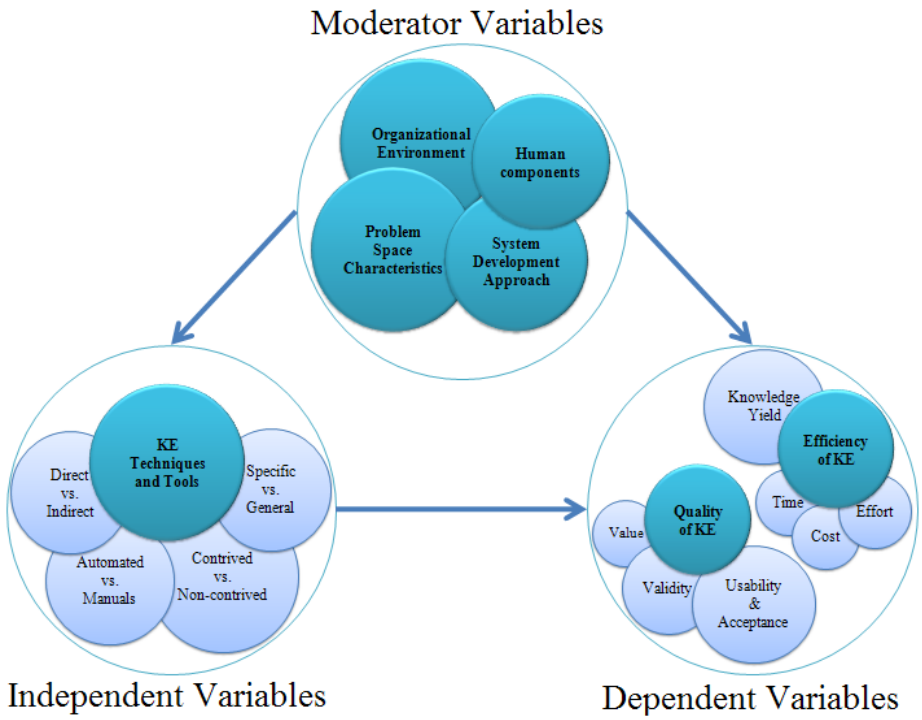

Figure 4 A framework for evaluating KE strategies (Dhaliwal and Benbasat, 1990)

According to the framework proposed by Dhaliwal and Benbasat (1990), there are three variables that could be used for evaluating KE strategies and elicitation techniques: moderator, independent and dependent variables. As shown in Figure 4, the quality and the efficiency of KE processes (as dependent variables) are directly affected by KE techniques. Furthermore, dependent variables could be directly and indirectly influenced by moderator variables via KE techniques. The unsuccessful implementation of KE strategies could be because of different obstacles concerning

moderator, independent and dependent variables. The factors included in each variable are shown in Table 6 and briefly described afterwards.

Table 6 Factors involved for evaluating KE strategies

Variables	Involved factors	Details
Independent	Knowledge capturing	Automated vs. manuals
		Direct vs. indirect
		Specific vs. general
		Contrived vs. non-contrived
Moderator	The human component	Attribute of source expert
		Attribute of knowledge engineer
	Problem space characteristics	Attribute of application domain
	System development approach	Prototyping
		Traditional life cycle
	Organizational environment	Past organizational experience
		Level of management support
		Organizational awareness/commitment
Dependent	Quality of KE	Validity
		Value
		Usability and acceptance
	Efficiency of KE	Cost
		Time
		Effort
		Knowledge yield

3.1.1 Independent variables

These variables refer to the classification of KE techniques previously described in Section 2.5.2. They are divided into four factors; *automated vs. manual, direct vs. indirect, specific vs. general* and *contrived vs. non-contrived*. As illustrated in Figure 4, the factors related to the selection of KE techniques could directly affect the quality and efficiency of KE processes. Therefore, independent variables should be evaluated since each KE technique differently affects the efficiency and quality of KE (Dhaliwal and Benbasat, 1990).

3.1.2 Moderator variables

According to Dhaliwal and Benbasat (1990), moderator variables should be considered when choosing KE techniques. As shown in Table 6, *attribute of source expert* refers to individuals' difference and personality variables that should be considered for evaluation of KE strategies. In fact, this factor relies on the psychological characteristics of experts whose knowledge should be elicited. Additionally, *attributes of the knowledge engineer* could be named as another factor involved in human components.

The familiarity of knowledge engineer with the knowledge domain, experience with the KE techniques being used and the past experience of knowledge engineer in KE could influence the success in implementing KE strategies. It could also be added that knowledge engineers have a more visual role in some KE techniques such as interviews, where their characteristics are also important. Patience, effective communication, diplomacy, conceptual skills can be named as some of those characteristics.

Problem space characteristics play a significant role as a moderator variable when KE processes are under observation. Attributes of application domain as a component of problem solving characteristics refer to uncertainty and complexity of knowledge domain that should be elicited (e.g. managerial, technical, administrative knowledge). In other words, the complexity and the level of uncertainty of knowledge domain should be considered before choosing appropriate KE techniques.

System development approach is also another important factor that should be considered when evaluating KE processes. The system development consists of two main approaches: rapid prototyping and the traditional life cycle. The second approach is commonly used for some elicitation techniques such as unstructured interview, protocol analysis and sorting where there is no need for a prototype system until bulk of knowledge has been acquired.

Organizational environment is a vital factor in successful implementation of KE strategy. It could reveal the level of awareness and commitment of organizations towards KE. The competitive and strategic importance of KE to the organization, past organizational experience in KE, level of management support for a technological culture could be considered as evaluation criteria.

3.1.3 Dependent variables

According to Dhaliwal and Benbasat (1990), *validity* refers to the validity of recommendations and outputs gained from elicited knowledge. It is an important factor that should be considered when evaluating KE strategies since the elicited knowledge must have sufficient validity to be reused in the future. *Value* could be also considered in terms of benefits that users gain from implementing KE strategies. These benefits would be measured by asking a group of experts about the applied KE processes based on quantitative criteria (e.g. degree of user satisfaction or actual tangible saving cost when applying this specific strategy).

Usability and acceptance turns to the level of system acceptance by the users and includes ease-of-use, naturalness and flexibility of using in terms of interaction with human experts. Considering this criterion, the employees' satisfaction could be evaluated. Furthermore, c*ost, time* and *effort* of both experts and knowledge engineers should be accounted for since they are costly resources for every organization. Therefore, minimizing their individual efforts and times are extremely desirable from an economic point of view. Furthermore, *knowledge yield* could be named as the last factor involved in dependent variables. The importance of this factor is its effectiveness on increasing the efficiency of KE.

According to Hoffman et al. (1995), knowledge yield could be evaluated by counting how many *informative propositions* each KE technique produced per *TTM* (Total Task Minute). The informative propositions could be defined as "*those which were not in the initial documentation-based first-pass knowledge base*". TTM includes total amount of time needed for preparing knowledge engineer for the session, time of the session and time of analyzing the transcript.

3.2 Designing and conducting interviews

In order to acquire required information about KE processes in the chosen construction consultant firms, six semi-structured interviews were conducted all in April and May 2010 (3 senior managers at White Arkitekter AB, 1 senior manager at Sweco Infrastructure and 1 expert in each company). The responsibilities of senior managers interviewed at White Arkitekter AB were Director of R&D Department (Fredrik Nilsson), Quality and Staff Manager (Gisela Carlen) and Head of Project Management Network (Simon Svensson). The interviewed senior manager at Sweco Infrastructure was CEO of infrastructure division (Johan Dozzi). In addition, an Area Manager (Ulrica Nilsson) at Sweco Infrastructure and also a Senior Architect (Åke Johansson) at White Arkitekter AB were interviewed as experts.

The interviews were conducted through a series of questions designed on the basis of the framework in Figure 4. Interview questions also attempted to compare the findings from interviews with senior level managers. Questions for acquiring experts' perspectives were designed in three main themes, experts' background, the strategy towards KE and the implementation of KE techniques currently applied in the organization. In addition, the interview questions for senior managers were designed in accordance with both the framework mentioned in Figure 4 and the questionnaire template used by Carrillo et al. (2004) in their research. The questionnaire template was divided into 5 main parts as follows.

- *Section A*: the detail information of respondent (e.g. name, position, experience, etc.)
- *Section B*: company background (e.g. annual revenue, number of employees, organizational structure, clients' types, etc.)
- *Section C*: different tools used for knowledge management (e.g. techniques used for KE and their weaknesses and strengths)
- *Section D*: performance measurement (e.g. the models used for performance measurement)
- *Section E*: knowledge management awareness and commitment (e.g. details of knowledge strategy implementation in the organization, barriers, available resources, etc.)

To prepare the interview questions, several questions supported by literature review and the proposed research framework were designed. Afterwards, it was attempted to merge and sort the questions into five sections mentioned above. Finally, 29 questions for senior managers and 14 questions for experts were finalized, which are presented in Appendix. To clarify vague questions and improve them, all designed questions were given to three persons for review. Two persons had no managerial background and they were completely unfamiliar with the knowledge management context.

Another reviewer had managerial background but not exactly on knowledge management. The reason of such reviewers' combination with different backgrounds was to make all questions as clear as possible so that they were clearly coherent for all interviewees.

Since different organizations might have different interpretations of KE, a terminology was provided to create a common understanding with interviewees. This terminology list accompanying interview questions were sent to interviewees in advance in order to get more structured and comprehensive information from interviews. In addition, extra questions were also asked during the interview as follow-up questions. Interviews with senior managers were conducted within 2 hours each while the interview duration with experts was 1 hour.

4 Empirical data

Findings of all interviews are described in this part. The empirical data of this study is divided into three main categories. First, the general background of case organizations is explained. Afterwards, the results gained from interview with senior managers in both case organizations are described. Finally, the interview findings on experts' perspective towards KE process in their companies are unfolded.

4.1 Case organizations' backgrounds

As mentioned in Chapter 3, two construction consultants were chosen as case organizations to investigate: Sweco Infrastructure and White Arkitekter AB. To be able to get more precise results, it was intended to choose similar organizations in terms of size, the number of employees, office dispersion, etc. The general background of the case companies is described as follows.

Sweco was founded more than a century ago and today has different sectors working on the projects in ninety countries worldwide. Sweco Infrastructure is the largest division of Sweco. Currently, there are over five thousand employees working in the whole company (Sweco). The Swedish Division has 2500 employees and it is divided into nine companies. A total number of 570 employees with Civil Engineering, architectural and environmental background are currently working in Sweco Infrastructure. Sweco Infrastructure is also divided into sub-divisions geographically spread into East, South, North, Mid-Sweden and two offices in Stockholm since it is a large district. One of the offices in Stockholm is working on heavy constructions and geotechnology while another office is responsible for road planning. The turnover of Sweco Infrastructure was around nine hundred million SEK in 2009. The net profit of this division of Sweco was ninety two million SEK in 2009.

White was founded by Sydney White in 1951 and the company was transformed to a limited company (White Arkitekter AB) in 1961 and since then it has been owned by the employees. Currently, White Arkitekter AB has around one hundred employees as main shareholders. The total number of employees working at White Arkitekter AB is around five hundred people. The company currently has eight offices in Sweden and two offices in Denmark. White Arkitekter AB is working in an international framework and its turnover was forty nine million SEK in 2009. White Arkitekter AB is working on all parts of architectural design such as product design, interior design, exhibition design, urban development planning, etc.

4.2 Senior managers' perspective

The interview findings from all senior managers interviewed at both case organizations are described in this section. First, the senior managers' background and their responsibilities are explained. Afterwards, the strategies of Sweco Infrastructure and White Arkitekter AB towards KE are investigated. Different tools for KE applied

in both companies, their strategies for performance measurement and finally case organizations' awareness and commitment on KE are explained in this section.

4.2.1 Senior managers' backgrounds

As mentioned in Section 3.2, four senior managers (3 persons at White Arkitekter AB and 1 person at Sweco Infrastructure) were interviewed in order to acquire information about the KE strategies currently applied in both case organizations.

Johan Dozzi (called SM1) was the only senior manager interviewed at Sweco Infrastructure. He started working at Sweco Infrastructure in 1994 after graduation with an M.Sc Civil Engineering. SM1 was working for five years as a Civil Engineer with the responsibility of designing infrastructures such as bridges and tunnels. For six years, he was the supervisor of fifteen engineers working for construction of nuclear power plants. Thereafter, Johan was assigned as Area Manager of Stockholm in 2005. He is CEO of Sweco Infrastructure since 2007.

Gisela Carlen (SM2) was one of three senior managers interviewed at White Arkitekter AB. She had a Civil Engineering background and started her job at a Swedish construction contractor (NCC) in 1991. After 11 years experience in a construction contractor, she joined White Arkitekter AB in 2002. She is currently in charge of Quality department and the Staff Manager. Gisela was also one of two vice presidents at White Arkitekter AB. As a head of quality management department, she was responsible for quality control through life cycle of projects in accordance with ISO 9001:2000 and ISO 14001:2004 standards.

Simon Svensson (SM3) was another senior manager interviewed at White Arkitekter AB. He was Civil Engineer and responsible for the knowledge part of project management network, which is one of the 15 different networks called knowledge construction division (Kunskapsbygget in Swedish). The project management network is divided into three different regions and totally has 28 employees (13 persons in Gothenburg, 10 persons in Stockholm and 5 persons in Uppsala). He was working for 10 years at White Arkitekter AB. SM3 was assigned in his current position in 2004 when the necessity of capturing knowledge by standard methods was perceived.

The Director of R&D department was the third senior manager interviewed at White Arkitekter AB. Fredrik Nilsson (SM4) began his work at White Arkitekter AB in 2000. He had architectural background and his responsibility was to transfer other companies' knowledge to White Arkitekter AB by analyzing what is being carried out in other companies. He was assigned as Director of R&D in 2007 while he was working 50% in the industry and 50% in academia. He mentioned that working simultaneously in both fields gives him the opportunity of being familiar with the existing gaps between academic context and what is being carried out in the industry.

4.2.2 Companies' strategy for knowledge elicitation

According to SM1, as Sweco is a consultant company, the process of knowledge management has started with its foundation. He believed that knowledge is the only

issue that a consultant sells; therefore knowledge management basically began with the establishment of the consultant firm. However, the last time that the Sweco steering group emphasized on knowledge management strategies was three years ago when they put the stress on knowledge creation within the company. As SM1 mentioned, every leader basically had a specific strategy for knowledge management and knowledge creation within the company. However, there is no specific department for knowledge management at Sweco Infrastructure.

Similarly, SM2 believed that White Arkitekter AB started the process of knowledge management with its foundation. She pointed out that since White Arkitekter AB is a consultant company, it could only survive in the market by knowledge creation. According to SM2, the fact that her company is not dependent on a person, it clearly shows the importance of knowledge management at White Arkitekter AB that has created such an environment.

Organizational structure and KE

Sweco Infrastructure has no formal department for knowledge management. However, SM1 mentioned that there are 8 technical organizations that work as cross-functional departments. The main responsibility of technical organizations is to capture the knowledge through different departments with regards to various expertise (e.g. tunnelling, road, nuclear power plant, etc). According to SM1, the captured knowledge by technical organizations is stored in databases for future reuse.

On the other hand, White Arkitekter AB established a knowledge construction division called Kunskapsbygget (in Swedish) as a sub-division of R&D department. That was the most important strategy of White Arkitekter AB towards knowledge elicitation that SM2 pointed out. The purpose of establishing such a division was to work on knowledge management with a formal structure. As SM4 mentioned, White Arkitekter AB was working on knowledge management since its foundation in 1961 with an informal structure, but they are currently working on KM in a more structured manner after the foundation of their knowledge construction division (Kunskapsbygget).

According to SM4, regarding the formal structure of White Arkitekter AB in knowledge management, the strategy of establishing 15 networks was applied. These networks separately work in various competencies such as project management, environmental issues, etc. However, they are connected in different ways to share their knowledge with other networks. These networks are basically knowledge-based and try to capture the specific knowledge domain (environmental, managerial, architectural, etc.) within the company and share it with all other offices. As SM4 mentioned, the company believes that there is lots of knowledge within the organization that must be captured to make it visible for every employee.

Performed efforts for KE

According to SM1, Sweco Infrastructure has two strategies for transferring experts' knowledge. The first approach that he mentioned was to assign an experienced employee in charge of the project as a coach of 2 or 3 juniors. In this case, the younger engineers could work on the assignments under supervision of an expert

engineer. On the other side, juniors who are more professional than experienced engineers in computer programs could accelerate the process of performing assignments.

The second strategy that SM1 named was a program called mentorship. It is a small group of employees (2, 3 talented juniors) working with 1 or 2 experienced engineers. They frequently have meetings (once a month or once every other week) to discuss about what has happened since the last meeting. In this case, the less experienced engineers could acquire the seniors' knowledge towards solving the problems.

White Arkitekter AB has similar strategies towards capturing experts' tacit knowledge. As SM3 mentioned, White Arkitekter AB has a traditional approach on knowledge management since every junior employee works in pairs with a senior level. In this case, the valuable knowledge of the senior managers could be directly captured by junior employees. Similar to SM1 interviewed at Sweco Infrastructure and SM2 at White Arkitekter AB, SM3 believed that the process of knowledge management especially knowledge elicitation begins when a consultant company is founded. His reason for such a conclusion was team work in construction consultant firms. According to SM3, every task is performed at White Arkitekter AB by a group of employees including 1 senior manager, 2 midway employees and maximum 3 juniors.

As described, Sweco Infrastructure and White Arkitekter AB have a similar strategy for capturing experts' tacit knowledge. However, they have different approaches towards knowledge elicitation with regards to expert categorizations. According to SM1, Sweco Infrastructure does not have any strategy for capturing experts' tacit knowledge in terms of experts' categorizations (academicians, practitioners and samurais). However, they consider such categorization when recruiting new employees. As SM1 mentioned, Sweco Infrastructure prefers to employ the expert engineers rather than training juniors since training programs are costly and time consuming.

Conversely, SM2 mentioned that White Arkitekter AB applies different strategies for eliciting experts' tacit knowledge. She believed that it is totally impossible to apply only one strategy and extend it to all other employees. SM2 mentioned that current strategy applied at White Arkitekter AB considers different categories of experts. According to SM3, the tacit knowledge of experts classified as samurai (auto problem solvers) could be elicited through mentorship where they work with juniors. In addition, SM2 believed that practitioners could easily get the information from their colleagues since they are located at the office based on their performing assignments. Considering the academician category, SM2 believed that the tacit knowledge of this kind of experts is captured through conducting seminars, symposia or workshops.

Regarding the strategies for knowledge elicitation performed in chosen organizations, SM1 mentioned that everything Sweco Infrastructure delivers to the clients is in the form of written documents such as drawings. Therefore, they store all written documents in a database as archives. According to SM1, these written documents consist of various points that designers used for a specific project. As a result, the stored documents could be reused in the future when designers are working on similar

projects. In this case, there is no need that the same engineers work on similar projects since their knowledge is already stored in accessible databases.

On the other hand, SM4 believed that their networks are a process of KE applied at White Arkitekter AB. He mentioned that the head of each network is responsible for connecting the knowledgeable employees to each other in order to share their knowledge. All networks have a special homepage in the company intranet. According to SM4, all important issues are stored in the relevant homepage and they are available for everybody who is interested in it. According to SM2, every network has the same templates and routines for storing documents in the database. Having such a database, which is available for every employee, leads to significant reduction of the cost of travelling due to office dispersion. As SM2 mentioned, the network meeting is held only once a year in order to discuss existing problems within the specific field of the network that should be brought up in the annual symposia.

In addition, White Arkitekter AB has another strategy toward KE called travelling seminars. As SM4 mentioned, there are short lectures held by several experts who travel between different offices. This strategy could reduce the cost of travelling since there is no need to gather all employees in a place every year. Holding annual symposia and workshops is another strategy of White Arkitekter AB that SM4 pointed out. Symposia are the larger events that have 50-150 participants. They are divided into different teams of 10-20 experts and discuss about a general issue. Specific issues are discussed during workshops. As previously mentioned, every important outcome of these events is stored on the homepage of every relevant network, which is accessible within the organization.

White Arkitekter AB has another strategy for knowledge elicitation. They publish the result of some of the research and development projects in the form of books, lectures and seminars. These projects could be financed by White Arkitekter AB or some external funds. They have also another annual event called a study trip for all employees. According to SM4, that event would be very important since all architects not only could become familiar with different architectural designs but also they could know more people working in the same fields.

Future strategy for KE

Both companies had different visions for their future strategy on knowledge management in their organizations. SM1 mentioned that Sweco Infrastructure is trying to capture knowledge within the project life cycle (Live capture). He believed that this is the most efficient way to learn new knowledge leading to knowledge creation within the organization. On the other hand, both SM2 and SM3 pointed out that White Arkitekter AB will carry on with the strategy that knowledge construction division (Kunskapsbygget) is currently pursuing. SM2 believed that the current strategy is useful; however it should be improved in the process of implementation. According to SM2, she receives around three hundred reports every year that would be a valuable source to get feedback in order to improve the current strategy towards knowledge management.

Considering continuous improvement strategies for KE and retaining knowledge in the organizations, both Sweco Infrastructure and White Arkitekter AB have almost

the same strategies. According to SM1, Lloyd's Register audits the quality systems of Sweco Infrastructure every year. Therefore, it could help the company to continuously improve its quality towards knowledge management. Similarly, DNV is the external auditor of White Arkitekter AB. According to SM2, the semi annual audit by DNV could also help them to improve current processes of knowledge management.

4.2.3 Different tools used for knowledge elicitation

Sweco Infrastructure and White Arkitekter AB are not exactly using any of the ten common techniques mentioned in Section 2.5.1 for eliciting expert tacit knowledge, but the applied techniques in both organizations could be similar to the chosen techniques. According to SM1, cognitive (causal) mapping, protocol analysis, structured interview, rating and sorting and log-in system have never been applied at Sweco Infrastructure. Furthermore, SM2 mentioned that cognitive (causal) mapping, protocol analysis, narrative interview, rating/sorting and decision analysis have not been used at White Arkitekter AB.

Applied techniques for KE

As SM1 mentioned, task analysis is a method currently applied at Sweco Infrastructure when juniors work under the supervision of seniors. Although they are using task analysis, the seniors' tacit knowledge acquired by juniors is not documented. SM1 compared unstructured and narrative interview with the mentorship program conducted at his company. He mentioned that narrative interview is usually applied when the experts are talking about their experience gained from past projects in the form of face-to-face conversations. However, such dialogues are not recorded for highlighting learning points from prepared transcripts.

Although SM1 pointed out that a log-in system is not found at Sweco Infrastructure, there is an intranet used to acquire information about mistakes in previous projects. He mentioned that in order to avoid occurrence of the same mistake in the project, the errors are collected and stored in the database. However, there is no possibility of storing this information directly in the databases by the expert. According to SM1, group decision making is a technique that Sweco Infrastructure applies especially during tendering where finding the best way is hard. Then, a couple of experts are gathered to find the best solution by brainstorming. As SM1 mentioned, it is important for the company to analyze the decisions based on existing risks. The outcome of this kind of knowledge elicitation is stored as written documents in databases for reusing in future tenders.

According to SM2, task analysis is used frequently at White Arkitekter AB (like Sweco Infrastructure). She compared the process of task analysis to the workshops conducted in the company. Furthermore, SM2 and SM4 considered White Innovation Process (WIP) as an elicitation technique, which is very close to the concept of task analysis and group decision making techniques. WIP is a special meeting that both designers and clients participate in to discuss about a specific assignment brought up by the client. However, no written document is being prepared for reuse in the future.

In addition, unstructured and structured interviews are conducted at White Arkitekter AB for eliciting experts' tacit knowledge. According to SM2, these two kinds of interviews (structured and unstructured) are used when there is more information required for a specific process. As an example of such a process, SM2 pointed out the new regulation recently provided for standardizing the process of solving assignments. They have conducted several interviews with some experts to be able to come up with formalized procedures.

Moreover, SM2 mentioned that log-in system is not used at White Arkitekter AB for eliciting experts' tacit knowledge, but a similar system exists for quality systems to share information. However, employees are not interested very much in getting required information from databases. According to SM2, White Arkitekter AB believes more in human contact and face-to-face discussions. In fact, they prefer manual techniques rather than automated methods for eliciting knowledge. She believed that group decision making is the common technique currently applied in her company. Meetings and workshops were two examples of group decision making that SM2 named. She believed that these techniques are used at White Arkitekter AB when they are trying to find the best solution for a certain problem. The outcomes of such meetings are sometimes documented in written documents.

SM2 and SM3 agreed with elicitation techniques currently applied at White Arkitekter AB while SM3 believed that the company does not have a clear strategy for documentation of elicited knowledge in a written format. He mentioned that his company had made some efforts to document captured knowledge, but because of time limitations and lack of sufficient human resources their attempts failed.

Strengths and weaknesses of applied KE techniques

As described in this section, SM1 compared the mentorship program applied at Sweco Infrastructure to unstructured and narrative interviews. According to SM1, the strength in mentorship programs could be the acquisition of valuable knowledge of experts by junior engineers and creation of a suitable atmosphere for inexperienced employees to properly think about specific issues. He counted this technique as a relatively strong technique currently applied in the company. However, he believed that they are not applying a really strong technique at Sweco Infrastructure.

SM2 named group decision making as a strong technique currently applied at White Arkitekter AB. Since every employee could be a shareholder of the company, she believed that everybody could contribute to the process of knowledge elicitation. Therefore, different opinions of employees could be discussed through the group decision making technique. As SM2 mentioned, documenting and storing the outcomes of such meetings in the databases relevant to each network, which is internally accessible, would be the main strength of this technique.

On the other hand, there are some weaknesses related to the techniques applied for eliciting tacit knowledge that interviewed senior managers were concerned about. According to SM1, the weakness of mentorship, which is similar to unstructured and narrative interview, is the inability to clarify which part of the knowledge would be important for sharing. He believed that the knowledge is too deep and broad and it is impossible to learn and teach everything to someone else. Furthermore, SM1 believed

that storing the knowledge that has been elicited is not very efficient since there is no guarantee that the elicited knowledge would be used in the future. For instance, the elicited knowledge from designers working on nuclear power plants might not be reused in the future since there is no guarantee that Sweco Infrastructure might have this kind of project in the future.

Both SM2 and SM3 agreed with existing weaknesses of elicitation techniques currently applied at White Arkitekter AB. They believed that the applied techniques in their company are not structured enough. In addition, SM3 believed that working with structured techniques needs more expert employees who are professionals in that field. Furthermore, SM2 mentioned that they apply the elicitation techniques regardless of where and what method is most suitable, but as SM3 mentioned, most of the outputs from applied techniques are not documented (except group decision making).

4.2.4 Performance measurement

All senior managers at both two organizations were asked about their organizations' strategies for measuring the amount of elicited knowledge, to validate the captured knowledge, to measure employee satisfaction on KE process, to reduce employees' workload and to get employees' feedback. The interview findings on these issues are described as follows.

Strategies for measuring elicited knowledge

The results showed that none of the organizations have structured methods to measure the amount of elicited knowledge. The interviewed senior managers at both companies have different opinions of this kind of measurement. As SM1 mentioned Sweco Infrastructure does not measure the amount of elicited knowledge. He pointed out that they measure the total amount of knowledge existing in the organization. Sweco Infrastructure considers the experience as the same as knowledge. This is the only method they use to quantitatively measure the amount of knowledge. According to SM1, this method is not only applied by Sweco Infrastructure, but is also used by a government client, Banverket (the Swedish Transport Administration), and other Swedish construction companies such as Skanska, NCC and Ramboll.

At Sweco Infrastructure, the total amount of knowledge is calculated by summing up the experience of employees in years multiplied by the number of employees who have the same amount of years of experience. Although this method is the only way for Sweco Infrastructure to measure the amount of knowledge, SM1 believed that this is not the best way since it is too approximate. He pointed out measuring the amount of elicited knowledge would be impossible at this moment.

White Arkitekter AB has a different approach towards measuring the amount of knowledge. According to SM2, DNV as an external auditor is responsible for qualitative measurement of the amount of knowledge. It should be mentioned that White Arkitekter AB does not measure the amount of elicited knowledge as well. SM2 believed that such measurement performed by DNV is not very thorough.

According to SM3, no standard method is used at his company for measuring the amount of elicited knowledge.

Strategies for validating elicited knowledge

Both companies have different approaches for validating captured knowledge in terms of accuracy. According to SM1, Sweco Infrastructure does not have any formalized and standard method to validate elicited knowledge. Since they make experience equal to knowledge, they believe that the knowledge of experienced employees is accurate enough to be reused in the future.

On the opposite side, SM4 mentioned that there are a number of experts at White Arkitekter AB who are responsible for validating elicited knowledge before storing it in the networks' databases. However, SM4 believed that just general solutions are stored in the databases. According to SM2, the most experienced employees are assigned to validate the elicited knowledge before sharing them through intranet. Furthermore, SM3 pointed out that the experienced employees who are in charge of knowledge validation frequently attend network meetings to keep in contact with the details discussed about specific topics.

Strategies for measuring employees' satisfaction on KE process

Considering the measurement of employees' satisfaction on elicitation techniques currently applied in chosen consultants, both companies have no formal strategy to measure how much the employees are satisfied with current KE processes. SM1 mentioned that every expert at Sweco Infrastructure is apparently satisfied with currently applied techniques for knowledge elicitation. He believed that most experts at Sweco Infrastructure are enthusiastically willing to share their knowledge with junior employees. This kind of enthusiasm was counted by SM1 as a sign of experts' satisfaction with current processes in knowledge elicitation.

Although White Arkitekter AB has also no specific strategy for evaluating employees' satisfaction on KE processes, they distribute several surveys to employees to get their feedback in general. According to SM2, this method could not clearly show the level of employees' satisfaction with applied KE strategies. She believed that according to the flat organizational structure at White Arkitekter AB, they are able to get employees' feedback continuously and measure their level of satisfaction. Furthermore, SM3 mentioned that they measure the employees' satisfaction with applied KE processes by having face-to-face discussions with both lecturers and participants in workshops, seminar, symposia, etc.

Strategies to reduce employees' workload in KE process

SM1 believed that being too engaged in the projects is not pleasant for the managers since they prefer to distribute their efforts in different projects. Therefore, Sweco Infrastructure usually puts less experienced experts to manage the project and assigns the senior experts to look over all the ongoing projects. In Sweco Infrastructure, they do not want the experts to be involved in irrelevant issues and decision making so they assign the responsibility to the experts with sufficient competency but less experience. According to SM1, there is an ongoing struggle between consultants and

clients since these insist that the best experts should work full time on their desired project. In addition, it should be mentioned that Sweco Infrastructure does not have any financial plan for motivating experts to contribute in the process on knowledge elicitation.

On the opposite side, White Arkitekter AB has an extra bonus for participants in KE processes. According to SM2, experts who contribute in KE processes get an extra bonus from the central budget allocated to such activities by the R&D department. This kind of financial bonus could satisfy the employees as compensation to heavy workload. In the meanwhile SM3 believed that employing more people is a solution towards reducing workload on experts. However, it could raise the company's expenses. Furthermore, using paired management in the form of two people working as project responsible where one is less experienced and the other expert is more skilled is a decision of White Arkitekter AB to reduce employees' workload.

Strategies for getting feedback on KE process

Investigation on the issue of getting feedback from experts regarding the acceptance of elicitation methods revealed that Sweco Infrastructure does not have any formal procedure to get experts' feedback on KE strategies. However, SM1 believed that the company culture is so that if there is an issue regarding the KE processes, the experts are welcome to talk about existing problems.

Similarly, SM2 as the senior manager in White Arkitekter AB believed that the open environment and the openness of the manager to questions and opinions create an environment where employees could express their beliefs and suggestions. SM3 also added that there is a process of getting participants' feedbacks after holding the events such as workshops and symposia. It was also mentioned that there are regular meetings performed by the project management department in the division of knowledge construction (kunskapsbygget) where responsible people gather from all the divisions to give feedback on the specific situations.

4.2.5 Knowledge management awareness and commitment

In accordance with the importance of knowledge in construction consultant firms as KBOs, all interviewed senior managers unanimously believed that their survival in business is to sell their knowledge. However, both Sweco Infrastructure and White Arkitekter AB have various strategies towards knowledge elicitation. In accordance with different strategies of case organizations, different perspectives of senior managers about companies' awareness and commitment on KE are described.

Company's responsible for KE

SM1 believed that everyone is responsible for capturing knowledge at Sweco Infrastructure. From the senior managers to the area managers and division managers they are responsible for capturing knowledge and their main aim is to turn juniors into well known experts. The investigation showed that there is nobody at Sweco Infrastructure in the position of knowledge engineer with the clear responsibility of eliciting experts' tacit knowledge.

In the same manner, SM2 believed that everyone feels the responsibility to manage and capture knowledge at White Arkitekter AB. Both SM2 and SM3 pointed out the Director of R&D Department (SM4) as one of the people who is explicitly responsible for knowledge management. This is while SM3 also believed that the heads of networks as sub-divisions of the knowledge construction sector (kunskapsbygget) are responsible for KE and facilitation of knowledge sharing. All senior managers interviewed at White Arkitekter AB agreed that there is no knowledge manager in their company who is explicitly responsible for knowledge elicitation.

Based on the fact that there is no knowledge engineer in both companies by the definition presented in the literature, the backgrounds of the people who had the closest responsibilities to knowledge engineers were considered. As mentioned by SM1, the backgrounds of these employees are mainly the same and they are all Civil Engineers at Sweco Infrastructure. SM2 interviewed at White Arkitekter AB believed that there has been an evolution in her company during the last ten years from pure architects towards various professions that fit to the job description. Confirmatory to this fact, SM3 mentioned that his employees with different backgrounds such as Civil Engineering are currently working at White Arkitekter AB.

Priorities for eliciting knowledge domains

Considering the knowledge domain elicited in the investigated organizations, SM1 mentioned that the main domain of knowledge that they are concerned with at Sweco Infrastructure is the managerial knowledge where the main emphasis is on capturing the experience to manage projects in the organization. He believed that the technical knowledge stands in the last priority where administration and regulations are second and third in the ranking. According to SM1, the reason that technical knowledge stands at the end of the list was that there are no two designs that are totally similar to each other. Therefore, the details of the designs are different and impossible to generate to all other projects. He also added that the main focus is to elicit non-technical knowledge especially in cases where the company wants to make a bid for a contract or managerial issues as mentioned above.

This is also the case for White Arkitekter AB. SM2 and SM3 believed that managerial knowledge is the most important domain that should be elicited since it could be easily reused in the future. They assigned the lowest priority to technical knowledge. SM3 also believed that the regulation domain could be also ranked with the lowest priority since it does not change very much over time. All senior managers interviewed at White Arkitekter AB agreed on the reason of ranking technical knowledge with the lowest priority. Similar to SM1 interviewed at Sweco infrastructure, they believed that every project is unique and technical knowledge is not something that could be used in different projects.

Strategies for KE efficiency

According to four parameters involved in efficiency of KE strategies (time, cost, effort and knowledge yield), both companies had different strategies for combining and prioritizing them. SM1 believed that the combination of these parameters could be different under various circumstances. He mentioned that the cost of giving juniors to experts for being educated could impose a high amount of cost to them since their

main costs are the salaries that they pay to the employees. SM1 mentioned that because of the lack of the seniors with the experience between 30 to 40 years, Sweco Infrastructure has a hard condition to balance the time between knowledge elicitation from experts and their occupation on projects. SM1 also believed that continuing this attitude would not be in favour of Sweco Infrastructure since there would be lack of knowledge transfer in the company.

In addition, both SM1 and SM3 mentioned that knowledge yield and effort have the same meaning for them. Since occupying available time leads to escalating costs, SM1 interviewed at Sweco Infrastructure believed that they have also the same meaning. According to SM3 interviewed at White Arkitekter AB, since their employees are willing to share their knowledge, they do not need to consider their employees' efforts. For SM2, the issue of cost had the dominating importance and she also mentioned that they should also think about the cost of not eliciting knowledge in the organization. According to SM3 time is the most important issue in the efficiency of KE strategy while money was the vital factor for SM2. Overall, the result of investigation showed that there is no unique opinion at White Arkitekter AB on the priority and combination of four mentioned factors that could affect the efficiency of KE strategy.

Strategies to motivate employees on KE

The investigation of both companies on the incentive programs to motivate employees in the process of KE showed that Sweco infrastructure has no such plan. According to SM1, Sweco Infrastructure has no financial bonuses counted for experts in return of eliciting their knowledge. He believed that there is no need for such bonuses since their experts have a high salary due to their importance for the organization.

On the other hand, SM2 reminded that White Arkitekter AB is owned by the employees so this is enough motivation for them to participate in knowledge elicitation processes. SM3 added that the culture in White Arkitekter AB is a basis for motivation among employees. He also mentioned White Awards for outstanding projects and also the paired management style for employees as a good motivation for experts to share their knowledge with juniors. He also added that many employees are motivated because in return of sharing their knowledge they would get a better reputation in their business. Therefore, these are reasons that engage experts in the process of knowledge elicitation.

Strategies towards employees' psychological attributes

Considering the question about psychological attributes of experts before designing processes to elicit their tacit knowledge, SM1 mentioned that they are using the DISC assessment which is an abbreviation for Dominance, Influence, Steadiness and Conscientiousness at Sweco Infrastructure. Through using this method they can understand the personal attributes of the experts. According to SM3, White Arkitekter AB has also the same method to find the personal characteristics of the experts. SM2 mentioned that through her experience she has understood that different people have different understandings of the attitudes towards them. As an example, some employees need to be reminded through email while some need to be contacted through face-to-face interactions.

Sweco Infrastructure does not have any plan for showing the purpose of knowledge elicitation to the experts. SM1 believed that there is no need to visualize to the experts the purpose of knowledge elicitation processes. The reason he thought was that firstly no standard technique was applied at his company. He also believed that the importance of knowledge sharing is rooted in the mindsets of the employees because they already know it. Similarly, SM2 could not define any plans for visualizing the process of knowledge elicitation at White Arkitekter AB. According to SM3, since experts are involved in the development of the plans for further processes, they are already convinced about the importance and the processes of knowledge elicitation.

Issues in implementation of KE strategies and possible solutions

In the case where the intention was to investigate the reasons and objectives that hamper the implementation of KE, SM1, SM2 and SM3 believed that since experts are always occupied with their assignments, they could not find enough time to concentrate on KE processes. SM4 mentioned that there are difficulties to formalize KE processes. He also added that some experts believe that if a formalized KE process is applied, the dynamic and creative nature of the work would be lost. According to SM2, the current techniques of KE used at White Arkitekter AB are not very useful since finding a way to reach experts minds is hard and an unknown issue to them.

Geographical dispersion of offices is one of the problems that could also hinder the process of knowledge elicitation. Based on the findings from interview with SM1 at Sweco Infrastructure, he pointed out that the solution to overcome this problem is the presence of regular meetings with the experts from all over the divisions. SM2 and SM3 also believed that IT tools and intranet connections have been helping to overcome this problem. Chat boards, video meetings and telephone meetings are examples of such. Adding to these, SM3 also thought that if the experts are obliged to report their projects before closing down the project, this could help facilitate the process of capturing knowledge. He also generally added that having more employees and earning more income could help increase the efficiency of knowledge elicitation. Hiring more employees in the desired experience range of thirty to forty years is also considered.

Regarding the problem of employee resistance in the organizations, SM1 mentioned that the regular meetings scheduled twice a year in Sweco Infrastructure have created the atmosphere for sharing knowledge. According to SM1, if he is confronted with some expert who is not willing to cooperate, he would remind that this is part of their responsibility to give their knowledge and also the monetary sanctions are considered as a solution to reduce employee resistance. Unlike Sweco Infrastructure, SM2 believed that the reason that employees want show resistance is that they want to have the option to choose their desired project before they are assigned to it. She believed that the solution to this resistance is the implementation of the belief system that employees have to go through their own path of knowledge. SM3 also mentioned that he usually gets resistance in the form of the answer "*sorry I don't have time now*" that could be reduced through earlier planning to meet the experts.

In general, efforts to facilitate knowledge elicitation in the organization were mentioned by the senior managers. SM1 believed that changing the interior design of

the company from a closed room to open rooms could facilitate the communication between experts. However, he did not point out anything regarding the documentation of elicited knowledge as the main purpose of knowledge elicitation. In response to this question SM3 also believed that employing more people to be responsible for capturing knowledge and planning further strategies is a resolution to the upcoming problems of knowledge elicitation.

4.3 Experts' perspective

In this section, interview findings from experts are described. This section is divided into three different parts. First, the experts' backgrounds and their responsibilities are explained, thereafter, the experts' perspectives on KE strategies in general followed by their opinion on implementation of KE strategies in their organizations.

4.3.1 Experts' backgrounds

Ulrica Nilsson (called E1) was the expert interviewed at Sweco Infrastructure. Her responsibility was as area manager in Stockholm. She has been employed in the company for a year and her past experience is from the Swedish road administration (Vägverket). Her main responsibility is to take care of the issues that concern management in the areas of bridges and tunnels and in the Stockholm region.

The expert interviewed at White Arkitekter AB was Åke Johansson (called E2) with architectural background. He has been working at White Arkitekter AB since he graduated in 1974 and after 12 years he was one of the partners of the company. He has been working as a multi tasked person: partly responsible for architectural projects and partly in the leading role. First, E1 was working in Linkoping and after 1991 he was promoted to chief executive in Gothenburg branch until 2006. Thereafter, he has left his leadership role to a younger partner and continued as a senior architect.

4.3.2 On knowledge elicitation strategy

While moving further to investigate the strategies in the company the respondents were asked to discuss the importance of being informed about the purpose of knowledge elicitation to their thoughts. Unlike E2, E1 mentioned that it is important to know the importance of sharing and eliciting knowledge since the experts do not have enough time and it is important for them to know who and why they are sharing their knowledge with.

She further explained that to make a feasible KE process, it should be attempted to justify the importance of sharing knowledge. This process could be done by emphasizing that there is someone who is important to share their knowledge with. E2 believed that there is no need for highlighting the importance of KE in the organization and the reason is that there is a hidden incentive in the culture of White Arkitekter AB based on better reputation in return of sharing their knowledge. He further pointed out the problem of employee resistance in the case of sharing knowledge with other people who they feel might use the knowledge to seek predominance over them. According to E2, he is confident to share his knowledge

through a face-to–face interaction. Therefore, he never gives his knowledge out through an interface where he has to sit and report his knowledge by himself.

E2 believed that sharing and eliciting knowledge is basically possible when the person that the knowledge is given to has the same background and is aware of the terms used in the conversation. E1 could not confirm the presence of knowledge engineers in Sweco Infrastructure and also believed that she has no experience of people interested in eliciting expert's knowledge. Furthermore, she concluded that since the knowledge sharing is in the form of face-to-face meetings at Sweco Infrastructure, there is no knowledge engineer who is responsible for eliciting experts' tacit knowledge.

4.3.3 On implementation of knowledge elicitation

E1 believed that a closed database system was an unsuccessful experience that Sweco Infrastructure had since bulk of information was available with less usability. However, she mentioned that having an open database with easier search functions that comprises all the projects could help the employees to search and find relevant information in an easier way. On the other side, E2 believed that the inherent weakness in current applied elicitation techniques at White Arkitekter AB is related to lack of routine and standard techniques for eliciting and sharing knowledge. He mentioned that the transfer of knowledge at White Arkitekter AB is currently based on ad hoc and random situations where employees get to share their tacit knowledge with others in case of interaction. He also believed that seminars and symposia are based on choosing employees who have a valuable knowledge that is worth sharing in large scale with others.

E1 believed that the culture of sharing knowledge at Sweco Infrastructure and experienced personnel are strengths for Sweco Infrastructure with regards to KE processes. She mentioned that highlighting the importance of knowledge sharing from the leaders is a way to reinforce the company's culture for sharing knowledge. Similarly, E2 believed that culture is the dominant strength of White Arkitekter AB in KE processes. As he mentioned, the knowledge construction division (Kunskapsbygget) is another strong point for the company. According to E2, holding seminars and gatherings by this division could help the organization to share knowledge more easily.

According to E1 interviewed at Sweco Infrastructure, having the chance to participate in gatherings and events such as conferences is a good incentive for employees to be willing to share knowledge. She also added, rewarding and highlighting the competency gained through these participations could lead to more interest in giving out knowledge. As E2 interviewed at White Arkitekter AB mentioned, the incentives that can motivate an expert could be gaining a good reputation for sharing knowledge in the company and resulting in gathering more creative employees and creating a better project. Furthermore, having monetary incentives was considered as a useful method to motivate the experts for sharing knowledge.

Further investigation about the issues concerning implementation of KE techniques revealed that Sweco Infrastructure has no formal procedure for KE. According to E1, she is usually exposed to questions from people inside and outside of the company

asking her to share knowledge with others. She could not categorize the phases for knowledge elicitation during her work period at Sweco Infrastructure. According to E1, mentorship groups which have been formed to spread experts' knowledge to the junior employees are also a matter for KE in the company. On the other hand, E2 believed that there is an ongoing KE process at White Arkitekter AB. This process includes informal communications between experts, occasional seminars and gatherings that happen from time to time.

E1 interviewed at Sweco Infrastructure believed that the elicitation of knowledge is possible just through interactions between people who need knowledge and people who are willing to share their knowledge. Therefore, she believed that knowledge could not be shared via an intermediate (e.g. knowledge engineer). In other words, it is hard to share the knowledge with a knowledge engineer since he/she is not the main and final receiver of knowledge. Similarly, E2 believed that there should be an interface to share the knowledge between employees in order to implement proper KE. He pointed out that he has not done any reporting through self report interfaces.

Although E2 did not recognize any knowledge engineer at White Arkitekter AB, he found the Director of R&D as the function closest to the definition of knowledge engineer who attempts to facilitate knowledge sharing. Furthermore, E2 came to believe that for sharing knowledge, both individual and group interactions could be useful and he was aware of their usefulness by the content. However, his main interaction in daily routine is through face-to-face meetings with others.

According to E1, the case of competition was an important issue. When the person who is giving the knowledge belongs to a competitor company, it makes the situation uncomfortable. In general, she believed that nothing would create uncomfortable conditions when she is sharing knowledge with her colleagues inside the company. As E1 mentioned, during the group decision making, she tried to convince the person who is not accepting her advice. E2 in response to the same question believed that the factors that create an uncomfortable situation for KE would be where the expert feels that the person sitting in front of him/her does not understand what he/she is talking about. Furthermore, when the audience is asking very challenging questions, it would make the situation uncomfortable. However, E2 believed that the nature of construction consultant firms needs such a challenging discussion.

Considering the factors that hinder KE processes, E1 interviewed at Sweco Infrastructure believed that the nature of engineers' attitude towards problems makes them see every issue as a new problem. Therefore, they attempt to solve problems by themselves, which is time consuming and costly. As she mentioned, it is hard to find a user friendly knowledge database with easy search and keyword functions. She believed that having a third person such as a knowledge engineer as mentioned earlier is not efficient and hampers the sharing of knowledge. According to E1, spending time to share the knowledge with a person who is not the user of elicited knowledge could not be useful.

The factor that E2 believed that could hinder the implementation of the KE process could be mainly job security especially in recession time. In fact, in recession time the employees tend to keep their knowledge as a key factor since they are afraid of being laid off due to budget limitation. The second priority issue that can hinder the process

of knowledge elicitation is organizational culture. According to E2, if an organization does not have a strong culture for knowledge sharing, it can be an important obstacle for KE.

In accordance with the classification of experts when solving problems, E2 mentioned that he mainly seeks advice from colleagues due to the nature of his work environment. In the next level, he also uses references and academic literature in order to meet the needs of the assignment in hand. However, E1 mentioned that she is mainly concerned with making decisions by herself and second in place is taking advice from other colleagues. Both experts interviewed at Sweco Infrastructure and White Arkitekter AB agreed that the way they solve problems in their working environment mainly depends on the situation that they are exposed to.

Since both companies (Sweco Infrastructure and White Arkitekter AB) do not have any formalized procedure for KE, both interviewed experts tried to choose the most useful KE techniques considering the nature of construction consultant firms. They attempted to select the most familiar and feasible ones amongst ten common KE techniques listed in the terminology list that they received in advance. E1 believed that task analysis and group decision making would be suitable techniques. In addition, she believed that automated methods (e.g. log-in systems) are inappropriate. Meanwhile, E2 mentioned that decision making, cognitive mapping, protocol analysis, and both structured and narrative interview techniques are capable of being implemented and introduced based on the current characteristics of the environment. Considering the nature of tasks in an architectural firm, E2 personally preferred group decision making as the most suitable method for implementation in his assignments.

5 Discussion

In this section the evaluation framework (Figure 4) is used as the main road map to evaluate findings. The discussion in this chapter is divided into three sections where the main intention is to evaluate and propose arguments based on this framework. Before moving into the first section some general discussions and findings on the overall status of the case organizations are brought to sight. The first part goes through the evaluation of independent variables (Section 3.1.1) with the main focus on elicitation tools and techniques. The second phase moves in depth to discuss the current moderator variables (Section 3.1.2) and analyze their status in case organizations. Finally, the third section of the discussion is concerned with evaluating the dependent variables (Section 3.1.3) in the case organizations with the aim to base the arguments on the theories mentioned in Chapter 2.

Based on the theory by Nonaka et al. (1994) organizations should benefit from the circulation of knowledge on a platform where knowledge is transferred from tacit to explicit and vice versa. Thus, our findings do not consent to this fact because construction consultants that were chosen as case studies mainly focus on transferring tacit knowledge from experts to other experts. This method is identical to *socialization* based on the SECI model proposed by Nonaka. This is while *externalization* is missing in both case organizations based on interviews with their senior managers. In these interviews none of the methods applied in companies focused on documenting elicited knowledge which is the final step in making a complete KE process.

Among the barriers to implementation of KE techniques listed by Kivrak et al. (2008) both Sweco infrastructure and White Arkitekter AB suffer from lack of standard processes, insufficient time and budget for eliciting tacit knowledge as also mentioned by Carrillo et al (2004). Among the barriers, employee resistance was not an issue for either of the companies. The IT tools in White Arkitekter AB are not as robust as expected by the managers. This is while Sweco Infrastructure has strong IT systems although they do not use it as expected to capture knowledge. Lack of a routine process is one of the problems that are inherent in both Sweco Infrastructure and White Arkitekter AB. Budget limitation and the risk of losing organizational culture were also highlighted by the expert at White Arkitekter AB. Also the expert in Sweco Infrastructure pointed out the problem of time consumption and high cost of implementing the methods.

5.1 Evaluation of independent variables

Polanyi (1966), as the pioneer in tacit knowledge theory, followed by Carrillo et al. (2004) emphasized the importance of documentation in the process of knowledge elicitation and the inherent problem of communicating the articulated tacit knowledge. The importance of documentation in KE process was also confirmed by the senior managers at White Arkitekter AB and shows the match between findings and the basic dilemma in elicitation of tacit knowledge.

Considering the classification of different KE techniques summarized in Table 4, both case organizations only apply manual and non-contrived KE techniques. Except task analysis classified as an indirect technique, all other techniques applied at Sweco Infrastructure and White Arkitekter AB are direct methods. The interview findings showed that the case organizations apply both specific and general elicitation techniques, which can be used to elicit specific and general forms of tacit knowledge.

Attempts to identify KE techniques used in companies led to the understanding that the case companies do not use these techniques under the exactly same definition and names, but what they actually do in their organizations has similarities to KE techniques brought up in the interviews. Sweco Infrastructure could identify task analysis, unstructured interview, narrative interview, group decision making and decision analysis as techniques that are currently applied. White Arkitekter AB also identified task analysis, unstructured interview, structured interview and group decision making. The applied techniques in both case organizations are evaluated as follows.

5.1.1 Evaluation of applied KE techniques in case organizations

Task analysis is the common technique in both companies, although they have no documentation on the tasks they analyze. Hoffman et al. (1995) emphasizes the toughness of the test cases in elicitation procedures that could affect the quality of the elicited knowledge. This is while none of the companies consider the toughness of the tasks as a factor. It could be added that the tasks analyzed in the companies are not from the archives and are mainly real case analysis based on their ongoing projects rather than a task analysis. Furthermore, unstructured interviews are the second common methods used in the companies. There is also no recording of the sessions while Schreiber (2000) indicates that recording the interview increases the accuracy of the elicited knowledge.

Group decision making as the third common technique for eliciting knowledge in the companies is very close to the definition presented by Hoffman et al. (1995). Sweco Infrastructure mainly uses group decision making to create templates for tendering phases. White Arkitekter AB does record the knowledge with less emphasis on documentation. WIP (white innovation process), meetings and workshops are considered as examples of group decision making techniques conducted at White Arkitekter AB.

Narrative interviews are only common in Sweco Infrastructure. Kwong and Lee (2009) argue that it is essential to record and transcribe the interview to get the results, but Sweco Infrastructure does not perform these two steps. Therefore, it is arguable that experience is mainly transferred from expert to expert rather than being recorded and retained. These unstructured interviews and narratives are actually integrated into mentorship programs at Sweco Infrastructure. Decision analysis as the other technique applied in Sweco Infrastructure is mainly used for tendering decisions. As mentioned by Bradshaw et al. (1991), the outcome of decision analysis technique should be in the form of a mathematical model to base the decision on it. The only thing that does not conform to the definition of decision analysis technique is the absence of a knowledge engineer for analyzing the decisions.

Structured interview is a method that is also used solely at White Arkitekter AB. This method is mainly used to get feedback from the employees on certain issues. This method is not very common at White Arkitekter AB and the process lacks the recording step in structured interview as it was highlighted by Schreiber (2000).

According to Table 5, the strengths and weaknesses of the currently applied KE techniques in case organizations are highlighted in order to pin-point the main reasons for utilizing them at Sweco Infrastructure and White Arkitekter AB. The main strength common to the applied techniques is the ability to reveal the reasoning path of the expert while making decisions. However, task analysis technique only reveals what the expert performs. Among all the interview techniques used as a method, ability to clarify vague points to the experts is considered as a strength point. Senior managers also conform to the theories through highlighting these points as their desired outcome. For instance they use these techniques when their intention is to find and draw a plan for a new project which contains several steps for decision making.

The greatest weakness that is evident in the methods used in both case companies is time consumption (task analysis, unstructured interview, decision analysis). Furthermore, among all the interview techniques applied in case organizations, two main obstructions are inherent in these techniques. First, it is the inability to understand the important parts of the interview for the knowledge engineer. Second, the expert might not reveal all the knowledge due to the chance of being jeopardized. This also is in accordance to the findings from interviews showing that the main obstruction during KE process is the lack of time on behalf of the experts. This fact was also highlighted by Turner (1990) and Schreiber (2000). Total weaknesses and strengths of applied KE techniques were summarized in Table 5.

Based on the recommendation by Hart (1985) emphasizing on the combination of KE techniques as a solution to overcome inherent weaknesses in each elicitation tool, the interview findings showed that both case organizations applied various techniques for capturing and sharing knowledge. However, the applied techniques could be improved by documenting the elicited knowledge, which is considerably poor in both case organizations.

The study trips of White Arkitekter AB are used as a tool for knowledge creation and knowledge sharing. It could be said that this method is a method tailored to the needs of the company. Since White Arkitekter AB is more of an innovative company, this technique could be useful. On the other hand, it would not be useful for Sweco Infrastructure since this company is more of a centre with relatively repetitive assignments that have the same theme. However, the future strategy of Sweco Infrastructure is worth mentioning. As they indicated, the company is planning to move towards live capture of knowledge, which is in accordance with the recommendation by Tan et al. (2007). On the other hand, White Arkitekter AB is satisfied with their current strategy and is planning to move forward in the current approach.

As mentioned in Section 2.3, Desouza (2003) divided the tools for transmission of tacit knowledge into two main categories: IT tools (email, chat etc.) and people-centred approach (face-to-face meetings). Our findings have shown that seniors in the case companies prefer to use the people-centred approach rather than IT tools. It could

be concluded that the IT tools have not been successful in attracting the interest of experts for KE. The experts have both mentioned this fact and prioritized face-to-face interactions. This is while the strategy in Sweco Infrastructure is towards live capture of knowledge. As Tan et al. (2007) discussed on the issue of live capture, the use of IT tools is inevitable for this kind of approach. Therefore, it could be claimed that Sweco Infrastructure should turn their focus on more robust and user friendly IT tools.

5.1.2 Potential KE techniques to be applied

It can be argued that protocol analysis is in some ways useful for the organization. Schreiber (2000) emphasizes the fact that protocol analysis could be conducted both with and without the presence of a knowledge engineer. It could be suggested that the use of this elicitation model is useful for the company to identify the thinking process of the experts when solving a problem or making a decision. Rating and sorting methods are also useful to identify the categories hidden in the mind of an expert with regards to various definitions and keywords related to a specific knowledge domain. This could help the designers of the knowledge systems to create search functions that are based on the mind map of experts.

As addressed by Ambrosini and Bowman (2001), cognitive map is a useful method to elicit personal knowledge and experience of an expert regarding a specific task. Since the output of this technique is in the form of a graphical representation, it could be useful to be applied in architectural consultant firms. The reason is that architects are handy with graphical forms. The expert interviewed at White Arkitekter AB also confirmed the suggestion via the interviews by proposing this method as a useful method in the company. This method is highly dependent on the presence of a knowledge engineer. However, the lack of knowledge engineers is evident in both case organizations.

Log-in systems are amongst the techniques that are not being used. If it is properly applied, this technique could have fruitful results. Since based on Tan et al. (2007) the presence of knowledge engineer is unnecessary for this technique, it could reduce the costs for the company and solve the problem of expert dispersion in organizations. This suggestion was criticized by the expert interviewed at Sweco Infrastructure as she believed that automated techniques are not as useful as expected.

5.2 Evaluation of moderator variables

As mentioned in the evaluation framework (Figure 4), four main factors must be considered when evaluating KE process: human components, problem space characteristics, system development approach and organizational environment. Considering these moderator variables, KE processes of both case organizations are evaluated in this section in accordance with components mentioned in Table 6.

5.2.1 Human components

Individual attributes of the experts should be considered as an element that could affect the methods and dependent variables for KE. Both companies consider their employees attributes through utilizing appropriate diagnostic methods. For instance, Sweco Infrastructure chose to implement the DISC assessment method. White Arkitekter AB is also using a method similar to DISC. These tools are a means to find the characteristics of the experts to facilitate communications with them. However, they are not used in selection of KE techniques.

When choosing appropriate elicitation techniques Schreiber (2000) argues that tools for eliciting knowledge are dependent on the individual attitudes of the experts. He divided experts into three main categories (academicians, practitioners and samurais). The findings show that Sweco Infrastructure does not divide their experts into any categories and White Arkitekter AB conversely does consider the attributes of the experts. It could be argued that when choosing the techniques for eliciting knowledge, one should consider the approach of the expert towards problem solving since it could affect the choice of elicitation techniques.

The framework also emphasizes the attributes of knowledge engineers. While Von Krogh et al. (1997) highlighted the role of knowledge engineer in facilitating KE, the findings showed that neither of the companies had an explicit definition for knowledge engineer. In fact, the role of a knowledge engineer was empty in both organizations. The expert in Sweco Infrastructure also was sceptical about the presence of a knowledge engineer since she thought it would create chaos in the company. Maybe this view could be due to the absence of a clear definition of what a knowledge engineer could perform as a facilitator in the companies On the other hand, in White Arkitekter AB, the patterns of experts who were somehow close to the definition of knowledge engineer where noticeable.

Further on Tan et al. (2007) drew on the fact that having the same background as the experts is a positive point for knowledge engineers since it could create a mutual understanding. We could conclude that this fact is true since the expert in White Arkitekter AB believed that having the same background as the knowledge engineer is a strength point in relation to communication with each other. Senior managers also confirmed that the people responsible for eliciting knowledge in White Arkitekter AB generally have the same background in the company. The experts similarly believed that if there is to be a knowledge engineer, the background of them is important and it is better for them to discuss their professions with someone who could understand their domain of expertise.

5.2.2 Problem space characteristics

The complexity of the knowledge domain is also a fact that is considered in the evaluation framework. None of the companies have strategies for designing the elicitation routines based on the complexity of the knowledge domain as mentioned by Dhaliwal and Benbasat (1990). Attempts to investigate the knowledge domains that case companies are covering led to the result that they mainly focus on the managerial knowledge and that the technical domain stands at the lowest level of

priority. The reason they are weak in capturing technical knowledge as mentioned before was the difficulty of covering technical knowledge and the complexity of technical data. They believed that technical designs are not similar; therefore, storing them is useless and hard to implement. It could be thought that the companies are somehow addressing the difficulty in categorizing technical domain. It would be suggested that if companies move towards tools that could help categorize the domain in a useful manner this would solve part of the problem.

5.2.3 System development approach

Neither of the case companies have a system development approach. Their main focus has been on capturing data regardless of having a database system designed for it, which is identical to traditional life cycle definition in the evaluation framework. This method is being used without any consideration of rapid prototyping in the companies. Since they are not using techniques such as log-in systems, they would not be in need for any rapid prototyping system before eliciting experts' tacit knowledge. As also mentioned by an expert in Sweco Infrastructure, the database developed for retaining knowledge was a difficult attempt and had problems.

5.2.4 Organizational environment

Organizational environment should be considered as an input that could affect the choice of independent variables along with the dependent variables. The awareness and commitment in the organization, level of management support and past organizational experience are the three main factors of organizational environment. Although the senior manager at Sweco Infrastructure mentioned that there have been movements towards organized knowledge creation in the company, it could be fairly said that there still has not been any significant attempts towards eliciting the knowledge in the company. This is while White Arkitekter AB has more focus on knowledge capture and sharing in the company.

The formation of a knowledge construction division (Kunskapsbygget) in White Arkitekter AB shows that there has been more attention towards formal knowledge management than at Sweco Infrastructure. All the interviewees were highly aware of the importance of knowledge management and elicitation since their survival is dependent on their profit from selling knowledge as their main asset. Showing the purpose of KE has also been highlighted in the academic literature. The findings showed that the senior manager interviewed at Sweco Infrastructure believes that there is no need to visualize the purpose of KE while the expert working at Sweco Infrastructure believed that it is important for the expert to know who they are delivering their knowledge to.

Kwong and Lee (2009) have addressed the necessity of voluntary participation of experts in knowledge elicitation sessions. The findings showed that Sweco Infrastructure does not have any specific incentive for motivating the experts; rather they have focused on classifying KE as part of the employee's responsibility. This is while White Arkitekter AB benefits from a hidden incentive for the employees. That is the opportunity given to the employees for buying a share of the company. This

makes the experts feel that they are responsible for the survival of the company since their money is involved too. The presence of an incentive program was highlighted by Carrillo et al. (2004). This presence is pointed out by the interviewed experts as an obvious motivation factor. The expert in Sweco Infrastructure added that one of the possible motivations could be through the utilization of travels and participation in symposia and educational events.

Carrillo et al. (2004) highlight the barrier to communication due to hierarchical structures in the consultant companies. This is while the findings showed that both companies have implemented structures in order to resolve this issue. Sweco Infrastructure has developed its technical organizations, which are cross functional units. White Arkitekter AB has also developed networks, which also have the same role in the company. This is suggested by the same author as a solution to the problem.

Employee resistance as mentioned by Kivrak et al. (2008) is an issue that hampers the KE process in organizations. The findings showed that there is not much employee resistance evident in the case companies. The reason could be the presence of a knowledge sharing culture. This was also pointed out as a strength point by the experts in case companies. White Arkitekter AB also has the advantage of the ownership of the company by the employees. This could have important advantages resolving employee resistance in the organization.

Wong and Radcliffe (2000) criticize the process of "learning by doing" due to its high cost and low time efficiency. The findings showed that Sweco Infrastructure has a so called mentoring program where experts spend their time to educate new employees while they are performing in projects. Although this is a useful method for creating a robust basis for juniors' education, the mentoring program imposes a high cost for the company and takes time from the experts. This happens while the senior manager at Sweco Infrastructure mentioned a rate of junior employee turnover. From this perspective, the company is investing in an individual asset whereas it should have focused on creating organizational assets through documenting the knowledge gained from experts. Should this be the case, knowledge would be retained in the organization and the time and cost spent for educating junior employees would be saved for other uses in the company.

From another perspective, when experts leave the company (for instance due to retirement), they take their valuable tacit knowledge with themselves. Hoffman et al. (1995) mention that if there is no strategy for capturing and retaining experts' knowledge, this could mean a strong loss for the organization. As findings show, Sweco Infrastructure and White Arkitekter AB have their eyes on this fact, but still they do not have a structured plan for eliciting and documenting experts' tacit knowledge. White Arkitekter AB has implemented a school for educating their juniors by the seniors who would be leaving the company, but this is not the substitute for documentation of experts' tacit knowledge.

5.3 Evaluation of dependent variables

According to the evaluation framework shown in Figure 4, both case organizations were evaluated based on dependent variables, which are efficiency and quality of KE. These two issues are separately described in this section.

5.3.1 Quality of KE processes

Among the dependent variables affected by different elements mentioned in Table 6, validity generally refers to the accuracy and reliability of the knowledge captured through KE techniques. This validation is important since it could affect the quality of the elicited knowledge. The interviews revealed that Sweco Infrastructure does not consider elements that could affect the validity of the captured knowledge. Although they believe that the amount of experience is in direct relation with the accuracy of elicited knowledge, there are many hidden biases in this approach that could not be diagnosed without proper evaluation routines. The findings showed that there are some general criteria at White Arkitekter AB for evaluating knowledge before moving it to the next stage. Mainly, the highly experienced employees in the organization have a responsibility to evaluate the captured knowledge.

The value of elicited knowledge is manifested through the degree of user satisfaction with the implementation of the KE process in different organizations. The interviewee at Sweco Infrastructure mentioned that nearly all the employees are satisfied with the current approach in the company towards KE. Since there is no formal survey at the company to measure employee satisfaction, it seems that this statement is general and there is no documented evidence that shows how much employees are satisfied with the KE process. The surveys at White Arkitekter AB are also general and like Sweco Infrastructure there is no template to focus on this issue.

The ease of use and flexibility of the system developed for eliciting experts' knowledge has been counted as an issue that could affect the quality of the elicited knowledge. Findings showed that White Arkitekter AB, through their feedback system, could improve their system so that they move towards more satisfaction and user friendly methods in the company. It is arguable that these methods are still general and not specific with focus on special terms in the knowledge domain.

Further on, Sweco Infrastructure and White Arkitekter AB have an open environment for getting feedback from their employees. The argument is that when employees do not have a frame for giving feedback, the validity of the comments could be criticized. It is important for the company to have an explicit feedback system where certain options are put forward for the expert to compare them and then decide which one is better or worse. If there is no specific frame for evaluation, then it would be hard for the expert to clearly make comments on KE process. It is also mentioned by Polanyi (1966) that in order to elicit knowledge from an expert the distal knowledge should be transformed into proximal knowledge by formats that suit the environmental characteristics.

Considering the evaluation framework mentioned in Figure 4, dependent variables could be directly affected by moderator variables. This relation could be argued in accordance with the human component as an important factor involved in moderator variables. The probable inability of experts to verbalize their tacit knowledge to the knowledge engineer has been emphasized by Hart (1985), Chervinskaya and Wasserman (2000) and Gerlter (2003). It is evident that since neither of the companies utilizes the presence of a knowledge engineer in elicitation sessions, this problem could escalate and affect the quality of the elicited knowledge.

5.3.2 Efficiency of KE

The issues of combining cost, time, effort and knowledge yield as mentioned in the evaluation framework (Figure 4) have a clear effect on the efficiency of KE in organizations. The findings showed that the senior managers give the same weight to time and cost and equalize knowledge yield with effort. This could be because the senior managers prioritize these factors while it should be the careful combination of these elements that would create a fruitful result for the company. Although economic status is an important issue, the long term economic benefits of the balance between these four items could be worth considering.

The findings revealed that case companies do not have any routine method for measuring the knowledge yield in a quantitative manner. This is while Hoffman et al. (1995) introduced a sample method to quantitatively measure the knowledge yield in the organization. As mentioned in Section 3.1.3, knowledge yield could be quantitatively calculated as the ratio of informative propositions per TTM. Knowledge yield is being neglected in the case organizations.

White Arkitekter AB and Sweco Infrastructure have implemented events such as symposia, education workshops and mentoring programs. Schreiber (2000) warned that as experts get used to day-to-day activities, they lose track of the processes that they base their decision on. This is because they get used to repeating same routines over and over again without having the ability to explain the process of performing the task. In other words, experts get more experienced in having "Know-x" ability. This form of tacit knowledge in engineering design was already mentioned in Table 1. Therefore, it could be discussed that when organizations use above mentioned events such as symposia they are actually risking the efficiency of their courses and workshop. If experts are unable to communicate their tacit knowledge to the audience, this could reduce the performance of such events.

6 Conclusions and recommendations

The investigations to understand the processes of tacit knowledge elicitation being performed in construction consultant firms led to conclusions discussed further. These results could be a basis for future improvements in construction consultant firms to help them take advantage of the long term results of eliciting tacit knowledge in their firms. These improvements could be used as a means to reduce costs of losing valuable knowledge in companies and also lower experts' workload to concentrate on other issues.

The common KE techniques used in the companies were identified here. The companies mainly use task analysis, interviews and group decision making as their methods from getting knowledge from their experts. The main strength of the methods applied in the companies was the ability of the tools to reveal the reasoning path of the expert while making decisions. Furthermore, among the interview techniques used in the companies, the ability to clarify vague points to the knowledge elicitors is more evident. These were among the two main reasons that could be diagnosed as the motives for using such techniques in the companies. The main weakness for such KE techniques is their time consumption. This issue was highlighted several times by the interviewees. The two problems that are in the interview techniques used by companies is inability to highlight important parts of the interview and a bias from the experts. This bias concerns the chance of concealing some information from the expert's side in order to prevent problems with criticism from others.

The use of a combination of the techniques was a strength point in the companies. This helps companies tailor the methods to the characteristics of the environment they are conducting KE processes in. It is a good idea to customize some elicitation and knowledge creation techniques to the needs of the company, the experts and the context they are working in. The companies have developed their own way of transferring and eliciting knowledge in companies while their descriptions of the work frame fall into the common KE techniques mentioned in theories. There are also some inconsistencies with the mentioned techniques. The companies mainly do not use these techniques to document the knowledge they gain through their developed tools.

Considering the evaluation of KE process applied in both case organizations, it could be recommended that the companies would highlight the attributes of the experts in terms of their approach towards problem solving in their assignments. These attributes could help companies choose optimum methods to elicit knowledge from their experts. It could also be added that the presence of knowledge engineers in the companies could facilitate the KE process. The companies should have a clear frame for knowledge engineers and also consider the attributes of them, because their attributes could also affect the quality of KE.

The case companies have difficulties in eliciting technical knowledge in their organizations. This problem could be solved by the use of tools and techniques that could create a distinct categorization of the knowledge domains and the key words that are most common in those domains. The use of log-in systems as recommended earlier could call for the need to create a system development approach in the

companies. In this case, the quality and the validity of the elicited knowledge should be assessed before moving them into knowledge storage units.

The organizational environment could be enriched through using incentives for the experts in return of what they offer as their knowledge. A concrete organizational culture besides monetary incentives and engaging employees in the process of knowledge elicitation could be a good idea to facilitate KE process. The development of cross functional networks also creates an environment where all the divisions have the chance to benefit from experience gained from experts. Through these networks the problem of communication due to hierarchical structures in companies could be resolved. It could be recommended that through feedback systems that focus on the flexibility of the techniques and expert satisfaction these methods could be updated and adjusted to the needs of the company.

Finally, there is no doubt that financial status of a company is an influential factor in the future strategies. However, it should also be mentioned that the long term benefits of KE could cover the costs of a company for implementing a robust system that could reduce many problems. Implementing efforts to elicit knowledge in an organization creates a foundation for retaining valuable experience that in some cases is very costly to regain.

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Appendix

Terminology given to Senior Managers and Experts

1. **Tacit knowledge:** the knowledge which is in human mind and hard to share with others.
2. **Explicit knowledge:** the documented knowledge available to others. Example: email, reports, manuals, etc.
3. **Knowledge elicitation (capturing knowledge):** the process of transferring personal experience into documents and manuals.
4. **Knowledge domain:** such as managerial, technical, financial, administrative skills, etc.
5. **Expert:** the experienced employee whose knowledge should be captured by the company.
6. **Knowledge engineer:** person responsible for capturing knowledge from experts.
7. **Expert categorization:**
   - **Auto problem solver:** solves problems automatically without others help.
   - **Practitioner:** using others advise to solve problems.
   - **Academician:** using document and research.

8. **Elicitation techniques/methods:** the standard techniques used for capturing individuals' knowledge in the organization listed below:
   - **Cognitive (causal) mapping method:** started by asking broad questions on a specific subject which results into drawing links that show the thinking process of the expert.
   - **Task analysis method:** the experts are asked to analyze a specific task. The result is presented by the knowledge engineer in a written document.
   - **Protocol analysis method (think aloud problem solving):** a specific task is given to the expert and he/she is asked to think aloud (talk about their thoughts).
   - **Unstructured interview method:** this is an open dialogue interview including open-ended questions.
   - **Structured interview method:** pre-defined questions are used in the interview. The agenda is set and the role of interviewer and interviewee is clearly defined in advance.
   - **Narrative interview method:** the expert tells a story about past experience on a specific task (storytelling meeting). The entire interview must be recorded and transcribed by the knowledge engineer in order to extract the learning points.
   - **Rating and sorting method:** the expert is asked to sort and categorize the problems and keywords based on their relationship with each other.
   - **Log-in system method:** The experts have a personal username and password in order to log in the intranet and share their knowledge and experience by themselves via filling the special boxes.
   - **Group decision making:** conducted through brainstorming followed by decision making in the group.
   - **Decision analysis:** the expert makes a decision and then the **risk** of the decision is estimated. Then, made decision is evaluated based on the risk outputs.

Interview questions for Senior Managers

Section A: The detail information of respondent

1. Would you please briefly tell us about your responsibilities and general background in the company?

Section B: Company background

1. Could you please tell us about the number of employees in the company?
2. How much is the financial turnover in the company?
3. Would you briefly tell us about the organizational structure of the company?
4. When were the efforts for knowledge management started in your company?
5. What was done for capturing knowledge in the company since your company started knowledge management?
6. Could you please talk about the future strategy of your company for capturing experts' knowledge?
7. What is your strategy toward capturing knowledge when considering following expert categorizations?
    - Auto problem solvers
    - Practitioners
    - academician

Section C: Different tools used for knowledge capture

1. Which standard techniques are you using in your company? (cognitive mapping, task analysis, think aloud protocol analysis, interview, rating/sorting, graph construction, log-in systems, group decision making, decision analysis)
2. What do you think about the strengths of the methods currently used in the company?
3. What are the weaknesses of the techniques that you are using in the company?

Section D: Performance measurement

1. What do you do to measure the amount of captured knowledge considering currently applied techniques in the company?
2. What factors do you consider to evaluate the accuracy of captured knowledge among current capturing methods in the company?
3. How do you evaluate the level of experts' satisfaction on knowledge capturing techniques?
4. What do you do to reduce the workload on experts whose knowledge should be captured? (employees' overtime, excess effort)
5. How to get feedback from the expert regarding the usability and acceptance of elicitation methods within the company?

Section E: Knowledge management awareness and commitment

1. What are the reasons that make it important for your company to capture experts' knowledge?
2. Who are responsible for knowledge capture in your company?
3. What are their backgrounds if there is any?
4. What kind of knowledge domain are you capturing in your organization considering the following examples?

    - Managerial
    - Regulations
    - Technical
    - Administrative

5. Do you have any plans to show your experts the purpose of capturing knowledge before attending the capturing sessions?
6. If so, how do you plan to make this process visible to your experts?
7. How do you balance the combination of the following issues in the process of capturing knowledge?

    - Time
    - Cost
    - Effort
    - Knowledge yield

8. Which factors motivate your experts to contribute in the process of knowledge elicitation?
9. Do you consider psychological characteristics of the experts when choosing suitable knowledge capturing techniques? If so, which characteristics?
10. What issues do you think could hinder the process of implementation of knowledge capture?
11. Considering the problems caused by geographical dispersion of experts in the process of knowledge capture, what could be the possible solutions to overcome these problems?
12. Have you ever experienced expert resistance in the process of knowledge capture? If so, what are your solutions in order to reduce this resistance?
13. What have you done in order to facilitate the process of knowledge capture in general?

Interview questions for experts

1. Would you please briefly tell us about your responsibilities and general background in the company?
2. How often are you asked to participate in the knowledge capturing processes?
3. Do you think it is important to know the purpose of capturing your knowledge? If so, why do you think that is?
4. Do you prefer your knowledge to be captured by a knowledge engineer or shared by yourself? Why do you think is that so?
5. Do you think the knowledge engineer's background is important? Why do you think is that so?
6. Do you prefer group or individual knowledge sharing sessions? Why?
7. What things make you feel uncomfortable in the knowledge capturing procedures?
8. What do you think about the weaknesses/strengths of currently applied knowledge capture techniques in the company?
9. What could help in improving the current weaknesses?
10. What issues do you think could hinder the process of implementation of knowledge capture?
11. What incentives could make you more willing to share your expertise with your organization?
12. How do you mainly solve the problems in the company?

    - Solve by yourself
    - Take advise from colleagues
    - Look for documents and academic references

13. What method do you find comfortable for you to share your knowledge with the company? (cognitive mapping, task analysis, think aloud protocol analysis, interview, rating/sorting, graph construction, log-in systems, group decision making, decision analysis)
14. Why do you think that is?