DEVELOPING A ROADMAP FOR KNOWLEDGE MANAGEMENT IN CONSTRUCTION INDUSTRY

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ABSTRACT

DEVELOPING A ROADMAP FOR KNOWLEDGE MANAGEMENT IN CONSTRUCTION INDUSTRY

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High turnover rate of employees in construction cause companies in the sector struggle against knowledge loss. Due to the high competition in the market, companies differentiate by keeping and increasing their intellectual capital generally acknowledged as the main source of competitive advantage. Knowledge Management (KM) is defined as any process or practice of creating, acquiring, capturing, sharing, and using knowledge, wherever it resides, to increase learning and performance by sustaining organisational knowledge.

This study investigates the awareness of Knowledge Management (KM), applicability of KM tools and the role of intellectual capital assets to propose a roadmap for companies in the Turkish construction industry. For this purpose, the study employs a combination of a detailed literature survey, interviews with

ten leading medium large-scale Turkish construction companies, and the analysis of previous KM research and tools. Results are analysed, possible barriers are determined, benefits are identified, KM techniques are discussed in terms of their applicability and a four-staged model framework is developed and discussed in order to assist the construction firms in KM.

Keywords: Knowledge Management, Turkish Construction Industry, intellectual capital

ÖZ

İNŞAAT SEKTÖRÜNDE BİLGİ YÖNETİMİ İÇİN BİR YOL HARİTASI GELİŞTİRİLMESİ

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İnşaat sektöründeki yüksek çalışan sirkülasyonu nedeniyle şirketler bilgi kaybıyla mücadele etmektedirler. Bunun yanında, pazardaki büyük rekabet dolayısıyla, genellikle rekabetçi gücün ana kaynağı olarak gösterilen entelektüel varlıklarını koruma ve artırma yoluyla farklılık yaratmaktadırlar. Bilgi Yönetimi (BY), öğrenmeyi ve performansı arttırmak için kurumsal bilgiyi devam ettirmek suretiyle nerede olursa olsun bilginin yaratılması, elde edilmesi, yakalanması, paylaşılması ve kullanılması uygulamaları veya süreci olarak tanımlanmaktadır.

Bu çalışma, Türk inşaat sektöründeki firmalara bir yol haritası sunmak için firmaların BY konusundaki farkındalıkları, BY araçlarının uygulanabilirliğini ve entelektüel varlıkların rolünü araştırmaktadır. Bu amaçla, mevcut literatür detaylı bir şekilde araştırılmış, Türkiye'nin önde gelen 10 orta-büyük ölçekli firmasıyla karşılıklı görüşmeler yapılmış ve geçmiş BY

araştırmaları ve araçları analiz edilerek kombine bir çalışma uygulanmıştır. Sonuçlar analiz edilmiş, olası zorluklar belirlenmiş, sistemin faydaları açığa çıkartılmış, BY teknikleri uygulanabilirlikleri açısından tartışılmış ve şirketlere BY konusunda rehberlik etmeyi hedefleyen dört basamaklı bir model geliştirilmiştir.

Anahtar Kelimeler: Bilgi Yönetimi, Türk İnşaat Sektörü, Entelektüel varlıklar

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LIST OF ABBREVIATIONS

AEC - Architecture – Construction – Industry
CAD - Computer Aided Drawing
CD - Compact Disc
CoP - Communities of Practice
DVD - Digital Versatile Disc
ICT - Information and Communication Technologies
IS - Information Systems
IT - Information Technology
KM - Knowledge Management
PC - Personal Computer
PDA - Personal Digital Assistant
PDF - Portable Document Format
PDT - Problem Definition Template
REM - Regional Engineer Manager
UK - United Kingdom
US - United States

CHAPTER 1

INTRODUCTION

In the early 1990s, Knowledge Management (KM) appeared on the scene of management researchers just after "Learning Organization". Learning organization is defined as an organization talented at creating, acquiring and transferring knowledge and modifying its behaviour to reflect new knowledge and insights (Garvin, 1993 cited in Özorhon, 2004). The rapid expansion of information and communication technology (ICT) and the rapid development of new tools like intranet and groupware systems (Hibbard, 1997; Mayo, 1998) facilitated the information exchange among both individuals and groups. Anumba et al (2005) has stated that the main impulse behind KM expansion during the last two decades is due to the globalization and high competition, improvement in new information and communication technologies, financial implications of intellectual property rights, recent procurement ways, new work methods, employment regulations, and contradictory political and ethical underpinnings. From the academic point of view, theoretical developments like resource-based and knowledge-based views of the firms, which emphasize the importance of unique and inimitable assets called tacit knowledge (Grant, 1991; Penrose in Rutihinda, 1996; Roberts, 1998), served for the necessity and importance of KM to overall business management. The main driver behind the increasing interest of KM was the fact that knowledge was seen as an asset for the organization similar to other physical assets (Ives et al, 1998; Wiig, 2000). The employees leaving their jobs with the knowledge acquired through years

became a problem for the companies because the companies started to lose important knowledge by their quitting. Therefore, firms thought that there had to be a system or mechanism providing successful retention of the knowledge (DiMattia and Oder, 1997).

Initially, KM was considered as a branch of Information Management whose success depends on ICT. DiMattia and Oder (1997) observed that KM is developed to cope better with the huge amount of information accumulated in the workplace. Indeed, the earlier KM initiatives were driven by technologies such as document management systems, internet and e-mail. In today's highly developed world of technology, knowledge sharing is much simpler because of the improved internet usage, advanced network systems, cellular phones with data capabilities, palms, notebooks, PDAs, wireless technologies, Bluetooth technologies, etc. Hence, this technology supported knowledge management by facilitating the explicit knowledge sharing which is easier to codify (Gillingham et al, 2006). However, there were many KM projects that failed to satisfy the needs and targets of the companies despite the sharp development in ICT sector and best efforts performed by the organizations (Strassmann, 1998; Malhotra, 1998, 2002; Swan and Scarborough, 1999; Swan, 1999; KPMG Research Report 1999, 2000; Sapsed et al, 2000). Hence, it comes out that KM is not only about technology. It emphasized the knowledge embedded in, and obtained from or through social relationships and interactions as a management process (Nonaka and Takeuchi, 1995). Egbu (2000) supported this idea by noting that KM is about 90 % people, 10 % technology.

Under the brief evolvement of KM in the world, KM is defined as any process or practice of creating, acquiring, capturing, sharing and using knowledge, wherever it resides, to increase learning and performance in organizations (Scarborough et al, 1999). Due to the advantages of KM which will be stated in Chapter 3 of this thesis study, KM is applied by many leading organizations in

the world such as Texas Instruments, Chevron, Ernst & Young, Chrysler, Turner Construction, Arup, Balfour Beatty, Honda, Xerox, etc.. It is possible to extend this list with many organizations from various industries.

Although it is accepted and applied by many leading companies around the world, KM is a new philosophy aged 15-20 years. There is an exponentially growing interest on the subject shared both by the organizations and academics. Bhatt (1999) stated that business and academic societies believe that organizations can sustain its long-term competitive advantages by leveraging knowledge. Bechina (2006) supports this idea by pointing the management of diversified knowledge to cope with the challenges in the business environment like rapid technological changes, shortened product lifecycle, downsizing, high market instability. In the report of European Commission's Information Society Technologies Programme by Hearn et al. (2002), it is stated that organizations surviving in the future would be those in which people are holding rich and meaningful exchanges resulting in collective sense-making on the concerning subjects. However, organizations that are unable to produce new ideas and to co-create creative solutions will lose key personnel and markets and consequently disappear. As a result, in order not to disappear, different sectors such as manufacturing, pharmaceuticals, chemical, financial and the information technology, etc. have been undertaken into research, and companies who noticed the importance of knowledge have applied KM to their organizations. BP, Shell, Chevron, Hewlett Packard, Buckman Labs and Xerox are the first initiatives of KM (Anumba et al., 2005). The efforts of these companies in the researches performed by academicians changed and improved their KM capabilities.

Besides these developments in the world of knowledge management in various industries, construction industry did not watch the developments but even adapted. Today's construction industry desires the results in a faster way than

ever. Decisions must be given very quickly through electronic communication-putting too much pressure on the individual. Construction professionals must know past experiences constantly, and must produce new ideas to innovate faster than the competition because failure is not acceptable. This is an era of "right first time" or "never again" because that global competition rarely gives the second chance to the companies (Anumba et al., 2005). In this tough business environment, as an example, UK construction industry has been applied for a "movement of change" with the purpose of waste reduction, improving reliability, increasing efficiency, better risk distribution and enhancing the overall performance of the industry, specifically after the reports prepared by Latham (1994) and Egan (1998) (cited in Mukherjee, 2003). Many companies considered the use of IS / IT based tools to achieve the objectives set in the above-mentioned reports. However, the success could be the re-examination of the existing knowledge, adding value to it by using it differently or sharing because, in fact, construction is a knowledge-based industry. Even small projects need ideas, knowledge and experience from various resources like people, documents and electronic media, and construction companies have been managing knowledge informally for years (Constructing Excellence, 2004 cited in Gillingham and Roberts., 2006; Anumba et al., 2005).

There exist some problems with KM in the construction industry. Construction industry has a structure of frequently changing participants and project teams, non-repetitive nature of work, tight deadlines and pressure to complete, and lack of impulse to evaluate performance or improve overall project delivery (Patel et al., 2000 cited in Udeaja et al., 2006; Gillingham and Roberts, 2006). Moreover, it is a very competitive industry with low profit margins, which makes KM attractive to the companies (Carrillo and Chinowsky., 2006). There are some research projects investigating how KM can be exploited in construction industry. These include CIRIA's *Benchmarking Knowledge Management Practice in Construction* and *Building a Business Case for Knowledge Management*, Partners In Innovation's (PII) *Knowledge Management for*

Sustainable Construction. Besides, above-mentioned projects, there are other research projects at universities with industry collaborators highlighting the KM activities in the industry, benefits to be obtained and problems faced (Carrillo et al., 2006). In a survey conducted by Carrillo et al. (2004) (cited in Robinson et al. 2005; Carrillo and Chinowsky, 2006), 42 percent of the leading construction companies in the UK have a KM strategy. It is also reported that 32 percent of the surveyed companies plan to have a strategy in a short time. Moreover, many leading companies have appointed knowledge managers to implement their programmes within the organization. Amec, Arup, Balfour Beatty, Bovis Lend Lease, Taylor Woodrow, Turner Townsend, Cyril Sweett and Wates Construction are the names of these pointed companies (Carrillo, 2004). Those establish well the importance of KM in the construction business literature by their attitude towards KM.

As the subjects were investigated and companies were examined, the KM philosophy got complexity. Different aspects and requirements were noticed. The needs and demands of the companies have emerged. As a result, the researchers have developed some frameworks or models for serving different purposes of the companies. SeLEKT (Anumba et al., 2005), CLEVER (Kamara et al., 2002), IMPaKT (Robinson et al., 2004), CAPRI.NET (Udeaja et al., 2006), KLICON (Patel et al., 2000) and Dynamic Knowledge Map (Woo et al., 2004) are some of the approaches released for the benefits of the companies. SeLEKT is presented as a tool to choose the most appropriate technique and technology to be used within the organization as a part of KM strategy. CLEVER defines and determines a KM strategy according to the company necessities and requirements. IMPaKT is about facilitating and monitoring the impact of the knowledge initiatives on business performance. CAPRI.NET is a web-based tool used for live capture and reuse of the knowledge. KLICON is another project focusing on the role of IT in capturing and managing knowledge for organizational learning on construction projects. Dynamic Knowledge Map was developed for reusing experts' tacit knowledge in the AEC (Architecture-

Engineering-Construction) industry by providing an interactive conversation, and recording it to store and to be accessible for other users. Detailed information about these models will be described in Chapter 4 of this thesis study.

Although construction companies in Turkey apply some primitive methods for KM as all the companies in the world, Turkish Construction Industry participants should take the necessary structured precautions concerning the importance of knowledge and knowledge management if they want to survive as other competitors from UK, US, Canada, etc. As the competitors in the market innovate and create competitive advantage, it is inevitable for the Turkish construction companies to disappear. This thesis study aims at investigating the Turkish construction company in terms of KM understanding, applications and vision to find the best fitting model or models according to their needs, gaps and expectations from the Turkish construction industry. There were chosen three frameworks or models existing in the literature serving to different aims. The research methodology during the thesis is described below in detail.

Chapter 2 includes the details of definitions and infrastructural information about KM. Data, information and knowledge is described in this section, and their interrelations are set out with a meaningful example to assimilate better. The distinction between tacit and explicit is explained in this chapter. Moreover, the research papers investigated during the thesis study are summarized. These papers are grouped according to a logical sequence. First the theoretical papers are discussed. Then the case-study examinations in the world are illustrated. The papers having subjects on implementation criteria of KM is just placed following the case study investigations. Afterwards, the methods and frameworks developed by the researchers are mentioned. Finally, other papers related with the subject of KM and the contribution of this thesis study to the KM subject and literature are figured out.

The next chapter, Chapter 3, is about KM. KM processes, barriers to implementation, its benefits, the technologies and techniques used by the companies throughout the world are summarized in this chapter. The current situation of the construction industry in the globe and the importance of the KM systems for the construction companies are figured. Some illustrative examples from successful applications are given to have a better understanding of the subjects from construction industry.

The detailed presentations of the selected methodologies to be investigated from the Turkish Construction point of view are in Chapter 4 of the thesis study. These methodologies or applications will be searched through Turkish construction companies via interviews, which will be done to define the necessities and demands of the Turkish construction industry, to find the best fitting and required method or application for the firms.

Chapter 5 describes the research in detail made among Turkish construction companies. The aim of the research, research methodology, the key findings and their indications, the behaviors of the companies about KM are all sub sections of this chapter.

As a final chapter, the conclusions derived from the research among the construction companies, recommendations, the research limitations and the future works to be done after this thesis study is sketched in Chapter 6. The vision of the Turkish construction firms about the KM is summed up to have a better view of the future of the companies. The appendix is attached at the end of the thesis including the interview questions and structure to help the future researchers.

CHAPTER 2

DEFINITIONS and REVIEW of PAST STUDIES

2.1 Data – Information - Knowledge

Before commencing to the description KM concept deeply, it is better to comprehend the definitions of and distinctions between data, information and knowledge briefly. In today's business world, organizations examine plenty of data and information. However, as Davenport and Prusak stated (2000), comprehension of data and information results in confusion among management and sometimes this confusion results in the failure of knowledge management projects. The major mistake they fell into is that knowledge is derived from information and information is derived from data and data is a set of papers, documents, facts, etc. without any meaning.

It is really difficult to define data, information and knowledge. In general, data are the raw, unprocessed facts about events. Information is termed as the organized set of data shaped for a purpose, whereby its creator inserts meaning. Knowledge is dictated as "fluid mix of framed experience, values, contextual information and expert insight that provides a framework for evaluating and incorporating new experiences and information" by Davenport (2000). There are other definitions made by various researchers. Applehans et al. (1999) defined knowledge as "the ability to turn information into effective action"

whereas Dixon's (2000) definition was "meaningful links people make in their minds between information and its application in action in a specific setting." By these definitions, it can be said that without a meaning depending on the users' perspective, knowledge is information or data. There is a recursive relationship between data, information and knowledge, which depends on the "organization" and "interpretation" as shown in Figure 2.1 below. Organization is the difference between data and information and interpretation is the distinction between information and knowledge (Bhatt, 2001).

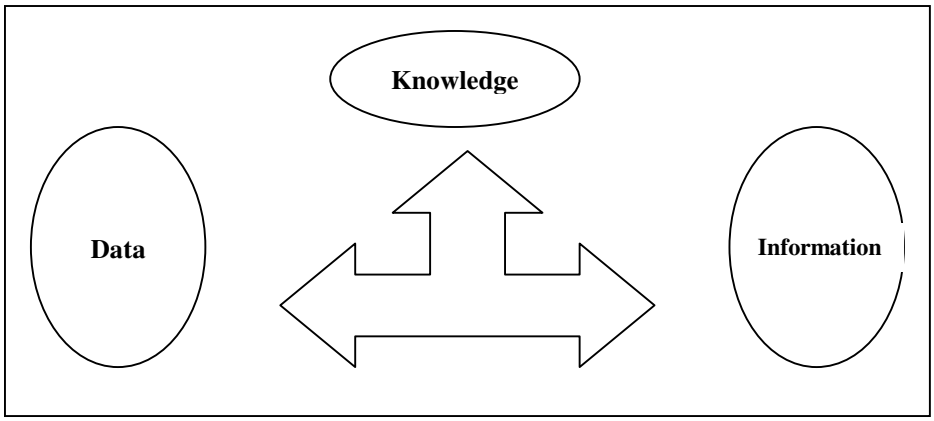


Figure 2.1 The recursive relations between data, information and knowledge

To express the difference between these concepts, let us think of a patient and a doctor as an example. The doctor obtains a lot of "information" from the patient about his/her disease. Some of this information is relevant for the diagnosis for the doctor whereas some becomes irrelevant hence data. According to the obtained information from the patient, doctor seeks through his/her own "knowledge base" for the diagnosis. If the gathered information is insufficient, then the doctor desires for lab-tests to increase the relevant information to find a correct match. He/She may even refer to another specialist doctor for medical inspection. The newly appointed specialist may find the irrelevant data as important information for the diagnosis of the patient; hence "data" for the initial doctor becomes "information" then "knowledge" (as medical diagnosis)

for the specialist. Therefore, both doctors move through data, information and knowledge repetitively. This endorses that they are all interrelated concepts with gradual distinctions.

2.2 Tacit and Explicit Knowledge

Polanyi (1966) proposed grouping knowledge as Tacit and Explicit. Explicit knowledge can be denoted as tangible, which means that capturing, codification, and sharing occurs easily. It can be shared through discussions, by writing it down, and it can be stored in databases and in repositories as documents, notes, etc. Nonaka and Takeuchi (1995) cited that the knowledge that can be documented, codified, transmitted and structured, and is conscious and externalized, is termed as explicit knowledge. Telephone directory, instruction manuals, a research report can be figured as the examples.

Tacit knowledge is personal, context-specific, and difficult to codify and share. It is embedded in the human mind, behaviour and perceptions (Nonaka and Takeuchi, 1995). It is linked to personal perspectives, emotions, intuition, values, know-how, experiences and beliefs. In contrast to explicit knowledge, it is intangible, difficult to articulate and can be shared through discussion, stories and social interactions. Apprenticeship, direct interaction, networking and action learning that consist of face-to-face social interaction and practical experiences are suitable methods for tacit knowledge sharing.

Tacit and explicit knowledge are both important for an organization. When they interact with each other, then the opportunities of innovation are created (Gillingham and Roberts, 2006). However, tacit knowledge is given priority in that interaction by the researchers. If somebody wants to achieve excellence in a business, he has to rule over the unstructured and intangible tacit knowledge (Haldin-Herrgard, 2000). Moreover, Brown and Duguid (1998) stated that the core competency of an organization depends rather on tacit “know-how”

knowledge than the explicit "know-what" knowledge. Tacit knowledge prevents work from problems, enhances the quality of it and draws the profession on the work. Efficient decision-making processes, serving customers or producing more accurate task performance are improved by the use of tacit knowledge. Besides, great time-saving developments can be achieved by experts in today's limited length of time which is of high importance (Haldin-Herrgard, 2000).

From the construction industry point of view, tacit knowledge within the organization is very crucial because of the fragmented, disperse and unique characteristics of the industry. Construction projects are time-limited projects in nature with an average project lifetime of 3 to 5 years. Project teams move from one project to another project after short durations. This mobile structure of the industry brings some problems to the construction organizations. Additionally, an employee working in a project for a long time may leave the job during the project duration due to any reason. This is a common event for the construction organizations. In such a case, the employee takes along all the knowledge he has secured through the project with him and moves to another project even with another company. The company starts almost from the beginning with recently appointed employer. However, if there is a system capturing the available knowledge in the employee mind, this knowledge can be easily transmitted to the new employee and to other employees working in the organization to solve the similar problems in other projects. This will reduce the time spent to solve the similar problems and may probably satisfy the client due immediate solution creation.

2.3 Literature Review

There is a lot of research studies performed on the subject of KM during the last twenty years period. There was a high/rising interest on KM in the mid 1990s. The number of research topics found in the literature evidences this argument. The below graph, Figure 2.2, will illustrate the interest on the topic obviously.

Therefore, some research papers were analyzed to have a deep sight about the KM subject, which is summarized below. The papers are grouped among each other as stated in the earlier chapter.

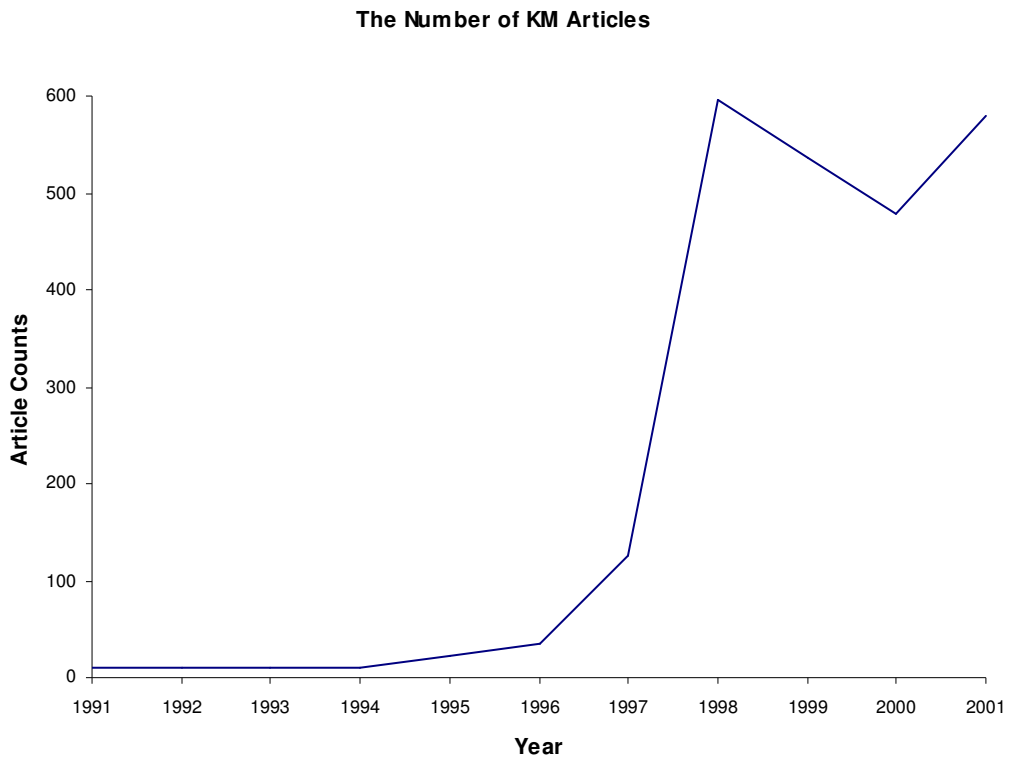


Figure 2.2 The Number of KM Articles, 1991-2001 (Ponzi and Koenig, 2002; sketched in Anumba, 2005).

Shariq (1997) discussed KM as an emerging discipline needed by various organizations to integrate studying, researching and learning about the knowledge assets – human intellectual capital and technology. He proposes an international society of knowledge professionals to nurture the collaboration among best minds and organizations. This society, consisting of experts from traditional academic disciplines like IT, management, cognitive sciences,

economics, finance, policy, law, social sciences, etc., can be the home of the development of the KM discipline.

Metaxiotis et al. (2005) have investigated the agreements and disagreements in the academic/practitioner community on KM issues. They stated that there is a consensus that the primary objectives of KM are to identify and leverage the collective knowledge in an organization to achieve the overriding goal of helping organizations compete and survive. It is also agreed that the successful organizations create new knowledge, spread it in the organization, and insert it with the new technologies and products to fuel innovation and thus lasting competitive advantage.

Mukherjee (2003) reviewed the developments to achieve KM in the construction industry. He stated the evolvement period of KM, its processes, implementation requirements and the need of KM in construction projects briefly. Further, he discussed the applicability of KM in construction by explaining the potential immediate benefits. He highlighted the need for a better illumination of the knowledge meaning.

There are some other research papers subjecting to some KM applications as case studies. Carrillo (2004) investigates two North American engineering, procurement and construction businesses in terms of the ways managing their technical knowledge. She then examined the virtues of their different approaches for UK civil engineering organizations from strategy and implementation to people aspect and performance measurement point of view. She has chosen two largest firms to examine in North America because KM there was considered more advanced than in Europe. Both of the approaches of the chosen companies were found applicable to UK companies because they both offer benefits, but one of the approaches is costly and the other requires a deep cultural change.

Tony Sheehan, the knowledge manager of Arup which is a global design consultancy company, explained the techniques for applying KM to aid the company competing in the new competitive business environment (Sheehan, 2000). He mentioned about two different approaches namely personalization and codification. In Arup, the KM team working with Sheehan has developed six principles according to the different needs of the units to satisfy their demands. These principles of the company can be named as; building on past successes, making knowledge-sharing a common principle, justifying the investment and focusing on value, using central services to capture knowledge, building new communities-knowing the staff, remembering the needs of the people.

As another case study company having a KM system within the organization is Turner Construction examined by Emma Skogstad (2005). Skogstad (2005) explained the history of the Turner Knowledge Network. The key issues related to the business at the conception stage are addressed. The roles of the implementation-responsible team members are also highlighted. The aspects of the Turner' Knowledge Network and the impact measurement of the network is also described. The paper is concluded with the lessons learned principles during the network implementation and with the future plans of Turner Construction Company.

Bechina (2006) analysed a Scandinavian Consulting Company in terms of its knowledge sharing practices. The study was started first at two departments of the company, but then spread to the complete organization. The purpose in this research is to identify what is being shared, why and how it is shared between whom. Some interviews with the managers were performed and some documents like reports, repository contents, papers, minutes, etc. were collected and analyzed to assist the purpose of the research and to capture the knowledge sharing mechanism in the company. The result obtained according to the interviews is that the responsible managers should define the strategies by

understanding the indicators and inhibitors for knowledge sharing in their company.

Some of the largest companies in the world applying KM systems to their organizations are searched and summarized above. To have these complex systems, researchers have searched the topics on implementation methodologies. Gillingham and Roberts (2006) studied the evaluation of KM best practices of the leading companies in the construction industry. The key findings obtained at the end of the research were the non-alignment of KM to business goals, lack of people communication, non-standard information systems and inability where to find knowledge.

Robinson et al. (2005) focused on the management of knowledge assets of UK Construction Companies and they propose an approach called STEPS to determine the maturity level of the company according to its knowledge management concept and activities. Four organizations in UK were investigated for KM implementation. As a result of the research, construction companies seem to be desirous in finding the systems to enhance their performance. KM can be a successful helping tool if suitable measurement of the benefits is achieved, implementation rules are well defined and broadcasted, and a strong connection between KM and business objectives is established.

The report prepared by Hearn et al. (2002) stated that European Commission tries to establish a community for KM subject in Europe under the Information Society Technologies Programme to simplify connections of ideas, people and projects to support organizational innovation through enhanced collaboration, flexibility and openness. Almost 40 research and development, and take-up projects have been initiated for investigating various aspects of KM. These projects will help Europe to be the most dynamic and competitive economy by 2010.

Bhatt (2001) examined the interaction between technologies, techniques, and people for KM in organizations. The writer champions the importance of balanced interaction of the technology and social systems that allow an organization to manage its knowledge effectively, thus sustain competitive advantage. He believes that if the management is serious about the priority of KM within the organization, the interaction between technologies, techniques and people should be monitored and even should be restructured according to the needs, continuously.

As the interest of the organizations increases to the subject of KM, there developed some models and frameworks to assist the companies in implementing their KM systems and satisfy their requirements. Kamara et al. (2002) developed CLEVER (**C**ross-sectoral **LE**arning in the **V**irtual Ent**ER**prise) model to help organizations selecting a KM strategy suitable to the organizational and cultural context. The framework questions the current and the desired situation of the organization by templates and recommends a KM strategy for the company.

Al-Ghassani et al. (2002) studied on CLEVER framework and improved it by converting into prototype software to have a simpler format and easier usage. Keeping the logic behind CLEVER in the software, the prototype was tested by the users and some recommendations and modifications are obtained.

Udeaja et al. (2006) proposed a method to "live" capture and reuse of construction project knowledge, namely as CAPRI.NET Approach. This is a web-based database system dependent upon the users' knowledge entry and search. The system provides a platform to the construction industry to capture and share the knowledge. Construction supply chains, clients, other project teams, construction industry itself will utilize the system due to the shared, stored knowledge, huge database, learning experiences of previous project teams, etc.

Walker et al. (2006) introduced the benefits of metaphors to express the complexities in the KM issues. Three different metaphors are figured out in detail with the necessary descriptions. However, it is pointed that although metaphors are useful methods to expound the complexities, it should be used carefully to avoid probable misunderstanding and confusing of the audience.

Robinson et al. (2004) introduced the IMPaKT Approach (**I**mproving **M**anagement **P**erform**a**nce through **K**nowledge **T**ransformation) into the KM literature. This performance-based framework aims at developing a business case for KM and facilitating the implementation of KM by demonstrating its benefits. The framework is tested through two industrial workshops and a questionnaire to show its robustness. Therefore, it was found a well-structured approach for developing business case.

Dynamic Knowledge Map is another method introduced by Woo et al. (2004) for reusing experts' tacit knowledge in the Architecture-Engineering-Construction (AEC) industry. Dynamic Knowledge Map (DKM) is a web based software prototype, which provides searching for experts in the database, and facilitates the communication with them via internet technology. After searching process, during the communication phase with the relevant expert, the dialogue between the user and the expert is recorded and stored in enterprise database systems to be searched by other users. The system requires a testing period to clarify the real benefits to the AEC industry.

Al-Ghassani et al. refers to the need of selecting the appropriate tools (technologies and techniques) for the KM implementation. Then SeLEKT Approach is proposed to due to the large number of products in commerce and the overlapping functions of them. The limitations of the existing methods proposed by other researchers in the literature played a crucial role in the development of SeLEKT.

As can be understood from the literature review and the evolvement of KM through the last 20 years, companies have been implementing KM systems to create a difference and gain competitive advantage. This thesis study investigates the Turkish Construction Industry and Turkish Construction Companies in terms of their KM situations, and discusses the applicability of the predefined frameworks or methods. Afterwards, this study tries to find and recommend an appropriate method or framework for the Turkish Construction Companies. Consequently, the KM profile of the company is assessed, the necessities and requirements are determined for future studies.

CHAPTER 3

KNOWLEDGE MANAGEMENT IMPLEMENTATION

3.1 Introduction

Edvinnson (1997) dictated that knowledge is the concealed asset of organizations, which needs to be cherished for long-term corporate sustainability (cited in Robinson et al., 2005). In this context, one of the most comprehensive definitions was made by a Xerox Manager: "[creation of] a thriving work and learning environment that fosters the continuous creation, aggregation, use and reuse of both organizational and personal knowledge in the pursuit of new business or organizational value" (Cross, 1998).

For the construction industry having a project-based structure, KM is fuelled by the need for innovation, improved business performance and client satisfaction within the dynamic and altering environment (Kamara et al. 2002). Kamara et al. (2000) pointed out that if construction businesses desire to remain competitive, and to satisfy the needs of their clients, the recognition of project and organizational knowledge management is necessary (cited in Kamara et al. 2002). Although many construction organizations perceive KM as an integral part of business improvement, they have difficulties related with the adoption, especially in the formulation and strategy implementation (Robinson et al. 2004).

This chapter first defines people, process and technology interaction of the KM systems. Then the sub-processes of KM are emphasized. The implementation requirements, barriers like culture, technology, etc. will be discussed. The tools, namely techniques and technologies, being used in KM applications will be expressed briefly. The necessity of KM for construction organizations, advantages of the KM systems applied by various organizations in the world will be introduced with some case examples.

3.2 People – Process – Technology Interaction

People, process and technology are defined as the soft and hard elements of KM systems participated in capturing, disseminating and sharing knowledge. These elements should be balanced to have a full advantage of knowledge sharing. People – process focus will lead to lack of IT infrastructure, thus lack of knowledge sharing. People – technology focus will lead to repeating the past actions. Process – technology focus will lead to the resistance of people to change (Gillingham and Roberts, 2005). In addition to people-process-technology triangle, on the other hand, Egbu and Robinson explained another factor in the book *"Knowledge Management in Construction"* edited by Anumba et al. (2005) that product types also affects the KM strategy in the construction context. From the product point of view of construction organizations, it is important to have knowledge about clients, end-users and market characteristics.

The role of people in KM is one of the most crucial and complex elements to handle (Gillingham and Roberts, 2005) because they are the one adding interpretation to information to create knowledge. Therefore, as Goffee and Jones (2001) stated, feeling of valued should be given to the people that they are in a community where they add challenge and reward (cited in Gillingham and Roberts, 2005).

Business processes are the activities and tasks we perform at work each day. They have an impact on customer satisfaction and the discrimination made by an individual to the organization (Gillingham and Roberts, 2005).

Technology enhances connectivity; hence, it is a great enabler supporting the processes (Anumba et al., 2005). Email, document systems, the internet, groupware, video conferencing and intranet are all KM tools that have been used by organizations as knowledge collaborators (Gillingham and Roberts, 2005).

3.3 Knowledge Management Processes

Bhatt (2001) defines KM as a process of creating knowledge, validating it, presentation, distribution and application. These five phases permit the organization to learn, reflect, and unlearn and relearn, generally thought necessary for creating, maintaining, and completing of core-competencies.

3.3.1 Knowledge Creation

Marakas (1999) defined knowledge creation as the ability of an organization to develop new and beneficial ideas and solutions (cited in Bhatt, 2001). Nonaka and Takeuchi (1995) presented the theory of knowledge creation, namely SECI model (Figure 3.1) into the literature (cited in Walker et al., 2006; Anumba et al., 2005; Gillingham and Roberts, 2006; Haldin-Herrgard, 2000)

	Tacit	Explicit
Tacit →	Socialization (S)	Externalization (E)
Explicit →	Internalization (I)	Combination (C)

Figure 3.1 SECI Model (Nonaka and Takeuchi, 1995; from Anumba et al.2005)

In SECI model, Socialization prepares the platform for tacit to tacit interaction through face-to-face interactions, communities of practice, etc. Externalization refers to the process of making tacit knowledge crystallized (explicit) so that it can be shared easily among the individuals, groups or organizations. Dialogue and reasoning are important actions to support externalization (Whelton et al., 2002). The Combination phase is achieved by exchanging, combining and breaking into pieces, and using different techniques to convert existing explicit knowledge (operating procedures, manuals, information bases, etc.) to more explicit knowledge (Whelton et al., 2002). Emails, CAD systems, databases, document management systems and project extranets ease this process. Finally, Internalization is the reverse process of externalization. It is related to learning by doing, training or exercising. The reframed explicit knowledge is embodied by individuals to have the tacit dimension.

3.3.2 Knowledge Validation

Knowledge Validation is the cycle of continuous monitoring, testing and refining of knowledge base to fit the existing and planned realities (Bhatt, 2001). As time passes, technology advances and the business environment changes, some previously defined knowledge may lose its importance, meaning and become data or information which should be eliminated and updated.

3.3.3 Knowledge Presentation

Knowledge presentation is the way of displaying the existing captured knowledge to the members in the organization. Its basic purpose is to simplify the access and transfer. Web publishing, video clips, documents, drawings, spreadsheet are some means illustrated by Anumba et al. (2005).

3.3.4 Knowledge Sharing

It is the process of making knowledge available to users (Anumba et al., 2005) to be exploited. The use of e-mail, intranet, newsgroup and bulletin board supports the distribution process. They also permit members to discuss, deliberate and interpret on the information through many aspects (Bhatt, 2001). Although it is easy to share explicit knowledge within and across the organization, Anumba et al. (2005) expressed that non-IT tools like face-to-face interaction and IT tools like groupware and multimedia tools are the examples of tacit knowledge sharing whereas searching knowledge base and obtaining stored knowledge is an example of explicit knowledge sharing.

3.3.5 Knowledge Application

Making knowledge more active and relevant for the firm to create value is the definition of knowledge application made by Bhatt (2001). Knowledge, like information, does not have any value unless it is applied to decisions and actions in a business context having a goal. Knowledge application and use is a complex subject with various aspects (Davenport and Marchand, 2001). Therefore, if organizations fail to locate the right kind of knowledge in the right form, the firm may have trouble in sustaining the competitive advantage (Bhatt, 2001).

3.4 Knowledge Management Tools

KM tools have been defined by very few authors. They are not simply information management tools because they should be "capable of handling the richness, the content, and the context of the information and not just the information itself" (Gallupe, 2001 cited in Anumba et al., 2005). Another popular definition is referred in Anumba et al. (2005) by Ruggles (1997). He defines KM tools as the technologies used to enhance and enable the implementation of the sub-processes of KM (e.g. knowledge generation, codification, and transfer). He identifies that not all KM tools are IT-based. Everyday tools such as papers, pens, and videos can be utilized to support KM. KM tools are not about IT alone. They are about both IT and non-IT tools needed to support KM processes such as locating, sharing and modifying knowledge (Anumba et al., 2005).

Non-IT tools can be denoted as the KM techniques like brainstorming, communities of practice (CoP), face-to-face interaction, post project reviews, recruitment, apprenticeship, mentoring and training. IT tools can be named as the KM technologies such as hardware technologies, software technologies, data and text mining, groupware, intranet, knowledge bases and taxonomy (Anumba et al., 2005). These techniques and technologies will be briefly explained in the following subsections. A comparison table between KM techniques and technologies is sketched below, Table 3.1 (Adapted from Anumba et al., 2005)

Table 3.1 A comparison between KM techniques and technologies

KM Tools	
KM Techniques	KM Technologies
• Require strategies for learning • More involvement of people • Affordable to most organizations • Easy to implement and maintain • More focus on tacit knowledge • Examples of tools: o Brainstorming o Communities of Practice o Face-to-face interactions o Recruitment o Training	• Require IT infrastructure • Require IT skills • Expensive to acquire/maintain • Sophisticated implementation/maintenance • More focus on explicit knowledge • Examples of tools: o Data and text mining o Groupware o Intranets/extranets o Knowledge Bases o Taxonomies / ontologies

3.4.1 Knowledge Management Techniques

Non-IT tools or KM techniques are important in KM context because they can be applied to most organizations. First of all, they do not require a sophisticated infrastructure. Second, they are simple to implement and maintain. Finally, they retain and enhance the key asset of organizations, namely tacit knowledge (Anumba et al.2005).

Brainstorming

It is a process of a group of people coming together to concentrate on a specific problem. The group people produce ideas whether logical or not. These ideas are noted down to evaluate at the end of the session. This process aids solving problems and creating new knowledge from the existing ones (Tsui, 2002 cited in Anumba et al.2005)

Communities of Practice (CoP)

These communities are brought together to construct a network consisting of knowledgeable experts. They work together to learn and solve complicated problems when needed. Generally, they perform informally through meetings, videoconferences, email to assist the responsible team (Woo et al., 2004). According to Anumba et al. (2005), the common feeling holding the community members together is to know what others know. Usually, there are many CoPs in an organization but the members of the groups may involve in more than one group. In a survey conducted by Robinson et al. (2005) among four construction companies in UK, CoP is one of the most mentioned knowledge sharing non-IT tools used by the companies with other tools such as Skills Yellow Pages, task teams and quality circles.

Face-to-face Interactions

It is the knowledge sharing approach, socialization, between the employees of an organization. It is very powerful. It supports enhancing the organizational memory, developing trust and encouraging effective learning. However, as written in Davenport et al. (1997), the value of face-to-face interaction can be decreased easily in this high technology, Internet, Lotus Notes and global communication systems era.

Post-Project Reviews

These are information gathering sessions to emphasize the lessons learned during the project. They are important because they give the chance to have knowledge about the failures, solutions, solution procedures and best practices in the project. Therefore, this knowledge can be utilized in the subsequent projects. The point to be stressed here is that, for construction companies, mostly it is very difficult to find the project participants at the end of the project to perform the post-project meetings. So, its time is very crucial (Anumba et al., 2005).

Recruitment

Recruitment is an easy way of finding knowledge by hiring an expert to use his experience. This method increases the knowledge base of the organization by adding new knowledge gained from the expert. Advantageously, members of the organization may learn from the expert, and even if the expert leaves the company, some knowledge is remained in the members' mind (Anumba et al., 2005).

Apprenticeship

The apprentices work with their master to gain experience through observation, imitation and practice. There is no formal status. The masters focus on their apprentices to improve the skills and reach at a desired level to perform tasks on their own (Anumba et al., 2005).

Mentoring

A trainee or a junior member is assigned to a senior staff for advice related to career development. This training type includes career objectives given to the trainee. The mentor is responsible to check if the goals are achieved and to provide feedback (Anumba et al., 2005).

Training

Training helps staff to improve their talents and hence enhance their knowledge. Training is usually in formal format. If training is given by senior staff within the organization, it is called internal training. If there is professional aid outside the company, it is called external training (Anumba et al., 2005).

3.4.2 Knowledge Management Technologies

Technologies capture, store and disseminate refined knowledge for the use of people (Gillingham and Roberts, 2006). KM technologies depend on IT as the main base for implementation (Anumba et al., 2005). Davenport and Prusak

(1998) and Tiwana (2000) stated that KM technologies consist one third of the time, effort and capital required for a KM system. The other two thirds are about people and organizational culture (cited in Anumba et al., 2005).

Bhatt (2001) brings up a matter that an organization can turn data to information with the help of IT, at best, to deal with an unexpected and new problem in this quickly changing environment. The use of high-technology computers and communication network facilities underpins an organization in data mining.

In the below subsections, the technological elements used in KM systems by organizations will be listed. Hardware technologies, software technologies, data and text mining, groupware, intranet, knowledge bases and taxonomy are the main headings to be summarized.

Hardware Technologies

These prepare the base for the software technologies to be used for storing and sharing of knowledge. Lucca et al. (2000) listed the hardware required for a KM system as below;

- PC (personal computer) or workstation to simplify access to the knowledge
- Servers with high capabilities to permit the organization to be networked
- Open architecture to ensure interoperability in dispersed environments
- Media-rich applications requiring integrated services digital network (ISDN) and fibre optic cables to guarantee high speed
- Asynchronous transfer mode (ATM) as a multimedia switching technology for dealing with the combination of voice, video and data traffic simultaneously
- Public network technology (e.g. internet) and private network technologies (e.g. intranet, extranet) to ease access and sharing of knowledge

Software Technologies

These technologies facilitate the implementation of a KM system. There are many software applications in the market. Therefore it is very difficult to determine the most appropriate software to be used (Anumba et al., 2005). Tsui (2002) categorized five models for deploying KM systems: Customised off-the-shelf (COTS), In-house development, Solution re-engineering, Knowledge Services, Knowledge Marketplace. However, there is no software technology that provides a complete solution to KM (Anumba et al., 2005).

Data and Text Mining

This is a technology for sieving the beneficial and meaningful knowledge from huge amounts of data and text. This approach is very useful for determining the secret relationships between data and thus creating new knowledge (Anumba et al., 2005).

Groupware

Haag and Keen (1996) defined groupware as a software product helping people communicate, share information, perform work efficiently and effectively, and ease group decision-making using IT. Email communication, instant messaging, discussion areas, file area or document repository, information management tools like calendar, contact lists, meeting agendas and minutes, and search facilities are the tools in Groupware programmes.

Intranet - Extranet

Intranet is like the Internet being not used by people in the globe but used by the members in an organization. Firewalls protect it from outside access. On the other hand, Extranet is the intranet allowing to limited access from outsiders and making them to collect and deliver certain knowledge on the intranet. This is a most widely used application by many companies, especially by the ones dispersed geographically. In a recent survey in UK conducted by Robinson et al. (2005), intranet was pointed as the backbone of the IT structure.

Knowledge Bases

These are the repositories of knowledge which can be found in books, websites, etc. This is different from the part of expert systems/case base reasoning (CBR) that saves the rules (Anumba et al., 2005).

Taxonomy - Ontologies

Taxonomy is defined as "the practice and science of classfication". "A taxonomy might also be a simple organization of objects into groups, or even an alphabetical list" (Wikipedia, 2007). Ontologies define "the terms and their relationships, but in addition, they support deep (refined) representation (for both descriptive and procedural knowledge) of each of the terms (concepts) as well as defined domain theory or theories that govern the permissible operations with the concepts in the ontology" (Anumba et al., 2005). They can be used a corporate dictionary defining key terms within the organization.

The table below, Table 3.2, is prepared by Anumba et al. (2005) to summarize the technology tools and related commercial software applications in the market to deal with the defined KM sub-processes.

Table 3.2 KM Sub-processes, supporting technology categories and software applications

KM sub-process	Technology tools	Commercial software applications
Locating and accessing	Experts directory	AskMe, Sigma Connect, IntellectExchange, Expertise Infrastructure
	Data Warehouses	Syncsort: http://www.syncsort.com
	Web crawler-meta search	MetaCrawler, SurfWax, Copernic Basic 2001, Livelink, Dogpile, Mamma, CNET Search

Table 3.2 Continued

KM sub-process	KM sub-process	KM sub-process
	Data and text mining	Data Mining: Knowledge SEEKER, RetrievalWare, XpertRule Miner, Clementine
		Text Mining: SemioMap, Intelligent Miner for Text, Megapture Intelligence
	Knowledge mapping-concept mapping	Knowledge Service, IHMC Concept Map
	Intranet/extranet	Livelink, Instant Intranet Builder, iLevel
	Search engines	Google, Yahoo, FAST, Excite, AltaVista, Infoseek
	Taxonomy/ontological tools	Autonomy, SemioMap, RetrievalWare Suite
	Web mapping tools	Web Squirrel, WINCITE
	Electronic document management systems	Documentum, BASIS, Dicom
	Electronic mail	Eudora, Microsoft Outlook
Capturing	Word processors	MS Word, Word Perfect
	Case-based reasoning-expert systems	CBR-Works, Kaidara
	Knowledge bases	Assistum, KnowledgeBase.net, XpertRule Knowledge Builder
	Knowledge mapping-concept mapping	Knowledge Service, IHMC Concept Map
Representing	Mind mapping applications-brainstorming	Mind Manager, The Brain
	Web publishing	KnowledgeBase.net
	Virtual reality tools	Maelstrom, 3ds max for Windows
	Word processors	MS Word, Word Perfect
	Computer-aided design	Autodesk products
	Spreadsheets	MS Excel, StarOffice/OpenOffice Calc, Lotus 1-2-3
	Knowledge mapping-concept mapping	Knowledge Service, IHMC Concept Map

Table 3.2 Continued

KM sub-process	Technology tools	Commercial software applications
Sharing	Web publishing	KnowledgeBase.net
	Communities of practice	AskMe
	Intranet/extranet	Livelink, Instant Intranet Builder, iLevel
	Web-based file sharing tools	KnowledgeDisk, Briefcase
	Instant messaging	NetLert 3 Messenger, Trusted Messenger, ICQ, AOL Instant Messenger, Yahoo Messenger, MSN Messenger
	Integrated groupware solutions	A group of Lotus products (Notes, Domino, Sametime, QuickPlace), GroupWise, BrightSuite Enterprise, MyLivelink, Plumtree Collaboration Server, iTeam, iCohere
	Multi-media tools - video conferencing software	MS NetMeeting, AbsoluteBUSY, eRoom, WebEx Training Center, WebEx Meeting Center, WebDemo
	Electronic mail	Eudora, MS Outlook
Creating	Data and text mining	Data Mining: Knowledge SEEKER, RetrievalWare XpertRule Miner, Clementine Text Mining: SemioMap, Intelligent Miner for Text, Megapture Intelligence
	Mind mapping applications/ brainstorming	Mind Manager, The Brain
	Knowledge mapping- concept mapping	Knowledge Service, IHMC Concept Map
	Data Warehouses	Syncsort

3.5 Knowledge Management Barriers and Suggestions

During the implementation stage of KM systems, firms have faced with some problems defined in the literature as barriers. Organizational culture is labelled as the one of the most important barrier to KM and, as Davenport et al. (1997) dictated, ”perhaps the most difficult constraint that knowledge managers must deal with”. Many experienced construction employees believe in knowledge as power and are not willing to share it (Hari et al., 2005). This attitude of people can be proved by the study of Robinson et al. (2005) surveyed among UK construction companies. The investigated companies mentioned that the organizational culture is the key barrier to KM. Hari et al. (2005) noted the same result after the survey conducted among 26 organizations. However surprisingly, most of them have not address the problem yet. Therefore, this survey shows that KM is not something only about IT or technology. The people’s fears, attitudes or resistances are the issues to deal with for a successful KM implementation. In CIRIA (2000) report, it is emphasized that a construction organization took more than four years to convince its staff to share their knowledge while some staff in another construction organization did not agree with the idea and even left the company. A change management strategy is inevitable for the organizations planning to have KM systems. During the implementation of Turner knowledge network, 50 percent of the employees older than 35 had difficulty in adapting to the system. To cope with the situation, Turner guided some applications like role-based dashboards, personal search pages, development plans and communities of practice (Skogstad, 2005). Another key barrier labeled is the demonstration and communication of the benefits of KM so that resources and support required for the successful implementation can be provided (Robinson et al., 2004). The announcement of the results of KM initiatives may assist maintaining KM as a high profile activity and raise the awareness even the first interest on KM is about to disappear (Robinson et al., 2005).

Besides the above-mentioned ones, there are some other barriers obtained from the surveys and researches. These can be denoted as the resistance to sharing knowledge, initiative overload, poor IT infrastructure which requires high amounts of investments, senior management commitment, bureaucracy associated with KM, conflicting priorities between KM and other business functions; moreover, lack of time, organizational structure, rewards and recognition, and emphasis on individuals rather than on teamwork (Robinson et al., 2005; Mukherjee, 2003).

To eliminate some barriers before starting to implement KM, Gillingham and Roberts (2006) proposes some initial steps;

- Determine the business vision/goals and knowledge objectives
- Assess the existing knowledge processes and systems. This creates the idea of how to expand, modify and improve existing system.
- Leverage best practices within and outside the company
- Start from the small unit where it is probably to affect and change the business. This will be the pilot project to show the outcomes and benefits for the next phase.
- Assign knowledge champions to promote knowledge sharing practices.

3.6 Knowledge Management Need for Construction Organizations

Knowledge management is an inseparable part of continuous performance improvement (Robinson et al., 2004). Due to the changing business environment today, organizations are dealing with the challenges of global competitiveness. In the face of such challenges, KM suggests a great potential to organizations to be as effective as possible (Anumba et al., 2005). As cited in Kamara et al. (2002), KM refers to the optimization of organizational knowledge to achieve high performance, increased value, competitive advantage and return on investment, through the utilization of several tools, processes, methods and techniques (Snowden, 1999; Skyrme and Amidon

1997). Demarest (1997) argued that companies without KM systems would not have the ability to maintain a competitive advantage and will lose market share to the firms applying KM (cited in Robinson et al., 2004).

Construction organizations have been dealing with diverse knowledge such as clients, partners, market information, competitors, project characteristics, employers, materials, suppliers, sub-contractors, vendors, etc. Therefore, a structured system is important and necessary for construction organizations. Larger firms, especially, have the difficulty of determining "who knows what" (Davenport and Prusak, 1998 cited in Robinson et al. 2005). These large companies are more likely to hire or assign knowledge responsible and to allocate enough resources for KM (Robinson et al., 2005).

Fragmented and unique nature of construction projects makes it difficult to form a continuous flowing system. At each project, different parties and employees are involved. Moreover, these employees are rarely left intact at the end of the project. They move to another project getting all knowledge with them. Besides this fragmented, crowded and mobile structure of construction industry, as Sheehan (2000) stated, in the construction industry, clients requesting the same high quality, efficiency and productivity as ever, however now they desire it faster and cheaper resulting in an effective decision-making system. Additionally, due to the low profit margins (Carrillo and Chinowsky, 2006), there is a need among the companies to minimize the mistakes, increase productivity and avoid re-inventing the wheel.

3.7 Benefits of Knowledge Management

The potential benefits to be obtained from KM are slowly being noticed in the construction industry (Robinson et al., 2004). In construction, Mukherjee (2003) stated that best practice examples would be disseminated and illustrated with the help of KM. He further explains some other benefits of KM in construction

organizations as project timescale reductions, reduction in the learning curve, supporting team building, fostering an innovative culture, managing risk better and increased and more efficient distribution of information and experience.

Robinson et al. (2004) expressed the benefits of KM in their IMPaKT Approach paper. Process and product improvements, saved money as a result of improvement in the place, sharing and accessing of various types of knowledge, responding to customer needs quickly results in money earning due to new or repeat works are some other benefits of KM. To endorse the benefits, it is better to illustrate some real values from the companies applying knowledge management. Table 3.3 below summarizes some cost savings from KM programmes.

Table 3.3 Examples of cost savings from KM programmes (adapted from Anumba et al. 2005)

- Texas Instruments saved itself the $ 500 million cost of building a new silicon wafer fabrication plant by disseminating best internal working practices to improve productivity in existing plants.
- Skandia AFS reduced the time taken to open an office in a new country from seven years to seven months by identifying a standard set of techniques and tools that could be implemented in any new office.
- Dow Chemical has generated $ 125 million in new revenues from patents and expects to save in excess of $ 50 million in tax obligations and other costs over the next ten years by understanding the value of its patent portfolio and actively managing these intellectual assets.
- Chevron Oil made savings of $ 150 million per year in energy and fuel expenses by proactive knowledge sharing of its in-house skills in energy use management.

The benefits of KM to the construction organizations are summarized by Anumba et al. (2005) in their book *Knowledge Management in Construction*:

- Innovation is more probable to thrive in an environment where there is a clearly stated KM strategy
- Improved performance will result from the pooling of an organization's knowledge as workers will be both more effective (adopting the most suitable solutions) and more efficient (using less time and other resources).
- KM is crucial for improved construction project delivery, as lessons learned from one project can be carried on to future projects concluding in continuous improvement.
- KM can ease the transfer of knowledge across a variety of project interfaces (participants, disciplines, organizations, stages, etc.)
- With effective KM, companies and project teams can avoid repeating past mistakes and / or reinventing the wheel.
- Increased intellectual capital is a major benefit for many companies, which is able to narrow the space between what employees know and what the organization knows.
- Companies that sufficiently manage their knowledge are better placed to respond immediately to clients' needs and other external factors.
- KM results in improved support for teams of knowledge workers in an organization or project team.
- Sharing of best practice is one of the conclusions of knowledge sharing- this can be happen both within and across organizations.
- Organizations can retain the tacit knowledge that would otherwise be lost when employees quit, retire or die.
- Enhanced value can be provided to the customers of construction companies through better KM.
- Construction firms can be more agile and better able to respond to organizational changes with effective KM.

- Risk minimization is a key benefit of KM. The companies deal with fewer uncertainties as their knowledge base expands.

CHAPTER 4

FRAMEWORKS FOR KNOWLEDGE MANAGEMENT IN CONSTRUCTION

Knowledge Management (KM) has gained popularity and received increased attention in the last ten years. Most of the companies from various industries have noticed the importance of safeguarding knowledge assets within the firm to gain competitiveness. KM has been widely researched in academic circles, and much such research has been conducted in collaboration between academic and private sectors. During such collaboration, various KM frameworks and models have been developed.

As all other studies of KM, construction researchers have developed many frameworks to meet the needs of the construction companies. These models accompany a wide range of issues of KM from capturing and storing knowledge to defining KM strategies. In the following three such frameworks will be described.

Kamara et al. (2002) developed and proposed CLEVER model as a beneficial tool helping companies defining knowledge problem and designing their knowledge strategy to overcome the problem. Robinson et al. (2004) studied the evaluation of the impact of KM on business performance and illustrated IMPaKT which examines the development of business strategies, analyzes the KM dimension of a business problem, and presents the likely impact of KM initiatives on organisational performance. Afterwards, SeLEKT framework was

developed in 2005 as a result of a three-year research program (Anumba et al., 2005). SeLEKT is an approach selecting the most appropriate KM tools according to the knowledge dimensions of the company.

Collaboration from the construction industry played an important role in developing of all three models, which are selected for description here since they have been accepted by industrial collaborators and now they constitute practical tools for implementation in construction firms.

4.1 CLEVER Approach

CLEVER (**C**ross-sectoral **LE**arning in the **V**irtual **E**nte**R**prise) is a framework for the selection of an appropriate KM strategy within an organization (Kamara et al., 2002). According to the surveys conducted among the companies within the scope of CLEVER project, the results show that the companies need assistance in the following subjects:

- identifying their high-grade knowledge
- helping in making high-grade knowledge to be explicit and highly controlled
- assistance in selecting appropriate strategies for KM that illustrates the unique features of their organizations

The purpose of the framework is to clarify an uncertain KM problem into a set of specific KM issues, set within a business context. There exist four stages in the framework:

- Define KM problem
- Identify “to-be” solution
- Identify critical migration paths
- Select appropriate KM process(es).

4.1.1 Define KM Problem

At this stage, the overall KM problem within a business context is identified. This stage includes the description of the identified problem and determining the underpinning business drivers. The characteristics, potential users and sources of this knowledge, the probable enablers and inhibitors, relevant KM processes (i.e. creation and transfer) are identified. At the end of this first stage, the user will obtain a clarified KM problem and a bundle of KM issues related with the problem.

To perform the above-mentioned activities, Problem Definition Template (PDT) is used. This PDT includes a structured set of questions in five sections. These sections are about "type of knowledge", "characteristics of knowledge", "sources and users of knowledge", "current processes" and "restatement of problem". The first two sections, the templates of Section A and B are illustrated below as Table 4.1 and 4.2 respectively. The questions in the PDT help users to "think through" a KM problem within the organization.

Table 4.1 Section A of the PDT (Type of Knowledge)

A1.What know ledge are you interested in?							
A2. Please select from the adjacent list, the class(es) of know ledge that best describes this know ledge	(a)Best Practice			(b)Equipment			
	(c)Product know ledge			(d)Quality standards/processes			
	(e)Operational process/procedures			(f)Domain/function know ledge			
	(g)Support process/ procedures			(h)Human Resources			
	(i)Strategies/policies			(j)Other (please specify)			
	(k)Control procedures						
A3. What are the business drivers for this know ledge problem?	**Category of Driver**	**Business Driver**	**KM Process**				
			Know ledge Generation	Know ledge Propagation	Know ledge Transfer	Know ledge Location and Access	Know ledge Maintenance /Modification
	Structural Change	Expansion					
		Restructuring					
		Merger and acquisition					
		Dow n-sizing					
	Other						
	External change	New market					
		New technology					
	Other						
	Continious improvement	Performance improvement					
	Other						

Table 4.2 Section B of the PDT (characteristics of knowledge)

B1:	What are the chracteristics of this know ledge? (indicate in the sliding scale how best this know ledge is characterised)	**Is the knowledge generally:** **Explicit:** can be captured, codified and formalized ← explicit … tacit → **Tacit:** (experience) usually in people's head **Auxiliary:** often general know ledge; never necessary in isolation ← auxiliary … critical → **Critical:** core to operational effectiveness and achievement of business goals **Discipline based:** emphasis on developing single discipline expertise ← discipline … project → **Project:** emphasis on developing multi-disciplinary expertise **Slow Change:** tends to evolve rather than increase rapidly ← slow change … rapid change → **Rapid Change:** frequent generation of new or amended know ledge *Other (please specify)* ← … →
B2:	Where is it located?	**Is the knowledge mostly:** **External:** know ledge existis outside the organization, e.g. it may be bought in ← external … internal → **Internal:** know ledge exists within the organization, tends to be owned **Individual:** know ledge held by individual(s) ← individual … shared → **Shared:** know ledge is shared and available across the organization **Specific to problem:** know ledge relates to defined problem context ← individual … shared → **Generic:** know ledge can be applied across a range of project contexts *Other (please specify)* ← … →
B3:	How is this know ledge acquired?	**Is acquisition (learning) mostly by:** **Learning by training:** know ledge gained by formal training or action on task or tool ← formal … informal → **Learning by interaction:** know ledge gained by interpersonal relationships; (in)formally *Other (please specify)* ← … →

4.1.2 Identify "to-be" Solution

The problem areas focused by the user are highlighted at this stage. This stage is used to confirm the characteristics of the current situation and to identify the desired future position on each problem area with regard to organizational policy and strategy. Some concerns are prioritized to identify critical migration paths for each problem. The output of this stage is a set of concerns or specific KM components of the whole problem which the user wishes to emphasize.

This stage processes through "Knowledge dimensions guide" which is a sliding scale allowing users to mark the current and desired future positions of KM.

After the establishment of CLEVER framework in the literature, Al-Ghassani et al. (2002) transported the framework to a prototype software application. The guide is sketched below as Table 4.3 (Classical and Software View).

Table 4.3 Classical View Knowledge Dimensions Guide

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

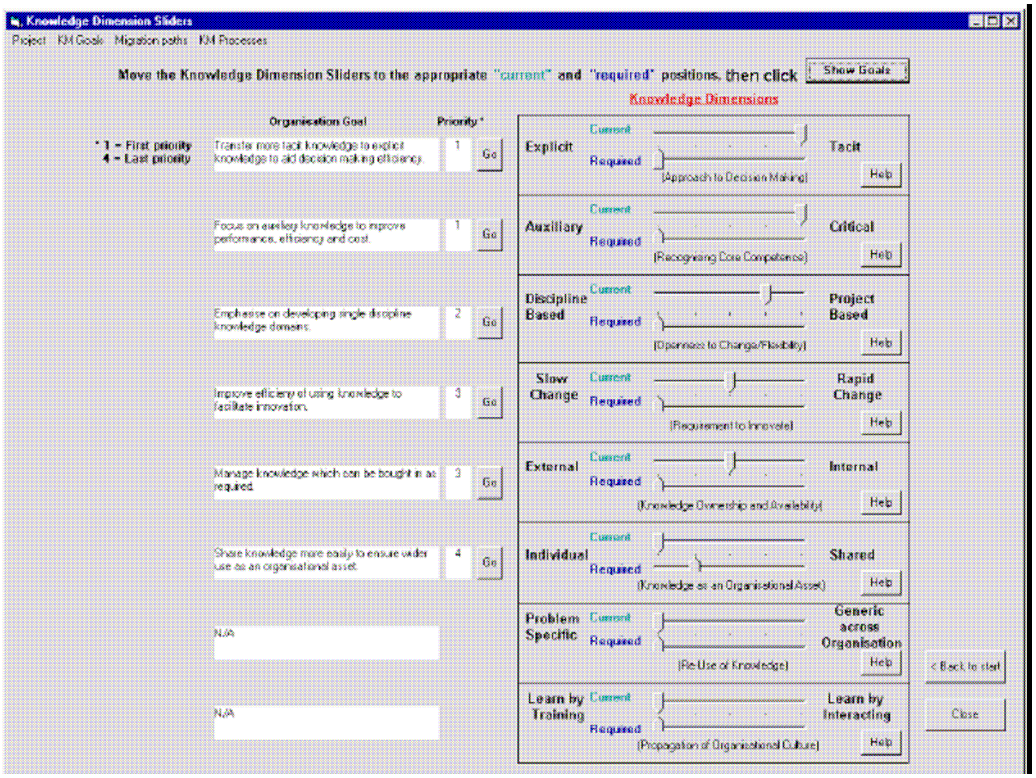


Figure 4.1 Software View of Knowledge Dimensions Guide

4.1.3 Identify Critical Migration Paths

This stage determines the way of the user from the current “as-is” situation to the desired future “to-be” situation. Predefined sets of “squares” are used to map out current position, to determine where they want to be and to track the path they move. At this stage, each identified problem is reviewed in turn. The overall set of migration paths are drawn for the overall KM problem under examination.

Examples of the matrices or “squares” are given below, Figure 4.2, to provide / secure a better comprehension. The user will determine the path to be followed according to the resources of the organization.

	SHARED INTERNAL			
EXPLICIT	Traceability and discipline in decision-making; mature operations with organization controls; knowledge as an asset, and can be allocated as required	⟵	More informed decision making; more chance of consensus & acceptance of decisions; greater agility; organization can use knowledge as an asset in critical process domains	TACIT
	↑	↙	↑	
	Non-strategic decision making; rigidity; knowledge is an under-used asset		Reliance on gurus; potential conflict in decision making; organization does not own its knowledge; harder to allocate / control scarce resources	
	INDIVIDUAL			

Figure 4.2 Critical Migration Path Matrice or "Squares"

The software application view of the migration paths is printed below as Figure 4.3.

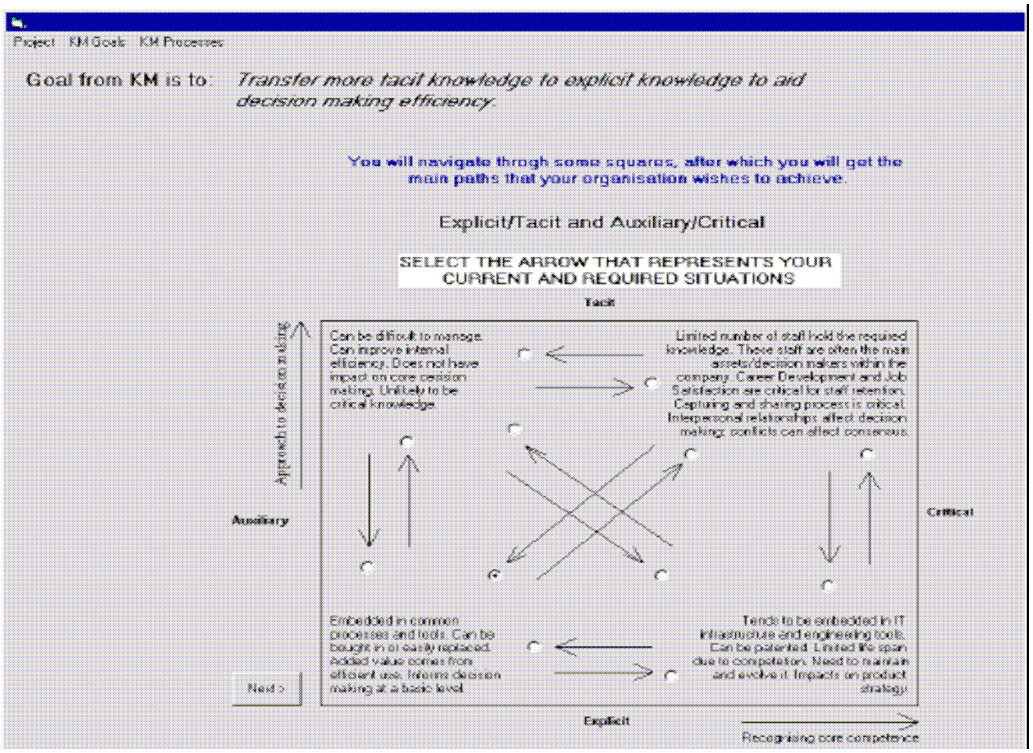


Figure 4.3 Prototype Software View of a Migration Path Matrice

4.1.4 Select Appropriate KM Process (es)

This final stage deals with choosing the suitable KM process(es) to move along each path defined at the previous stage. The related KM process is selected from a standard list of processes. Organizational enablers and/or resistors that may affect the implementation of the selected process are also identified. This will help organization develop specific plans according to the enablers / resistors to implement the chosen strategies related to KM problem.

"Generic KM process models" are used at this selection stage. For each migration path determined, a generic process (e.g. propagate/transfer knowledge) is chosen. Figure 4.4 below displays the generic process model for knowledge transfer.

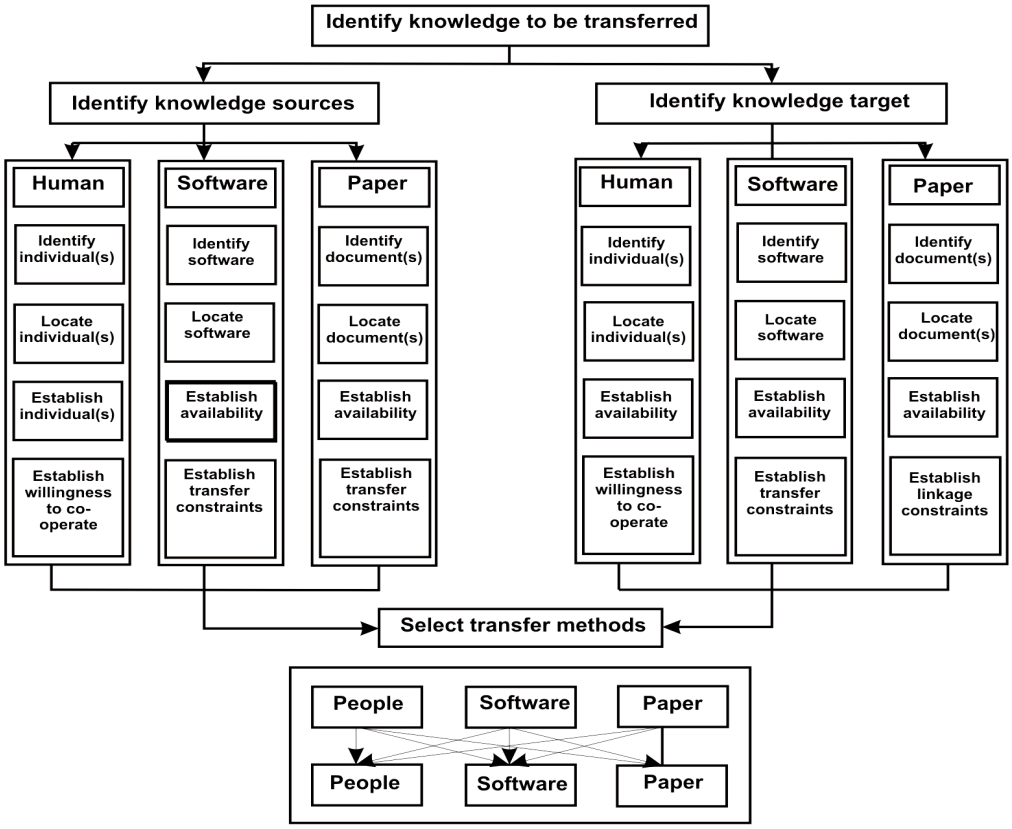


Figure 4.4 Generic Process Model for Knowledge Transfer

This process consisted of four steps: identifying knowledge to be transferred, identifying knowledge sources, identifying knowledge transfer target, and selecting the transfer method. Determining the source and the target of knowledge clearly will aid to identify whether it is people-to-people, people-to-paper, etc. transfer.

Figure 4.5 demonstrates the software view of knowledge migration path and their relevant KM process. Figure 4.6 illustrates generic processes of a KM process below.

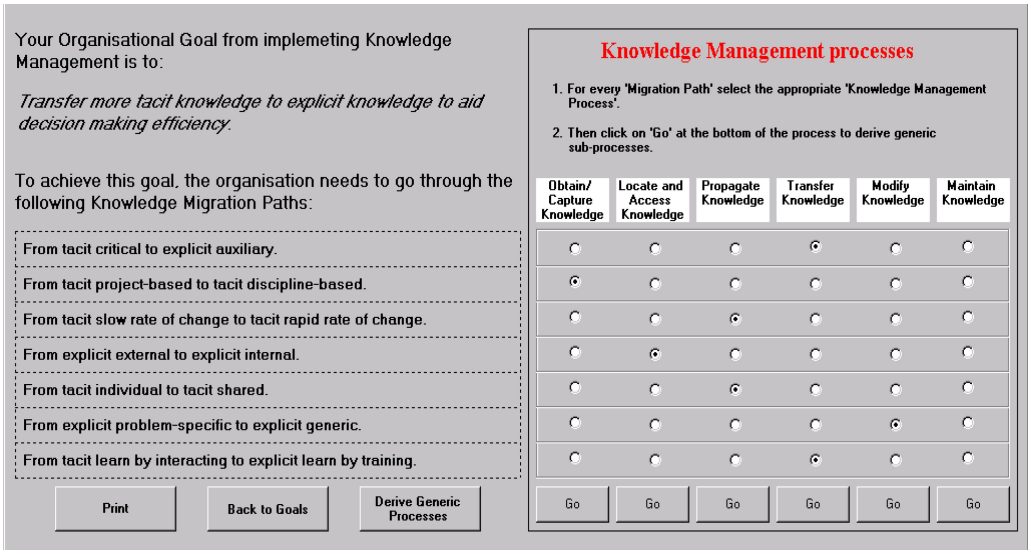


Figure 4.5 Knowledge Migration Paths and Relevant KM Processes

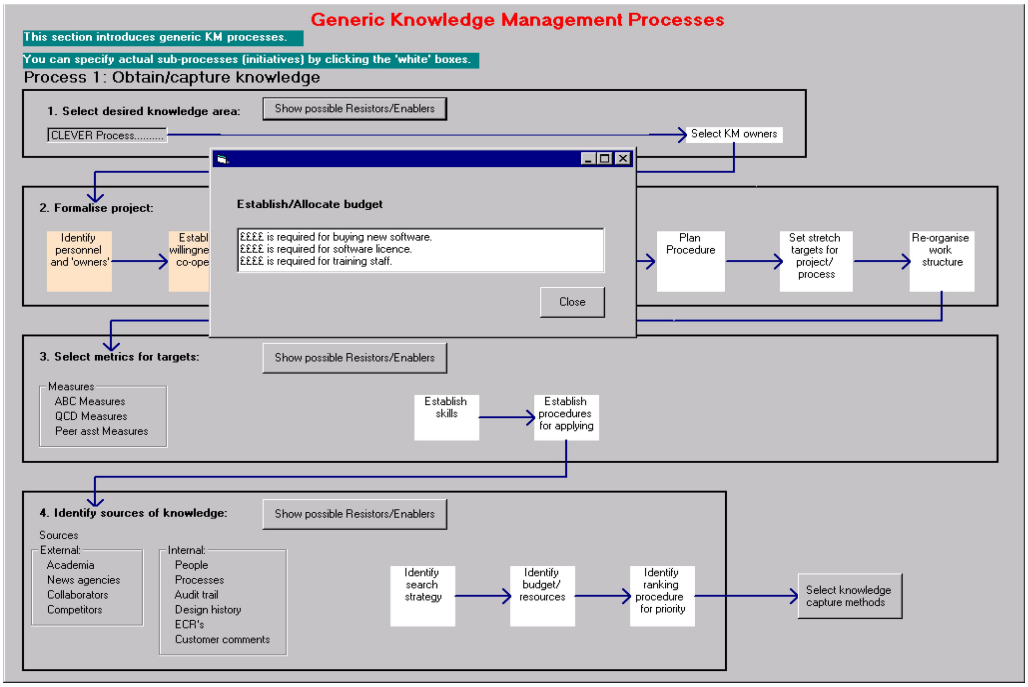


Figure 4.6 Generic Processes of a KM process

4.1.5 Conclusion

The CLEVER framework clarifies a vague KM problem within a business context into a set of specific KM issues. The obtained set of KM issues assists in selecting suitable processes to the identified problems. Figure 4.7 below depicts the final report of the software model.

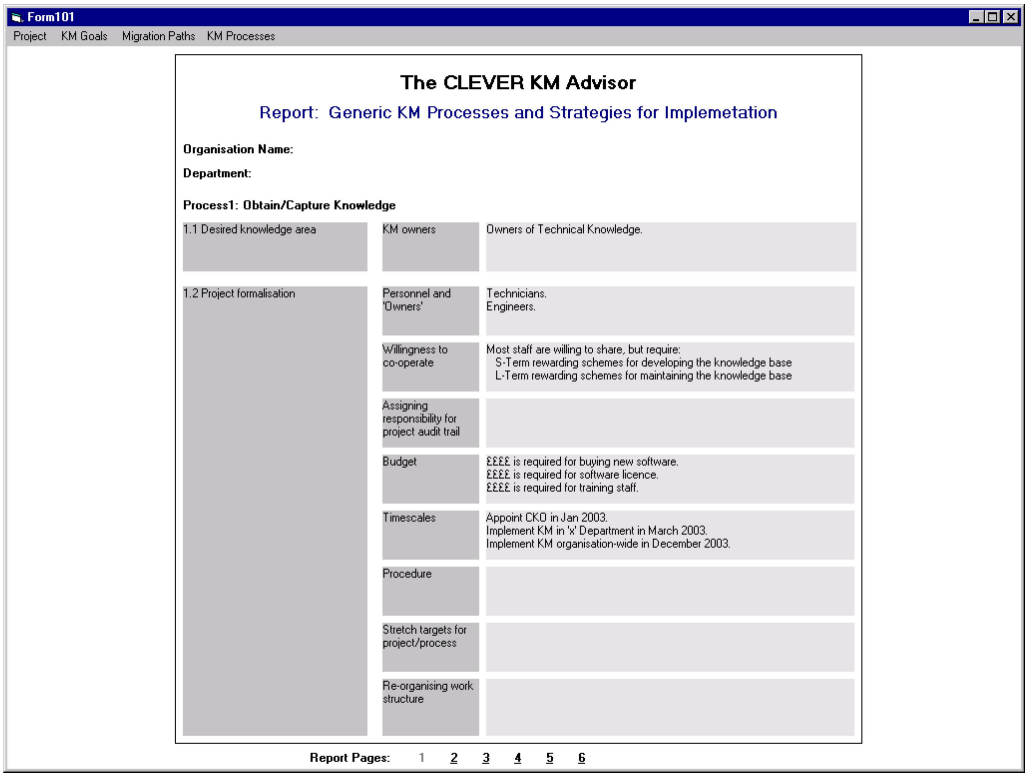


Figure 4.7 A screenshot of the report generated by the prototype software

4.2 IMPaKT Framework

As Davenport et al. (1997) argued KM is expensive and thus has the potential of gaining support in organizations primarily where it is linked to economic benefit or competitive advantage. A major challenge for the people responsible for KM is therefore to persuade the high-level management and stakeholders. A business case would be beneficial to senior management, to motivate employees and to increase participation and commitment to KM. Therefore, IMPaKT (**I**mproving **M**anagement **P**erform**a**nce through **K**nowledge **T**ransformation) was introduced by Al-Ghassani et al. (2004) to develop a business case for the organizations. The IMPaKT framework is shown in Figure 4.8 below.

The IMPaKT framework consists of three stages. Stage 1 is about developing a business strategy. Stage 2 is about developing a KM strategy and at the final

stage, in Stage 3, development of a KM evaluation strategy takes place. At each stage, there are conceptual questions, steps or thought processes to explore business problems or aims and their knowledge implications, to plan the KM responses and to assess their impact on business performance, respectively.

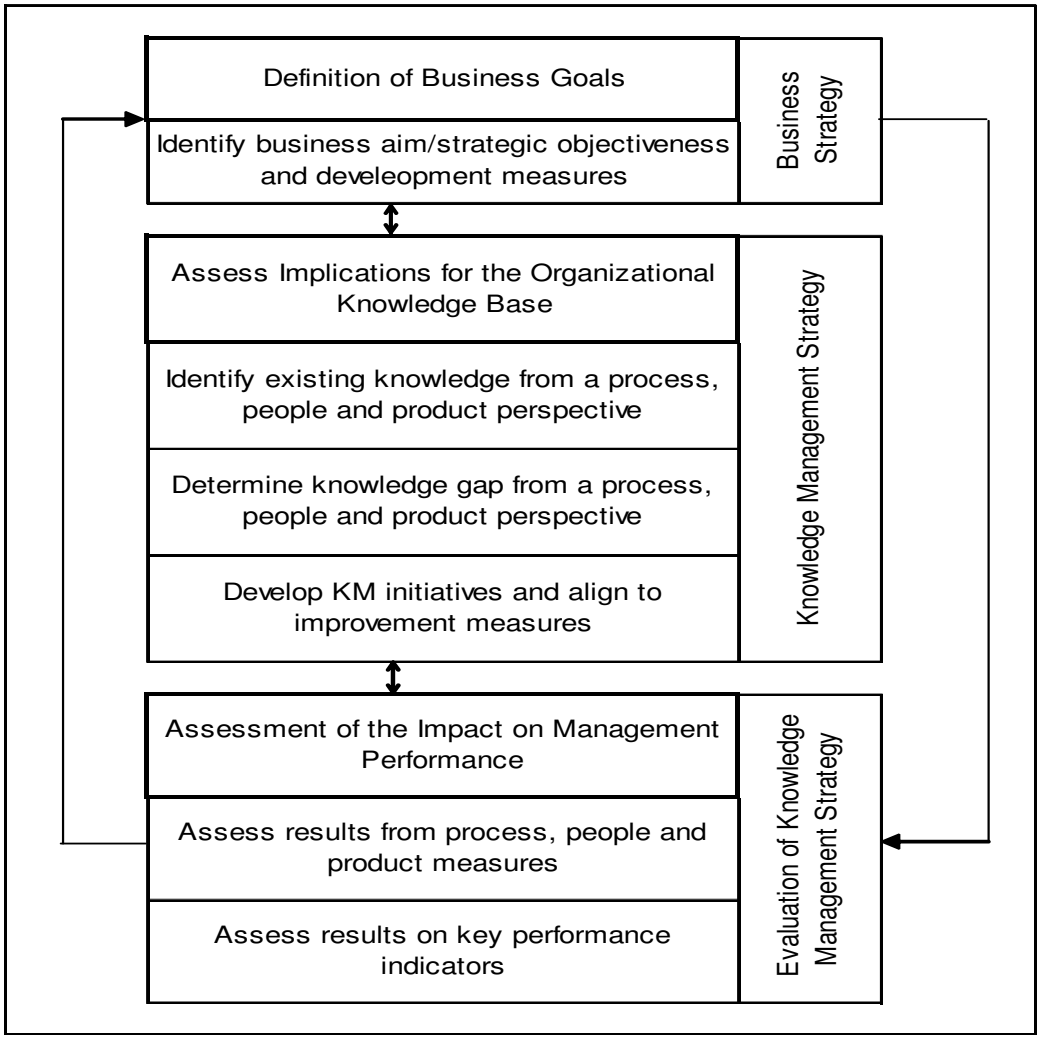


Figure 4.8 IMPaKT Framework

4.2.1 Stage 1: Developing a Business Strategy

There are four steps at stage 1 summarized in Table 4.4. The first step is to recognize the knowledge implications of the business problem(s) or objectives. KM problems occur due to failure of the sub-processes such as obtaining/capturing, locating/accessing, and sharing or the application of knowledge. The next step includes putting business problem in its strategic context by identifying organization's business drivers (external) and critical success factors (internal). External forces can be technological (need for innovation), market or structural factors (expansion/downsizing). Internal forces are the key factors on which the achievement of an organization's goals depends such as customers, employees, shareholders, nature of services or products. The selection of measures for performance monitoring is another important step. The glossary of key terms supports the framework.

For example, if the strategic objective is to expand, then the bidding process, supply chain and strategic partnerships, and customer relationship management processes could be affected. Bid/win ratio, customer satisfaction, new or repeat business volume, and success rate on joint bids are the measures to be given more priorities.

Table 4.4 Steps of Stage 1: Business Improvement Plan

	Stage 1 Steps	**Supporting Guide**
1.1	Choose a business problem with a knowledge dimension	Glossary of terms
1.2	Place the business problem in a strategic context by relating it to your external business drivers, strategic objectives and critical success factor	Glossary of terms
1.3	Select measures to monitor progress towards achieving your strategic objectives, and identify the business processes they relate to	Performance measures
1.4	Identify current and target scores for various measures and establish the performance gaps	Metric definition

Stage 1 outcomes with a business improvement plan with measurable indicators and performance benchmarks to evaluate progress.

4.2.2 Stage 2: Developing a KM Strategy

The purpose of this stage is to clarify whether the business problem has a knowledge dimension and to develop specific KM initiatives to address the business problem or goals. The steps included in Stage 2 are summarized in Table 4.5.

Table 4.5 Steps of Stage 2: KM and transformation plan

	Stage 2 Steps	Supporting Guide
2.1	Clarify the knowledge dimension of your business problem by identifying the KM process (es) involved	Problem diagnostic questionnaire
2.2	Develop specific KM initiatives to address the business problem/objectives	Problem diagnostic questionnaire
2.3	Select tools to support the KM process (es) identified and the implementation of the KM initiatives	KM tool selector
2.4	Prepare an Action Plan and identify change management and resources required	Readiness audit checklist
2.5	Identify relationships between KM initiatives and performance measures and show how they relate to the strategic objectives	Cause-and-effect map

Under the guidance of “problem diagnostic questionnaire”, step 1 defines the nature of KM problems. Some sample questions of “problem diagnostic questionnaire” are illustrated in Table 4.6 below.

Table 4.6 Problem Diagnostic Questionnaire (Sample Questions)

Sub-Process	Diagnostic Questions
Locating Knowledge	Do employees face problems in identifying where knowledge exists? (e.g. which people have the knowledge, intranet, software systems or database)
	Is there a need to catalogue and index knowledge sources?
	Do employees need new software and/or hardware to search for knowledge?
	Do employees know how to use different search methods to find knowledge?
Capturing Knowledge	Is there a need to codify knowledge that exists within the organization? (e.g. tacit knowledge about people, processes and products etc.)
	Is there a difficulty in codifying or representing tacit knowledge that exists within the organization?
	Is there a difficulty in obtaining and representing external knowledge?
	Do you have problems in identifying tools for capturing knowledge?
Sharing Knowledge	Is there a difficulty in sharing tacit knowledge between people across the organization?
	Is there a need to transfer explicit knowledge between people, software application and paper documents?
	Is there a problem in the learning process across the organization?
Modifying Knowledge	Is the knowledge base within your organization getting too large to maintain?
	Do you have a formal procedure for maintaining the knowledge base?
	Is there a problem with identifying individuals or groups who should validate any modifications to the content of the knowledge bases?
	Do employees face risk of using outdated knowledge stored in the knowledge base?
Creating New Knowledge	Is there a requirement to elaborate or combine existing explicit knowledge to generate new knowledge?
	Is there a need to re-use existing information to produce new knowledge?
	Do you need to encourage employees to generate new knowledge?
	Do you need to obtain knowledge creating tools other than those already in place?

In step 2, KM initiatives that are systematic goal-directed efforts to achieve business improvement, are developed. The user selects the most appropriate tools or in other words, techniques and tools from a large database in step 3. The third step is strongly related to Step 1 because this step identifies the most appropriate tool for implementation based on both the KM sub process (es) in step 1 and the additional characteristics of the KM initiatives in step 2. Afterwards, the organizational readiness should be checked in terms of resources, reform and result monitoring mechanism. If nobody updates the information in "Skills Yellow Pages" which is a tool allowing users to search for other employees in order to consult technical issues, and nobody monitors the benefit and usage, the system will disappear and be useless.

The outcome of Stage 2 is a KM strategic and transformation plan with a group of initiatives, implementation tools and an action plan to support business improvement.

4.2.3 Stage 3: Developing a KM Evaluation Strategy

Stage 3 provides a structure for assessing the impact of KM initiatives on business performance. Cause-and-effect map, evaluation roadmap, cost/benefit checklists and a priority matrix support the steps in the stage. The steps are summed up in Table 4.7 below.

Table 4.7 Steps of Stage 3: Developing a KM Evaluation Strategy

	Stage 3 Steps	**Supporting guide**
3.1	Use the cause-and-effect map in step 2.4 to evaluate the likely contribution of the KM initiatives	Cause-and-effect map
3.2	Assess the probability of success of your KM initiative in improving your performance measures (effectiveness measure)	Readiness audit checklist
3.3	Select an appropriate method to assess the impact of each KM initiative on your business performance	Evaluation roadmap
3.4	Identify the cost for each KM initiative and the possible benefits (efficiency measure)	Cost and benefit checklists
3.5	Prioritize your KM initiatives based on the two measures of performance	Priority matrix

The cause-and effect map, which is a dynamic tool, is used for exploring and clarifying possible relationships between KM initiatives, performance measures and the strategic objectives they are related to. It determines the impact of KM on business performance in terms of its effectiveness and efficiency. The cause-and-effect map is sketched below in Figure 4.9.

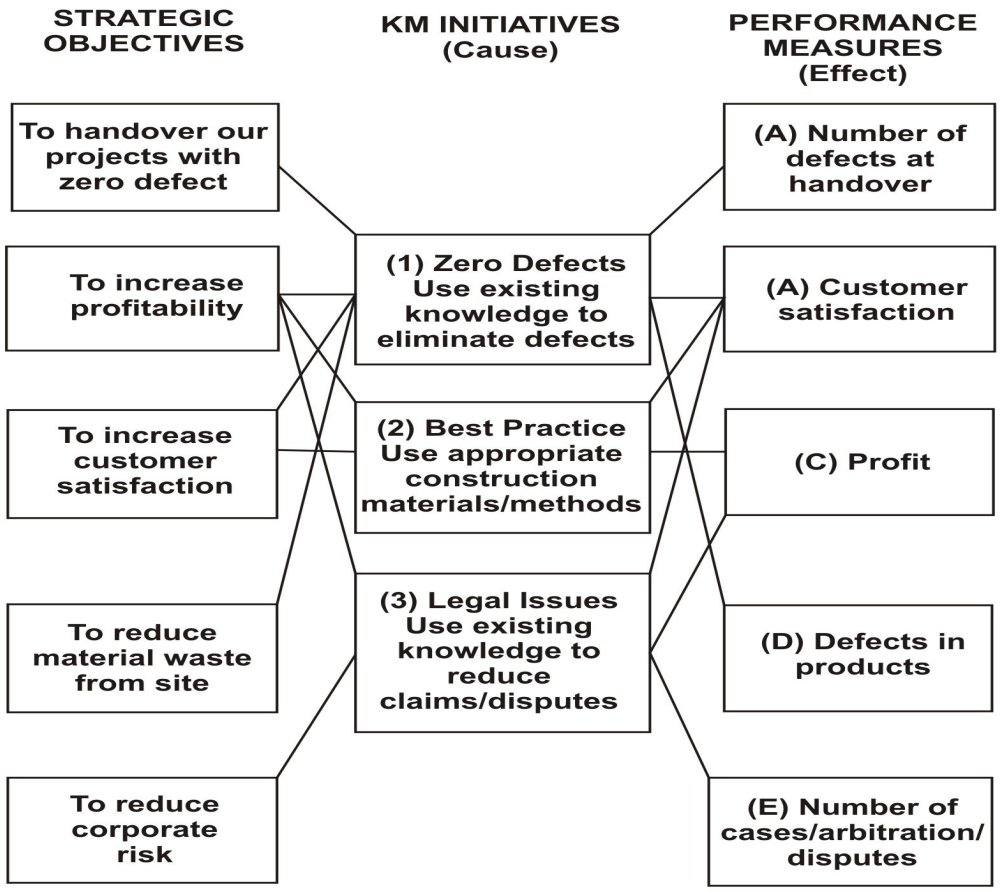


Figure 4.9 Cause-and-effect map

Effectiveness measures the degree or probability of achieved target performance measures. Efficiency measures the ratio of benefit or utility per unit investment. There are several techniques to evaluate the impact of KM initiatives: cost minimization analysis, cost effectiveness analysis, cost utility analysis and cost benefit analysis. The evaluation roadmap, Figure 4.10, is designed to guide users in the selection of the most appropriate technique based on a group of structured questions and the characteristics of inputs and expected outputs of the KM initiatives.

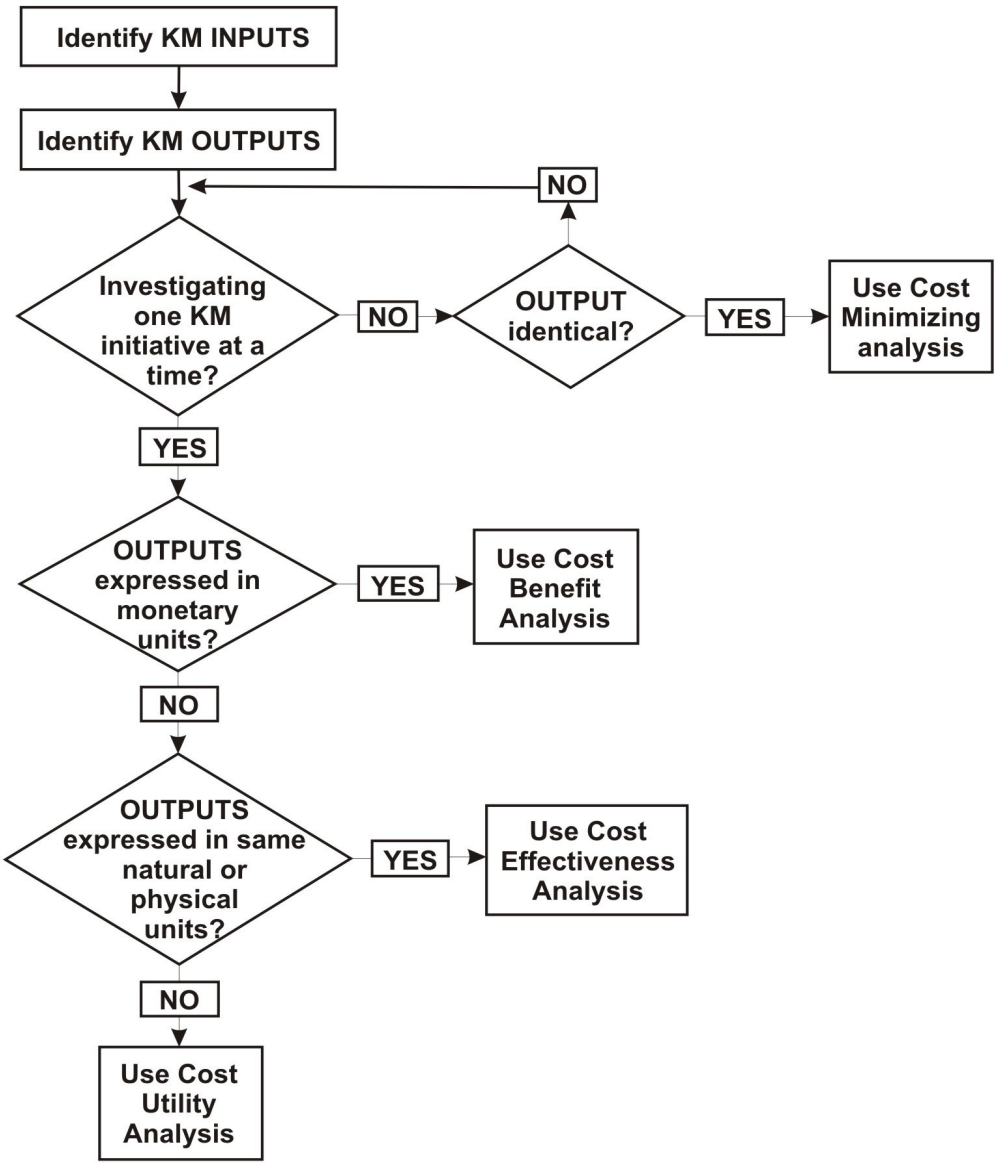


Figure 4.10 Evaluation Road map

Stage 3 enables users to create a priority matrix that incorporates both measures for effectiveness and efficiency to determine the best and worst performing KM initiatives. This could provide the basis for implementation or review. The outcome of this stage is a KM evaluation strategy and an implementation plan with an appreciation of likely impact of various KM initiatives on business performance in terms of effectiveness and efficiency.

4.2.4 Conclusion

The IMPaKT framework allows an organization to structure its business problems and to place it into a strategic context. It simplifies an exploration of the knowledge implications embedded in business problems and enables developing a KM response. Moreover, the framework provides a structured approach for devising and assessing KM strategies to guarantee that they are coherent and consistent with the overall strategic goals of an organization. Finally, it provides a set of complementary measures for evaluating the impact of KM initiatives on business performance.

4.3 SeLEKT Approach

The SeLEKT (**Se**arching and **L**ocating **E**ffective **K**nowledge **T**ools) methodology is the outcome of a three-year project called "Knowledge Management for Improved Business Performance (KnowBiz)" at Loughborough University, UK. The SeLEKT approach is a three-step process: identifying the KM dimensions, identifying required KM sub-processes and linking them to tool categories, identifying commercial software applications for the technology categories. These three steps will be explained in detail in the following subsections.

4.3.1 Stage 1: Identifying organizational KM dimensions

The aim of the first stage is to reflect the organization's current and required KM dimensions. There are three KM dimensions namely internal-external (knowledge transfer domains), individual-group (knowledge ownership form) and tacit-explicit (knowledge conversion types).

The knowledge transfer domains examines whether the knowledge exists within the organization (experts or available in knowledge bases) or outside the organization (consultants). The location of the knowledge is important to determine the technique or technology to manage. Communities of practice and intranets are examples to transfer knowledge internally. Extranets are used to change knowledge between organizations (internal to external or external to internal). Recruitment and knowledge bases are techniques for external-to-internal knowledge transfer.

To determine whether the knowledge is personal or shared (group) is important in identifying the technologies and techniques. E-mail, for example, is a technology enabling knowledge transfer between individuals or groups of people whereas e.g. mentoring is a technique used for transferring knowledge and experience from individual to another individual. Therefore, to determine the most suitable tools, it is to be identified who owns knowledge and who requires it.

Another knowledge dimension to be examined is between tacit and explicit. As other dimensions explained above, the techniques and technologies differ according to the tacitness and explicitness. Data-mining technologies are useful to search within explicit knowledge while expert systems are for tacit to explicit conversion. Face-to face meeting is a technique for tacit to tacit transfer. The below table, Table 4.8 summarizes and searches for the interaction between these dimensions in their current and required situations.

Table 4.8 KM Dimensions and their possible combinations

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

4.3.2 Stage 2: Identifying required KM sub processes and linking them to tool categories

The KM sub processes in SeLEKT are locating and accessing, capturing, representing, sharing, and creating new knowledge. After the first stage, identifying KM dimensions, it is to be determined which KM sub processes are affected. For example, if knowledge is to be transferred from "internal-individual-tacit" to "internal-individual-tacit", two KM sub processes are involved, namely "locating and accessing" and "sharing". These sub processes have the meaning that the individual having the knowledge should be determined and "sharing" of the knowledge should be facilitated for the other individual desiring it. This "locating" can be through *Skill Yellow Page* or *Experts Directory* and "sharing" can be through face-to-face interaction technique or groupware/netmeeting technology.

Capturing knowledge aims at capturing knowledge into systems such as document, knowledge base, software or even videotape. In many cases, it

overlaps with "representing" knowledge. Representing knowledge aims at facilitating knowledge access and transfer. Web publishing, video clips, documents, drawings and spreadsheets are several means of representation. Another main objective of KM is to create new knowledge. KM facilitates the process from existing knowledge by several ways. Knowledge maps assist in identifying the way knowledge sources in an organization relate to one another.

4.3.3 Stage 3: Identifying commercial software applications for the technology categories

After the selection of the technology category in Stage 2, the corresponding suitable software should be selected in Stage 3. However, the selection process depends on some factors like the functional capabilities of the individual applications, the existing applications in the organization, the ability to link existing ones with the new ones, the cost of the software, etc.

4.3.4 Conclusion

SeLEKT is an approach in the selection of convenient KM tools by incorporating three dimensions of knowledge. The approach set above requires that an organization should notice its present and future situation in relation to the three KM dimensions.

4.4 Knowledge Management Applications

4.4.1 Knowledge Online TM

In her research paper, Carrillo (2004) investigated two North American companies. One of them, Fluor Corporation, has a KM system called Knowledge Online ™ with a focus on its "knowledge communities". This system is a web-based knowledge environment using IBM, Lotus Domino ™

and Lotus SameTime ™ technologies. Fluor Corporation has 36 knowledge communities dealing with 14.000 employees on the subjects of project management, quality, risk, safety and functional engineering disciplines. These communities encourage KM and are supported business units that provide funding and resources. Each team consists of a knowledge manager, several experts and key people. They review and change goals consistently to obtain their value adding.

4.4.2 KM Library

The other company investigated by Carrillo (2004) did not allow its commercial title to be declared. The company's KM effort focuses on a lessons-learned database called the "KM Library". At the end of the project, the project manager invites 15 to 20 people including team leaders from various disciplines to guarantee covering all dimensions of the project. The sustainability of attendance is provided by enthusiasm (to submit items to the library) or by frustration (noticing something working improperly and a keenness to create solutions). A form is used during the session to identify the nature of the problem or opportunity. It lasts 1.5 hour to discuss the problem. Then, they are asked to mark where they think they could add to the problem. Participants vote the problems, solutions, lessons-learned discussed during the session. The most important lessons-learned are reviewed by a continuous improvement committee consisting of quality manager, chief finance officer and engineering manager. If approved, the issues are placed into the library.

4.4.3 Turner Knowledge Network TM

Skogstad (2005) examined Turner Construction. Turner has a knowledge Network system that includes subsections of business-unit intranet sites, Turner news, Turner tools, Turner University, AEC community e-store, and knowledge and learning objects. "Turner tools" is an online dashboard that connects

employees to corporate employee resources such as information on benefits, job postings and archived news. “Turner University” works on measurement, development, learning, and collaboration. In the university, online courses, seminars, and other development facilities take place for learners, administrators, and managers. The number of registered and completed courses, hours of web-based learning, number of users are some of the measures of Turner University. Branded goods and safety equipments are sold in the AEC community e-store to finance the learning in the organization. Moreover, there are videos, audios, PDFs, PowerPoint and Word-Excel Spreadsheets, etc. in the Turner Knowledge Network to codify tacit knowledge and make it reusable and searchable by all staff.

4.4.4 Arup Pages

Tony Sheehan (2000) discussed KM practices at Arup. He mentioned Arup Pages which is a corporate “Yellow Pages” listing skills of the employees. After a centrally managed version proved difficult to manage, a new improved version is controlled by individuals and skills networks. It is based on a network of personal web pages to allow people to volunteer content that they are enthusiastic to share with the rest of the company. On the web pages, the skills of the individual are listed. For example, when there is a complex problem set by Australian Rail Company asking for urgent competitive proposals to resolve, Arup utilized its intranet-based skill networks to access technical and operational information on four continents. The team obtained the best knowledge to generate a realistic and cost effective solution. “Feedback Notes”, including lessons learnt and 'watch-it' notes, and providing a potential route to well defined 'Arup Best Practices' in the form of explicit knowledge is another mechanism of the KM system used by Arup.

4.4.5 Regional Engineering Manager (REM)

Bresnen et al. (2003) investigated five case studies in UK at different industries: construction, telecommunications, pharmaceuticals, health and social services. REM model is a case study selected for the construction industry. The REM is proposed to the construction company and quickly appointed. The REM is responsible for increasing the value engineering of projects, improving coordination of engineering services provision and engineers' training and development across the regions. Therefore, it can be seen a knowledge management mechanism drawing upon the engineers' experiences on past and ongoing projects. This role is useful because it prevents the company from "reinventing the wheel" in that region due to the long-term employment of the REM. All REMs from different regions meet at every 3 months to argue a wide range of issues and to construct and strengthen personal contacts and networks for a well flow of knowledge. However, there are some communication and network problems within the REM system. In this REM role type of capturing and diffusing knowledge, there are some factors as enablers and barriers like the organizational structure; cultural context and the climate for change; skills and capabilities; communications, networks and information flows; technology; and objectives and outputs set out by the organization. The success of a REM heavily depends on the characteristics of the sub-employees working under the REM in terms of ability of supplying information. Therefore, the process of knowledge capture, transfer and learning depends on social patterns, practices and processes. These findings show the difficulties, limitations and challenges for capturing and codifying the project-based learning via technological ways in a project environment like construction.

CHAPTER 5

RESEARCH METHODOLOGY and FINDINGS

5.1 Introduction

Knowledge management (KM) has received increased attention in the last 10 years. It is now generally accepted that knowledge identification, creation, acquisition, transfer, sharing and exploitation are vital for efficient working in projects and for improving organizational competitiveness (Egbu, 1999, 2000). Organizational and individual knowledge is also vital for the construction business. However, the increasing attention focused in this area has not been matched by comparable empirical research studies in project-based environments and in the Built Environment disciplines. Similarly, there is paucity of research frameworks in knowledge management in Built Environment research (Egbu et.al. 2001).

KM has several aspects such as what kind of knowledge is kept by the companies, how is it stored, how is it utilized when needed, what are the barriers to implement such a system and what are the benefits of a KM system. These aspects play a significant role in the determination of the level of awareness in Turkish construction sector.

An interview-based approach is selected for the investigation of awareness, KM approaches and applications of the firms. The interview questions (Appendix A), were prepared to analyze the current practices of the firms in capturing,

storing, sharing, modifying and utilizing of knowledge. The survey results categorize the interviewed companies into four main stages. The properties of each stage are constructed according to the literature review on previous KM research, methods, industry applications and the interview results.

The following sections explain the characteristics of the companies interviewed, the detailed research methodology and findings. Afterwards, the step-wise approach will be introduced to categorize Turkish companies and properties of each stage will be mentioned. At the end, a roadmap schema for the companies to shift one stage up is introduced to provide a framework consideration.

5.2 Research of Companies

In order to gather information from the Turkish construction industry, medium-large scale companies were selected for interview. The main idea behind the choice is that large companies should have implemented more or less such a system to utilize from their past activities and projects. Each of the companies has high turnover rate, which is a factor to demonstrate the scale and many employees that make knowledge activities more crucial. Most of the firms can be denoted as general contractor, undertaking almost all kinds of projects from infrastructure to luxury buildings. One of the firms selected has rejected to interview because of their incapability of answering the interview questions on the subject. Only one out of nine is a leading design firm engaged with drawing and consulting all kinds of projects from mass housing to pipeline. Another important feature is the age of the companies because elder companies have more chance to structure such systems due to their institutionalized structure and experience when compared to the younger ones. Except for one of the companies, which is a joint venture between two large firms, the selected construction firms have appeared in the construction sector for 30 years or more. All the interviewed companies have projects abroad at various scales.

Table 5.1 illustrates the age of each company, its average turnover and number of employees, and the current position of the interviewee in the company.

Table 5.1 Characteristics of the Research Companies

Company No	Age of the Company	Average Annual Turnover	Number of Employees	Respondent's Position
1	37	20-100 m $	100-500	Board Member
2	29	20-100 m $	100-500	Deputy General Manager
3	38	>100 m $	>500	Business Development Manager
4	31	20-100 m $	>500	Tendering Division Manager
5	48	>100 m $	>500	General Coordinator
6	44	>100 m $	>500	Business Development Manager
7	14	20-100 m $	>500	Contract Manager
8	28	20-100 m $	>500	Chief Executive Officer (CEO)
9	41	>100 m $	>500	Business Development Manager
10	51	>100 m $	>500	No Response

5.3 Research Methodology

Reviewing the literature widely about KM, case studies and frameworks, the findings from the surveys and lessons-learned among companies in UK, US and Canada are considered and revised and reshaped according to the Turkish construction industry and the interview questions are prepared. The main

purpose of this interview is to evaluate the awareness of the Turkish construction companies and their knowledge activities. The questions in the interview are grouped under three categories. These are;

1) **Organization** investigates the basic characteristic information about the companies.
2) **KM Awareness** searches for the existing KM activities, knowledge usage, sharing, tools, etc.
3) **KM and Business Strategy** examines the relation between the business strategy of the firm and its simple KM applications.

The first group of questions queries information about the respondent company, the establishment date of the company, competences and international experience, average turnover and number of employees to identify the scale, structure and history of the company.

The second group asks the awareness of KM and KM strategy within the company. Then the knowledge types or areas related to the projects are determined with their storage type. This question investigates the knowledge types and consists of four main parts as the knowledge related to *project performance*, *parties involved in the project*, *existing market information* and the *human resources part*. Under each category, there is a list of most popular knowledge types utilized in projects. The interviewee identifies whether the knowledge is kept as *paperwork*, *in individuals' brains*, *in computers* or *partially in computers*. The results indicate the ability of the company knowledge to be transformed into a more structured system. Afterwards, the important knowledge areas and their storage kept are investigated. Within this group, the respondents help in identifying the identities of the people storing knowledge within the firm.

The tools that are used within the organization are highlighted in order to understand IT-infrastructure and to determine the means of the firm capturing, storing and sharing knowledge. Besides the tools emphasized, the ways to reach the stored knowledge and its utilization by the company is important because it is useless to invest on such a system or knowledge mechanism if you are unable to exploit it.

After these questions, a workshop part is to be worked out. This part is inspired by the CLEVER model in order to define the knowledge problem and its possible business drivers. This small-scale workshop helps to illustrate the knowledge-problem definition abilities of the companies. Another workshop, "knowledge-dimension", is also part of the CLEVER framework interrogating the current dimension of the organizational knowledge and the desired situation in the future. This makes it clear the current knowledge profile of the company and their intention in the future.

The next step requires to have an idea about the KM approach in evaluating the importance of a KM activity and its application in the organization. The respondent is given five KM activities to rate according to a Likert scale from "1" to "5" corresponding to "Very Low" to "Very High" respectively. Finally, this group of questions, the awareness evaluation stage, ends up with the identification of the possible barriers for the Turkish construction industry. The interviewee is forced to think through the whole construction industry in Turkey and to decide about the validity of the barriers and rate the relevant importance.

The final part of the interview lasts shorter than the previous group of questions with five questions. The main purpose of these questions is to stress the relation between business strategy and KM because as Robinson et al. (2004) declared, it is more likely to implement KM strategies if their contribution to business performance can be demonstrated. Therefore, in order to link the business performance and KM, there should be a business strategy and identified

business measures. The benefits to be gained from implementing such a strategy should be noticed and accepted to evaluate its contribution to the overall performance. Besides all, the human factor should not be discarded because the future of the system strongly depends on the behavior of the employees and the knowledge to be derived from them.

Finally, this interview aims at notifying the respondent about some basic aspects of KM like benefits, barriers, tools, etc. Due to their current positions in the companies, these interviewees' approaches and their opinions about implementing a KM system within their organizations would be beneficial to illustrate the acceptance by the Turkish construction companies giving some indication of the intention of breaking the conservative rules in the industry.

The interview results and research findings are described in the following section. After obtaining the results from the interviews, companies are graded into stages of KM maturity. The stages are constructed according to the companies' KM situations and the literature survey on KM levels in construction firms (Robinson et al., 2005; Finnemore et al., 2000; Finnemore and Sarshar, 1998). However, it does not mean that the companies retain all the characteristics of the stage they are in. Therefore, a perfect match of the companies at the stages is not considered. Companies are categorized according to the best-fit consideration.

5.4 Research Findings

The interviews were conducted among high-level managers such as general coordinators, business development managers to have a wider view of the KM activities within the organization. The questions, attached as Appendix A, were responded by the managers within half-day face-to-face meetings. Questions were discussed in detail to avoid misunderstandings. At the end of each meeting, the personal opinion of the interviewee was taken about the questions

and the subject it brought up in order to identify the insufficiency of questions. Moreover, the interviewee was assisted and guided forward with clear examples when there was a bottleneck about the subject or the applications. Such an approach was deemed necessary due to the general lack of detailed knowledge of KM.

It is important to note that all of the companies interviewed have encountered or at least aware of KM within their organizations. However, despite the high awareness rate, only half of them (55 %) pointed a KM strategy applied within the company and 22 % stated that they have KM activities on an ad hoc basis. The firms possessing a KM strategy, there is a dedicated KM person working for such activities to maintain KM. However, such people have other major duties taking precedence over KM like IT management increasing the workload.

After questioning KM elements of the companies, the interview questions look into the knowledge types they store and the ways of storage examining whether kept on paper, in minds of employees, in computers or partially in computers. The storage type is important because if the knowledge is kept in the computers whether partially or completely, it becomes easier for the company to share, search, find and modify which enhances the capability of the company about knowledge assets. These knowledge types about the construction projects are divided into four main headings: Project Performance (*unit costs, productivity, applied methods, etc.*), Parties involved in the Project (*client information, subcontractor information, etc.*), Market Information (*Laws & Regulations, construction demand, country characteristics, success factors, material prices, etc.*), and Human Resources (*Skills of Employees, Employee details, etc.*). Interviewees were set free to mark more than one storage type for the given project knowledge types. The results indicate that there is not a standard approach in storing knowledge and most of the companies are still storing their knowledge in paper forms. Moreover, some of the important knowledge about clients and subcontractors, experiences and lessons-learned from previous

projects are being kept in the minds of some key personnel. However, the general situation is not so pessimistic that there is a vast amount of computer-work to store knowledge. The results given by each organization is summarized in Table 5.2.

Table 5.2 Knowledge and storage type within the construction organizations

Knowledge Type	**Printed Documentation**	**Employees' Minds**	**In computers**	**Partially in computers**
Project construction information:				
Unit costs	4	3	8	2
Productivity	4	5	3	2
Applied methods	4	3	6	3
(Other) EXECUTION FACTS	1		1	
EQUIPMENT DETAILS	1	1		
Parties involved in the project:				
Client information	5	5	5	2
Subcontractor information	5	4	6	3
Market Information:				
Laws & Regulations	7	3	3	1
Construction Demand	6	4	5	1
Country characteristics	3	3	6	1
Success Factors	4	3	2	1
Material prices	4	2	8	2
Human Resources:				
Skills of Employees	3	5	5	1
Employee Details	6	3	7	1
(Other) Performance				1

The knowledge kept and the habits of storing knowledge are determined above. The next question is who stores these knowledge and how. From the responses given to these questions, importance given to printed documentation becomes clear. Project managers, construction managers, group superiors, technical office members and IT team have the main role in storing knowledge. What is interesting is that, although the companies utilize the database or data warehouse, according to the ratings, they do not use it to store their knowledge assets efficiently. Employees prefer to keep the knowledge in paper forms, in their personal computers or in their own minds.

Despite the paper habituation, companies have some tools used to capture, store and share knowledge. The main tools utilized by all the companies interviewed are internet and email. Almost 89 % of the companies have databases to store and perform project-end meetings to capture knowledge. At the end of these meetings, a detailed report is prepared about the whole project to be stored and easily accessible for other employees. After-action reviews are another tool to capture knowledge about the success or failure in performing a decision. It is useful in comparing the estimates and the outputs, and in evaluating the possible reasons. About two thirds of the companies benefit from the document management systems, instant messaging programs and web-based file sharing tools to manage, to create and to share knowledge. Technical networks and electronic discussion forums hang back with 22 % and 11 % usage respectively. Surprisingly, Intranet which is defined as the backbone of KM system by the organizations surveyed by Robinson et al. (2005), is utilized only by half of the companies. Above all, despite their international experience and geographically dispersed structure, only three out of nine companies have an extranet system. Other tools with their corresponding utilization percentages by the Turkish construction firms can be seen in Table 5.3 below.

Table 5.3 Tools utilized by the companies

Tools	Percentage	Tools	Percentage
Intranet	55.56%	Expert systems	0.00%
Extranet	33.33%	Video-conferencing	22.22%
Internet	100.00%	E-mail	100.00%
Database /Data Warehouse	88.89%	Information Mgt System	22.22%
Document Mgt System	66.67%	Visualizing	11.11%
Electronic Discussion Forum	11.11%	Virtual Reality Tools	0.00%
Groupware	33.33%	Knowledge mapping	0.00%
Communities of Practice	0.00%	Computer Aided Design	33.33%
Technical Networks	22.22%	Instant messaging	77.78%
Project-end Meetings	88.89%	Web-based file sharing	66.67%
After-action review	55.56%	Data and text mining	0.00%
Neural Networks	0.00%		

It is not feasible and logical to invest in KM systems to capture, store, share, etc. knowledge if there exist no contribution and benefit to business processes. There are two steps in knowledge utilization for Turkish firms according to the interview results. First, the employee searches for the knowledge through database if available or through archive documents for hard copies and soft copies in CDs or DVDs. Internet is also another source of knowledge for the companies to be searched. The second step is the utilization of the searched and acquired knowledge. Most of the Turkish companies exploit the knowledge through bid preparation and price analysis. The stored knowledge is also utilized effectively both in choosing subcontractors and in problem solving by learning from best practices with equal ratings of 77.78 %. In addition, two thirds of the companies evaluate the performance of the subcontractors and

compare similar ones to monitor the most efficient one. Companies generally do not prefer to analyze the previous data when entering into a new market. Personal relations of the company owners with clients may have an influence on this behavior because their decision is above all. Besides general applications of knowledge as described above, one of the surveyed companies noted another utilization of knowledge. That company records all the information about the machinery and equipments including their properties, capacities, maintenance problems, erection costs, etc. to be able to evaluate the suitability of the machinery or equipment to a new project. Then, decision is made about buying, hiring or transporting the available machinery to the project site.

On contrary to the achieved knowledge storage and utilization activities, there is a lack of capturing and storing technical expertise knowledge which has utmost importance in order to avoid reinventing the wheel.

As mentioned in the previous sections, CLEVER, IMPaKT and SeLEKT frameworks are utilized to prepare the interview questions (Kamara et al., 2002; Robinson et al., 2004; Anumba et al. 2005). Under CLEVER, which is a tool used to define a KM strategy, there exists a Problem Definition Template (PDT) questioning the existing knowledge problem of the organization to propose a strategy to overcome in terms of possible business drivers. This section is attached inside the interview questions as a workshop to have an idea about the abilities of the companies defining a knowledge problem they faced with in the past or at present. Unfortunately, it was very difficult and tiring to explain such a case situation. All of the companies involved are failed to fill that workshop table in the CLEVER framework.

The next question can be stressed as another workshop involved in the CLEVER framework with tiny modifications. The total knowledge of the organization is dimensioned according to the current situation of the company and the desired dimensions of the knowledge for future are extracted. If the

scale is valued from -2 at left anchor and +2 at right anchor dimension, the average knowledge of the whole companies can be marked as explicit with a value of -0.44. The investigated companies are not glad with their current situation because they desire their knowledge to be more explicit in the future, which is proved by their desired value of -1.33. They declared that the current knowledge is just a little bit auxiliary (-0.33) to their business and more project based (0.56) covering a multi-disciplinary expertise. This may be due high competition in the Turkish construction market because they have to work in a wide spectrum to survive. As a result, their total knowledge is identified as internal, shared and learning within the organization generally occurs by face-to-face interactions between employees with an average value of 0.67, 0.56 and 0.89 respectively. As obvious, there exists any sharp, absolute value among the given dimensions, which illustrates that the companies are performing activities in the middle square with slight shifts. For the future expectations or intentions, the firms desire their knowledge to be more auxiliary than the current with a gradual increase to -0.44. On the other hand, they want to keep their project-based knowledge and focus more on developing multi-disciplinary expertise, which would be one of the abilities to survive. In order to deal with a wider range of disciplines, companies believe in enhancing their internal knowledge capital and sharing the existing knowledge within the organization to have better and faster decisions. The ratings of having internal and shared knowledge are increased considerably to 1.00 and 1.22 respectively. As mentioned before, knowledge transfer or learning generally occurs by face-to-face interactions between the employees of the organization. The respondents are hesitant about the means of learning because the companies do not have a mission to teach; therefore, they want to keep personal interactions alive and scored 0.00. The balance between two may be acceptable when considered.

After having obtained the general cross section of the companies in terms of managing knowledge and knowledge assets, interviewees rated five KM activities for their importance and application within the firm in a Likert scale

from 1- very low to 5-very high. The average ratings show that the most important activities are knowledge storing and knowledge modification with an equal rating value of 4.33. Knowledge capturing and knowledge utilization have equal importance scores of 4.11. Knowledge sharing gets the minimum score from the respondents and becomes the least important activities for the companies. Nevertheless, knowledge sharing has denoted as of high importance with an average score of 4.00. Consequently, in fact, all the activities are accepted as important by the companies. However, such a ranking of the activities is not possible for their applications in the organizations since all the activities have surprisingly equal application ratings of 3.89. Table 5.4 summarizes the importance and application results of KM activities.

Table 5.4 KM Activities –Ratings in terms of Importance and Application

Activities	**Importance**	**Application**
	Average Rating	**Average Rating**
Knowledge capturing	4.11	3.89
Knowledge storage	4.33	3.89
Knowledge dissemination	4.00	3.89
Knowledge Utilization	4.11	3.89
Knowledge modification	4.33	3.89

During the implementation of KM systems in UK and US, researchers revealed a set of barriers endangering the initiation and survival of the system. It is possible and obvious to face with such obstacles in Turkey if to implement KM. The respondents highlighted the validity of technological infrastructure insufficiency with a corresponding rate of 3.44. The most important valid barrier is identified as the consideration of such a system not creating competitive advantage for the company with an importance rate of 4.20. However, only 55.56 % of the firms consider and rate this as a barrier. High

employee turnover of the construction industry is scored 4.14 with 77.78 % validity. Company structure and resource insufficiency cannot be discarded because they are considerable barriers having equal importance scores of 4.00 with high acceptance percentage. 66.67 % of the companies noted that the unsupportive nature of the construction industry does not pose a threat for KM. Convincing senior management, lack of support by both employees and top-level management and measuring and demonstration of benefits have high validity of 89 % as a barrier but of medium importance of 3.38, 3.63 and 3.50 respectively. In opposite to the companies successful in implementation of KM in the world, the Turkish construction giants do not consider project uniqueness of the industry as an important barrier threatening and rate it as the least crucial barrier with an average of 2.50. Respondents' considerations about the validity of possible barriers and corresponding average importance rates are shown in Table 5.5 below. These barriers provide having an idea about the possible problems to be confronted with during the implementation of a KM system.

Table 5.5 KM Barriers and Importance Scores in Turkish Construction Industry

Barriers to Knowledge Management	Validity		Importance Score
	Positive	Negative	
Cultural barriers	66.67 %	33.33 %	2.83
Company structure	77.78 %	22.22 %	4.00
High employee turnover	77.78 %	22.22 %	4.14
Project uniqueness	66.67 %	33.33 %	2.50
Unsupportive nature of the industry	33.33 %	66.67 %	3.33
Not creating competitive advantage for taking jobs	55.56 %	44.44 %	4.20
Resource insufficiency	88.89 %	11.11 %	4.00
Lack of consciousness	77.78 %	22.22 %	3.57
Convincing senior management	88.89 %	11.11 %	3.38
Identifying a KM strategy	66.67 %	33.33 %	3.50
Lack of support	88.89 %	11.11 %	3.63
Lack of Technological Infrastructure	100.00 %	0.00 %	3.44
Measuring benefits of KM	88.89 %	11.11 %	3.50

Almost all the benefits listed are appreciated by the companies. Only five items (client satisfaction, employee satisfaction, better risk management, decrease in rework and high quality) have been considered as invalid by one or two companies. The distribution of the rates of invalidity can be seen in Table 5.6 below. However, those denotations do not affect or change the consent and can be negligible because only minority rated the items as invalid. The major article

for survival and competitive advantage is the client satisfaction with an importance score of 4.63. Client satisfaction is also stressed by Carillo (2004) stating a company who won two large projects due its successful KM applications. This is thus demonstrating the real benefit to the organization. The secondary place is occupied by the experience gained through years. It has an average rating of 4.44 emphasizing the importance. Therefore, a company could not waste the knowledge it gathered and can shorten the time required to reach an experience level by proper KM strategies. On the contrary, two articles, being innovative and avoiding from mistakes and thus rework, have the least scores in rating. They have close scores of 3.78 and 3.88, as can be seen in Table 5.6, respectively corresponding to almost "high" in the scale.

Table 5.6 KM Benefits and Importance

KM Benefits	**Validity**		**Importance Score**
	Yes	**No**	
Client satisfaction	8	1	4.63
Employee Satisfaction	8	1	4.00
Better Risk Management	7	2	4.14
Decrease in rework	8	1	3.88
Fast decision making	9		4.11
Rapid problem solving	9		4.22
Innovation	9		3.78
High quality	8	1	4.13
Decreased time durations	9		4.11
Experience gained	9		4.44

Besides technological investments and infrastructure, it is vital for a KM system to be nurtured by some techniques used to derive knowledge from people, i.e. employees. These techniques are discussed in terms their applicability in

Turkish companies to feed the system. The consensus is the easy applicability of training / seminars sessions, face-to-face interactions and ongoing project meetings. These are beneficial techniques to transfer, capture and share knowledge. The majority of the companies, about 90 %, mentioned post project reviews and brainstorming as the means of performing lessons learned and creating solution to problems. Indeed, brainstorming is a no-name technique that occurs among high-level managers when a problem arises. That may be the reason they have a warm approach for its applicability. Besides these accepted techniques, one third of the companies declared that mentoring, apprenticeship and web-based learning are the techniques difficult to apply despite their relatively high applicability score with 70 %. Only three of the techniques listed in the interview have gathered "not applicable" comment. Communities of Practice and Web-based learning are highlighted as "not applicable" with two companies among nine. Brainstorming is the third one with 11 % rating. At last, one can easily select the appropriate techniques accepted by Turkish companies because there seems no problem of any technique in terms of their applicability except some "difficult" ones.

The importance of establishing a link between business goals and KM is explained in the above paragraphs. One company of every three interviewed has lack of a well-defined business strategy and business goals, and only four of the companies have a performance measurement system. This information demonstrates that the Turkish companies should accomplish the base to derive benefits from implementing such a system. The system only gains support and survives if the linkage with the business goals defined in a business strategy is established.

Finally, eight organizations declared that implementing such a system would be very beneficial and would be applied in the future within their organizations. The last firm does not have an idea about implementing such a system. The

subject may be clarified in another way to increase awareness and to convince them.

5.5 Classification of the Turkish Construction Companies

Analyzing the interview results regarding the KM levels, construction companies can be examined in four groups. These groups are formed according to the answers given by the interviewees from each company. The aim of such an approach is to draw a profile of the medium-large Turkish construction companies in terms of their KM maturity levels and propose them a roadmap to enhance their KM activities.

A four-stage KM model for construction organizations is developed as a result of the literature survey and the interviews conducted in the Turkish construction industry. The stages from the lowest level to the highest are; *Preliminary Stage, Awareness Stage, Knowledge Stage and Maturity Stage*.

The first stage of the classification is named as the *Preliminary Stage.* At this stage, companies are unaware of KM and its benefits. These companies have lack of a detailed business strategy which is a base for a successful KM strategy. They do not have a performance measurement system to monitor or evaluate the targets. They store some basic knowledge related to the company on papers, in computers or by individuals. There is no structured system to keep or share knowledge. This is most probably due to the inability of the firms to allocate enough resources for knowledge activities. Therefore, due to the lack of financial resources, they have a poor IT infrastructure, which is the backbone of a successful KM system. When this financial inadequacy merges with the conservative behaviour of the senior management and the unwillingness among employees to share/create knowledge, it becomes an impasse for KM throughout the organization. Senior management support and leadership for KM

is vital. The approach of the senior management to KM diffuses in the organization and thus among the employees which may at least trigger the change. Three companies, four with the non-respondent one, fall into this stage in terms of their existing KM applications. One of them differentiates from the others by its non-conservative senior management. However, it will take some time to structure the activities and to satisfy the requirements of the upper stage.

The following stage, the second one, is the *Awareness Stage*. These companies are aware of KM and its benefits. They apply KM solutions on an ad hoc basis within their organizations. Most of the time they have a well defined business strategy with certain targets and they have a performance measurement system to assess these set of targets. Allocation of enough resources to support KM activities facilitates the utilization of some technological tools such as document management systems, databases, etc. to store/manage information. Moreover, a well established and networked IT infrastructure between offices, construction sites and other external knowledge sources like universities, consulting firms, etc. empowers the ability of the organization to capture, share, store, use, modify, etc. knowledge effectively. These developments and activities are supported by the senior management of the company. Therefore, the companies in this stage are more susceptible to improvements in KM than the ones in stage one. However, they have difficulties in defining knowledge that is strategically relevant to business needs. They store all kinds of knowledge, which yields in complexity in the future because they cannot filter the strategic knowledge for future needs of the company. This may be due to the lack of an established leadership dealing with the subject widely because in the existing situation, IT-manager or team members, or group supervisors and similar positions take up the responsibility besides their routine, primary duties. There exist two companies out of nine fulfilling stage 2 requirements. These companies perform knowledge activities on an ad hoc basis throughout the firm. Even though they have assigned knowledge responsibilities to IT members or Quality Service,

they lack of a full time employee to deal with the subject and disseminate the idea to the whole company.

Stage 3 of the classification is the *Knowledge Stage*, which is one-step advance of the Awareness Stage. At this stage, application of KM activities has gained a structured way throughout the firm. There exists a change management program for the employees to adapt change and to convince them to share and store knowledge during their daily processes. Change management program is vital for a company because it is the people issues constraining the implementation of KM systems in the organizations. Because of the program, the employees will adopt changes easier and quicker, have less resistance and at the end will have a knowledge sharing culture. Application of such a program indicates the support of senior management and the importance given to KM. To control the performance of the employees and thus the firm, there is a complete performance measurement system, which can facilitate the monitoring and evaluation of the benefits of KM if the appropriate measures are set and linked. With the given support by senior management and sufficient financial resources, KM activities are underpinned by high technological infrastructure and by KM tools to encourage the initiatives. In addition, Knowledge manager(s) and responsible(s) are identified to manage the activities of the existing system, which seems to be a great problem in Turkish construction companies. Almost 45 % of the firms satisfy most of the requirements of this category. First, they have a similar problem with the ones at stage 2 in terms of KM workers. On contrary to stage 2 companies, they have full time knowledge workers to support the knowledge system. However, they do not have an identified leadership to champion KM and to demonstrate benefits. The major shortcoming of these companies is the absence of a change management system, which deals with the adaptation of the employees to change and minimize the resistance to such a system or strategy.

The final stage is defined according to the literature review and STEPS approach defined by Robinson et al. (2005). None of the interviewed companies fit in this final group. However, this stage is necessary to demonstrate that there is an upper level for the companies in terms of KM. Since it is the final stage defined, its name reflects the characteristics as the *Maturity Stage*. Within stage four organizations, KM is institutionalized and linked to the overall business objectives. It is completely diffused in the organization and accepted as an organizational culture. Moreover, it is embedded in human behaviour, culture, commitment, business processes and product development. There exists full senior management support with reward and incentive schemes to empower KM activities. It is easier for these kinds of companies to illustrate the visibility and communicate the benefits from most KM activities. In addition, these activities are integrated into strategic measurement models like Balance Scorecard and the Excellence Model to monitor and evaluate knowledge assets.

CHAPTER 6

CONCLUSION and RECOMMENDATIONS

The subject matter of this thesis study is to determine the awareness of Turkish construction companies in terms of Knowledge Management (KM). The applications, measures, evaluation methods, gaps, barriers and requirements are all determined through face-to-face conducted interviews with the construction companies. The literature is reviewed before commencing the investigation of Turkish construction companies to provide a coherent approach to the subject. The appearance of KM, its evaluation period, useful applications and case studies, existing IT and non-IT tools utilized by the companies in the world are discussed in the first three chapters. During the literature review, there noticed frameworks and models implemented by the construction companies to improve or to initiate their KM activities. Three of the investigated frameworks were chosen to assist preparing the interview questions and the workshops for the Turkish construction companies. Afterwards, the interviews are performed to draw a cross-sectional profile of medium-large scale construction companies. According to the interview results, the companies are grouped into stages that facilitate enlightening their current situation and to identify the absences within their organizations and draw a roadmap to assist in KM, which is the secondary purpose of the thesis study.

In the context of this study, the developments in the subject of KM are emphasized. The distinction between data, information and knowledge is

expressed with clear examples to avoid any confusion. The definitions of tacit and explicit knowledge, their importance in the construction industry are stated. KM activities are explained with the interaction of people, processes and technology. Then the vitality of the tools, technologies (IT tools) and techniques (non-IT tools), utilized by the companies to support their knowledge system activities is highlighted with certain definitions. Barriers to implementation, benefits gained by implemented companies with clear case studies are illustrated. The necessity and the requirements of such a system for the construction organizations are discussed. Finally, among the investigated models in the literature, three of them, namely CLEVER, IMPaKT and SeLEKT frameworks are selected and described step-by-step in detail. Besides these three models, some practical models created by companies are mentioned and referred.

As is expected before the survey, the interview study has revealed some amazing and illustrative facts of the Turkish companies in terms of KM. They perform some activities to capture and share knowledge even in a structured way but not in a professional manner. There is a great unconsciousness about the subject even though the surveyed companies are superior firms of the industry. It is not possible to attribute the results to the entire Turkish construction industry and judge all the companies in the market since the research study covers a small sample. However, it can be said that if the situation is so thought provoking for the large-scale firms, then the small companies in the market should be frightening. The following conclusions can be derived from the interview study.

Construction companies store basic project information including performance, parties in the project, related market characteristics and human resources. Printed documentation holds a major portion of the stored information related to a particular project despite the frequency of computer utilization. Moreover, it should be noted that a considerable amount of information remains in the minds

of individuals. Complex technical problems are diverted mostly to the consultancy firms for solutions and the solutions are not recorded for future use.

Project managers and construction managers play the major role in keeping the project information on paper and in their own PCs. The choice of database is not preferred by employees to store knowledge.

Internet, email, project-end meetings, databases, instant messaging and web-based file sharing protocols are noticed as the most utilized tools by the companies to create, store, share and apply knowledge. Surprisingly, companies lack of the usage of the intranet, which is defined as the backbone of a successful IT infrastructure.

Companies exploit the stored knowledge for various purposes. The most popular utilization occurs during bid preparation sessions and during price computation activities. They also take advantage of solving complex problems through learning from best practices and of assigning subcontractors.

Existing knowledge of the companies is denoted as slightly explicit, auxiliary and project based. The current knowledge almost exists within the employees of the firm and it is shared across the organization. Learning mostly occurs through face-to-face interactions between employees. However, in the future, companies desire their knowledge to be more explicit, auxiliary to achieve their business goals and project based covering a wide range of disciplines. Knowledge should remain in the organization and be disseminated widely throughout the company. There should be formal training sessions and seminars to satisfy the learning needs of the employees instead of previous dense personal interactions.

When the KM activities are reviewed, it can be noticed that companies are successful at application of all five activities with equal scores. However, they

noted that knowledge storing and its revision when needed are the two most important activities to be carried out in construction organizations.

The belief that KM strategies and systems do not create competitive advantage in the race for a new project is considered as the most important barrier to implementation. High employee turnover, organizational structure and insufficiency of allocated resources are identified as the other major barriers avoiding companies feed and survive the system.

When the respondents are asked to identify the factors to gain competitive advantage, client satisfaction is denoted as the most crucial accomplishment. Experience accumulated in the company over years is introduced as another factor that differentiates the company from others and increases the chance of winning new projects.

In order to provide knowledge to the system thus to the company and accepting the major source of knowledge as employees, training and seminars, face-to-face interactions and ongoing project evaluation meetings are ranked first in terms of their applicability in construction industry. However, the respondents are not against other techniques. On contrary, they believe that mentoring, brainstorming and even communities of practice are applicable to the industry.

Finally, a staging approach is developed to categorize the interviewed companies into groups and to assist them in the way forward. This approach will help in understanding the current dimensions of the construction industry in terms of KM. It can be said that the results of the interviews are summarized within this approach to classify the companies. Companies will be guided by the requirements of each stage thus by the current applications of other competitors in the market to move into upper stage. The characteristics of each stage defined are sketched as Figure 6.1 and a framework is prepared below, Figure 6.2, for

the companies to serve as a roadmap to increase their KM capabilities step by step.

For the companies at the very first stage, there should be a business strategy and acceptable business goals to build up other management techniques and issues. Seminars/meetings are beneficial tools to demonstrate the articles of the subject and to increase the awareness of senior management. After the education of senior managers, “the change” will be triggered within the organization. However, the change process will consume considerable time and monetary because of the needs of a performance measurement system, IT infrastructure, etc. The second-stage companies have easier requirements than the previous group of companies. They improve an existing and working system to go forward on the way of KM. They should disseminate knowledge activities to the entire organization to get full benefits. Therefore, they will certainly need a change management programme to minimize the resistance of the employees and a knowledge leader that champions the system. They also need some investment such as personnel and software programs to maintain the system. At the next one, Knowledge Stage, companies endeavour to make KM institutionalized. They should link knowledge objectives to the business goals to obtain certain results. They should provide reward and incentive schemes to increase the performance and willingness of the employees. Strategic measurement models should be replaced instead of current performance evaluation models. At the end, these companies are denoted as mature in terms of KM and domiciles at the last stage. They should improve their systems and add new techniques or technologies to the literature facilitating the maintenance of the system.

Figure 6.1 Characteristic Properties of Each Stage in the Model

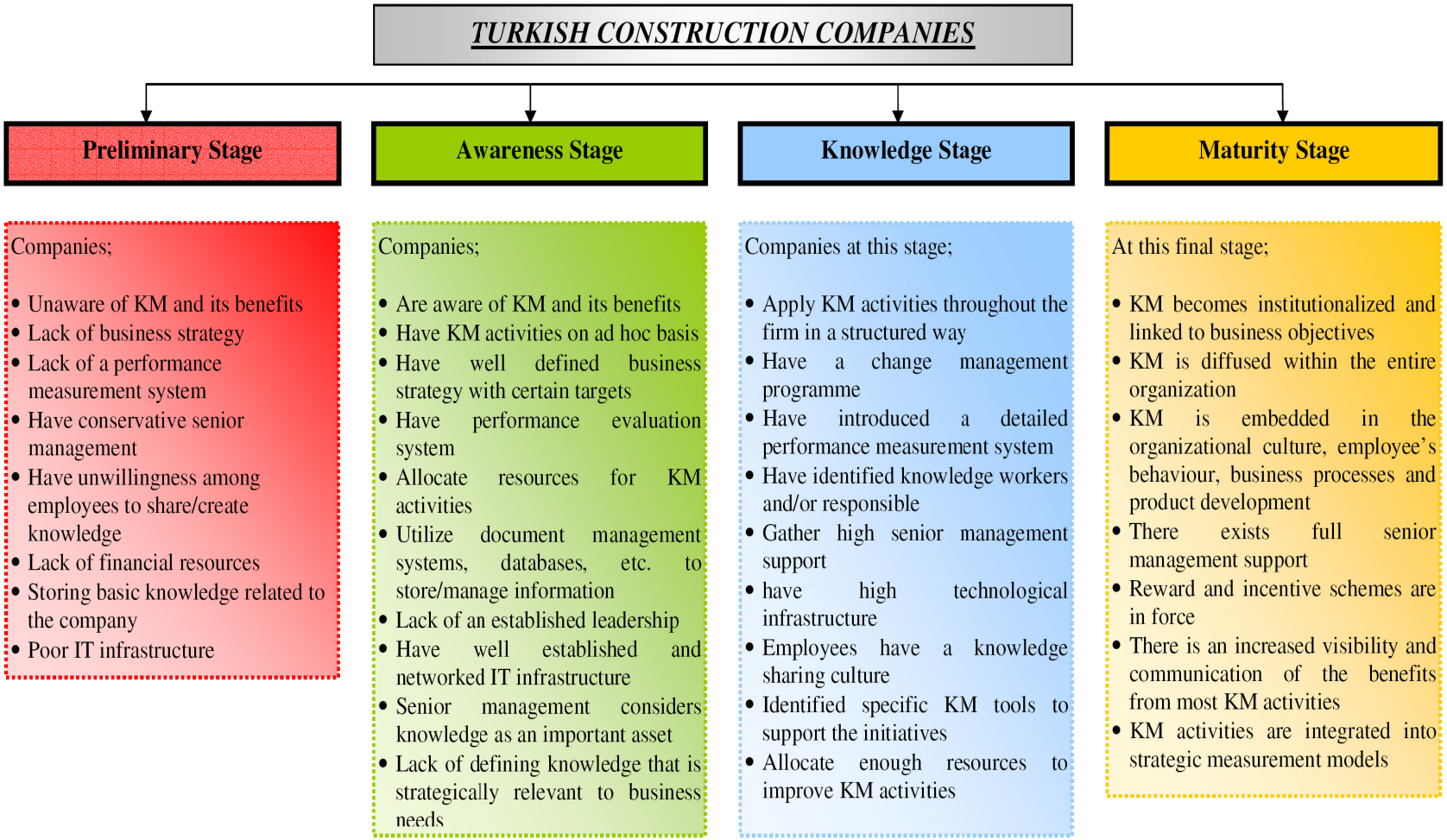
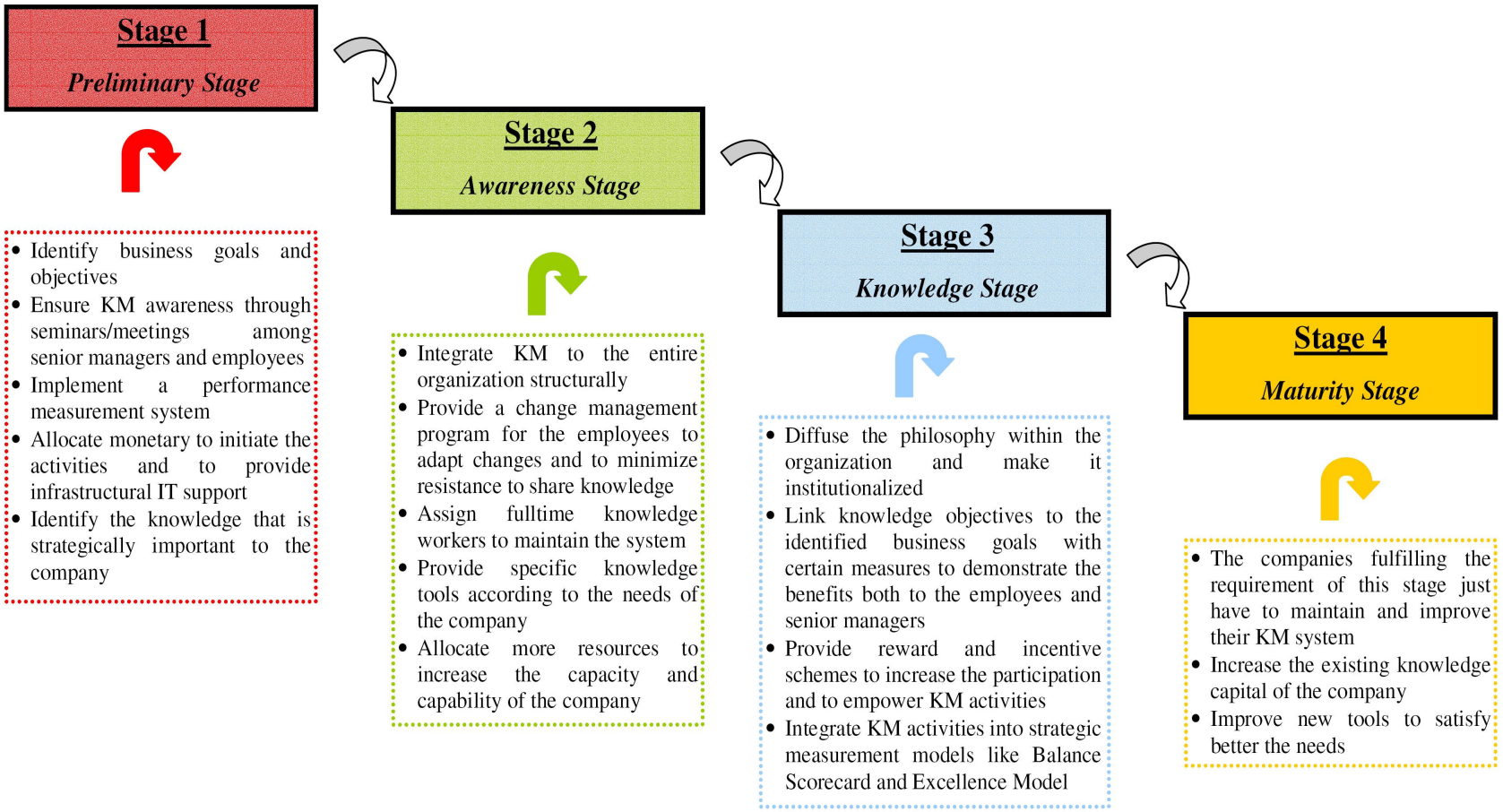


Figure 6.2 The Roadmap Schema for the Companies at Different Stages



As a future work, the number of the companies can be increased to have a better profile. Moreover, the spectrum of the companies can be enhanced with the participation of small and medium size companies because there is a considerable number of such scale companies constituting the industry. It would also be very beneficial to monitor the progress of a company chosen as a case study. Knowledge activities may be initiated within the organization under the supervision of the researcher and the achievements after some period may be recorded and analyzed. Capturing knowledge from the employees of a company is another important challenge to be struggled against. A research handling the methods to capture knowledge would be very beneficial for the companies to go forward on the way of managing knowledge.

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APPENDIX A

A SAMPLE OF INTERVIEW QUESTIONS

This survey is conducted as a part of the Master of Science thesis study being performed by Ceyhun Selim ERKAN under the supervision of Asst. Prof. Dr. Yasemin NIELSEN in the Department of Civil Engineering at METU. The thesis study examines the Turkish Construction Industry from the knowledge management (KM) point of view and proposes a roadmap for the organizations to implement or initiate KM systems. This survey aims at determining the current situation, the needs, and gaps of the Turkish Construction companies in terms of their approach and abilities to manage knowledge.

All the information gathered will be kept confidential and used only for the purpose of thesis.

There are 3 parts in the survey.

Organizational questions identify the necessary basic information about the company.

KM Awareness searches for the existing processes, applications, or methods within the organization.

Linkage between KM and Business Goals investigates the relation between the business strategy of the firm and its simple KM applications

A) Organizational Questions

1) What is the full name of the company?

…..……

2) What is your current position in the company?

…….……

3) For how many years does the company work for construction sector?

……

4) How would you define the proficiency of the company? What types of projects are you performing generally?

…..……..

5) Do you have projects (whether completed or ongoing) abroad? If yes, for how many years have you been active abroad?

……....

6) Would you please state your approximate annual turnover?

☐ < 20 m $ ☐ 20m $-100m $ ☐ > 100m $

7) How many employees do you have within the organization?

☐ < 100 ☐ 100 -500 ☐ > 500

B) KM Awareness

1) Have you encountered KM in your organization?

☐ Yes ☐ No

☐ Yes, but not directly related to my organization (conference, presentation, etc.)

2) Do you have such a KM strategy within your organization?

☐ Yes ☐No, we do not

☐ Yes, we have KM activities done on ad hoc basis

☐ It was found unnecessary

3) If your answer is positive for the above question or if you are planning to implement a KM system within your organization in the future, have you appointed a responsible manager or team to deal with the implementation?

☐ Yes, we have ☐ No, we have not ☐ Not yet but soon ☐not necessary

4) What type of knowledge is important to you (areas)? What knowledge do you keep within the company?

……

……

……

Please fill in the table below (Table 1) about the knowledge stored if applicable. (Inspired by Özorhon, 2004)

Knowledge Type	**Printed** **Documentation**	**In Employee Brains**	**In computers**	**Partially in computers**
Project performance:				
Unit costs				
Productivity				
Applied methods				
(Other)……				
Parties involved in the project:				
Client information				
Subcontractor information				
(Other)……				
Market Information:				
Laws & Regulations				
Construction Demand				
Country characteristics				
Success Factors				
Material prices				
(Other)……				
Human Resources:				
Skills of Employees				
Employee Details				
(Other)……				

5) Who stores the important knowledge and what is the way he follows? (Project manager, site chief, etc.. on CD-DVD, paperwork, database, etc..)

Employee	On-Paper	CD DVD	PC	Database	In his Mind	*(Other)* ……
Project Manager						
Construction Managers						
Group Superiors						
Technical Office Members						
IT Manager/Team Members						
Knowledge Manager/ Officer						
(Other)…… ……						

6) What kind of tools do you use within the organization to capture, store, share, explore, etc. knowledge?

Intranet	Expert systems
Extranet	Video-conferencing
Internet	E-mail
Database/Data Warehouse	Information Mgt System
Document Mgt System	Visualizing
Electronic Discussion Forum	Virtual Reality Tools
Groupware	Knowledge mapping
Communities of Practice	Computer Aided Design
Technical Networks	Instant messaging
Project-end Meetings	Web-based file sharing
Neural Networks	Data and text mining
After-action review	Other……

7) How do you search for and find / reach knowledge when you need?

……

……

8) For what purposes do you use the stored/codified knowledge?

No, we do not use

During bid preparation

Price Analysis

Performance evaluation & comparison

Choosing subcontractors

Problem solving through learning from best practices

Entering into a new market / country

(Other)……

9) How do you solve a complex, expertise or knowledge related problem when you face during construction period? (Consultancy firms, technical people within the company, etc...)

……

……

10) Please try to fill in the below table to investigate a knowledge problem depending on your company case.

A1. What knowledge are you interested in?							
A2. Please select from the adjacent list, the class(es) of knowledge that best describes this knowledge	(a) Best practice		(b) Equipment/tools				
	(c) Product knowledge		(d) Quality standards/processes				
	(e) Operational process/procedures		(f) Domain/function knowledge				
	(g) Support process /procedures		(h) Human resources				
	(i) Strategies/policies		(j) Other (please specify)				
	(k) Control procedures						
A3. What are the business drivers for this knowledge problem?	Category of driver	Business driver	KM process				
			Knowledge Generation	Knowledge Propagation	Knowledge Transfer	Knowledge Location and Access	Knowledge Maintenance/ Modification
	Structural change	Expansion					
		Restructuring					
		Merger and acquisition					
		Down-sizing					
	(Other)						
	External change	New market					
		New technology					
	(Other)						
	Continuous improvement	Performance improvement					
	(Other)						

11) Can you indicate the current and desired future dimensions of the total knowledge in your organization? please mark the current situation with "C" and the desired situation in the future with "F" on the scaling boxes between each dimension;

Knowledge Dimension	**Current vs. Future**	**Knowledge Dimension**
Explicit *can be captured, codified and formalized*	☐ ☐ ☐ ☐ ☐	Tacit *Usually in people's head (experience)*
Auxiliary *Often general knowledge, never necessary in isolation*	☐ ☐ ☐ ☐ ☐	Critical *Core to operational effectiveness and achievement of business goals*
Discipline based *Focus on developing single discipline expertise*	☐ ☐ ☐ ☐ ☐	Project based *Focus on developing multi-disciplinary expertise*
External *Knowledge exists outside the organization ,i.e. it may be bought in*	☐ ☐ ☐ ☐ ☐	Internal *Knowledge exists within the organization, tends to be owned*
Individual *Knowledge is held by individuals*	☐ ☐ ☐ ☐ ☐	Shared *Knowledge is shared and available across the organization*
Learning by training *Knowledge is taught by periodic training sessions*	☐ ☐ ☐ ☐ ☐	Learning by interaction *Knowledge is taught by interpersonal interactions*
(Other) ……	☐ ☐ ☐ ☐ ☐	(Other) ……

12) If you have to assess your organization in terms of KM activities, would you please rate the importance of the activities and their current usage within the firm? (Based on Özorhon, 2004)

KM Activities	**Importance**					**Application**				
	1 Very Low	**2** Low	**3** Medium	**4** High	**5** Very High	**1** Very Low	**2** Low	**3** Medium	**4** High	**5** Very High
Knowledge capturing										
Knowledge storing										
Knowledge sharing										
Knowledge Utilization										
Knowledge modification										

13) When the organizations utilizing KM systems in UK and US are investigated by the researchers, they noticed that the companies face with some problems during implementation. According to the Turkish construction industry, what do you think of the below prepared barriers in terms of their validity and importance? (inspired by Özorhon, 2004)

KM Barriers	Validity		Importance				
	Yes	No	**1** Very Low	**2** Low	**3** Medium	**4** High	**5** Very High
Cultural barriers							
Company structure							
High employee turnover							
Project uniqueness							
Unsupportive nature of the industry							
Not creating competitive advantage for taking jobs							
Resource insufficiency							
Lack of consciousness							
Convincing senior management							
Identifying a KM strategy							
Lack of support							
Lack of Technological Infrastructure							
Industrial Culture							
Measuring benefits of KM							
(Other)……....							

C) KM & Business Strategy

1) Does your company have a business strategy? What are your business goals? Please explain briefly.

……

……

……

2) When we think of the high competition in the construction market, what do you think about the below mentioned actions to survive and to gain competitive advantage.

KM Benefits	**Validity**		**Importance**				
	Yes	No	**1** Very Low	**2** Low	**3** Medium	**4** High	**5** Very High
Client satisfaction							
Employee Satisfaction							
Better Risk Management							
Decrease in rework							
Fast decision making							
Rapid problem solving							
Innovation							
High quality							
Decreased time durations							
Experience gained							
(Other)……..							

3) How do you measure your organization's performance? Are there any methods/criteria applied (Balance Scorecard, Excellence Model, etc...) to monitor the performance?

……

……

4) Would you please evaluate the techniques used in the literature in KM systems in terms of their applicability according to your employees' perspective?

KM Techniques	**1** Not Applicable	**2** Difficult to apply	**3** Easily Applicable	**Possible Reason** (Please clarify briefly)
Training / Seminars				
Mentoring				
Apprenticeship				
Recruitment				
Post-project reviews				
Face-to-face interaction				
Communities of Practice				
Brainstorming				
Web-based Learning within the organization				
Ongoing Project Evaluation Meetings				
(Other) …….				

5) What do you think of implementing such a KM system throughout your organization?

☐ Very beneficial ☐ Not necessary

☐ I do not know ☐ May be in future