CHAPTER ONE

INTRODUCTION TO KNOWLEDGE MANAGEMENT

1.1 Introduction

Knowledge management (KM) is now considered as one of the most important parts of any organization and a complement to the organization's business activities. With new economy increasingly becoming a more knowledge-based economy, knowledge is becoming the most important asset for organizational success among other assets such as capital, materials, machineries, and properties.

Many organizations claim to have large savings from the adoption of KM techniques in their companies. Through successful knowledge capturing, sharing, and creation, industrial companies can improve the process of organizational learning to enhance the performance and create more possibilities to gain competitive advantages for the organizations. Companies were encouraged to adopt KM techniques to maintain their competency against other companies. Organization's competitive advantages depend on the organization ability to learn faster than its competitors. The organizational learning process depends on the ability of the organization to collect and use knowledge, skills and behaviors which have the potential to enhance learning of its members and improve the organizational future performance.

1.2 Knowledge Management

1.2.1 Definition of Knowledge

Knowledge can be defined as the facts, skills and understanding that one has gained, especially through learning or experience, which enhance one's ability of evaluating context, making decisions and taking actions. Because knowledge combines information with experiences, by using KM organizations can provide their people with the ability to find and use methods and procedures that were created or used by others previously to solve similar problems, and to learn from past experiences, while maintaining the new created experiences to be used in the future. Many definitions have been developed in the KM literature to help understanding of knowledge and distinguish it from other forms of contents such as data and information.

1.2.2 Data, Information and Knowledge

Although the terms data, information and knowledge are extremely related, they should not be used interchangeably .In most literature the concepts of knowledge and information were used synonymously and inaccurately. According to Davenport et al. data, information and knowledge have different attributes that can be summarized and illustrated in Figure 1.1(system communication).
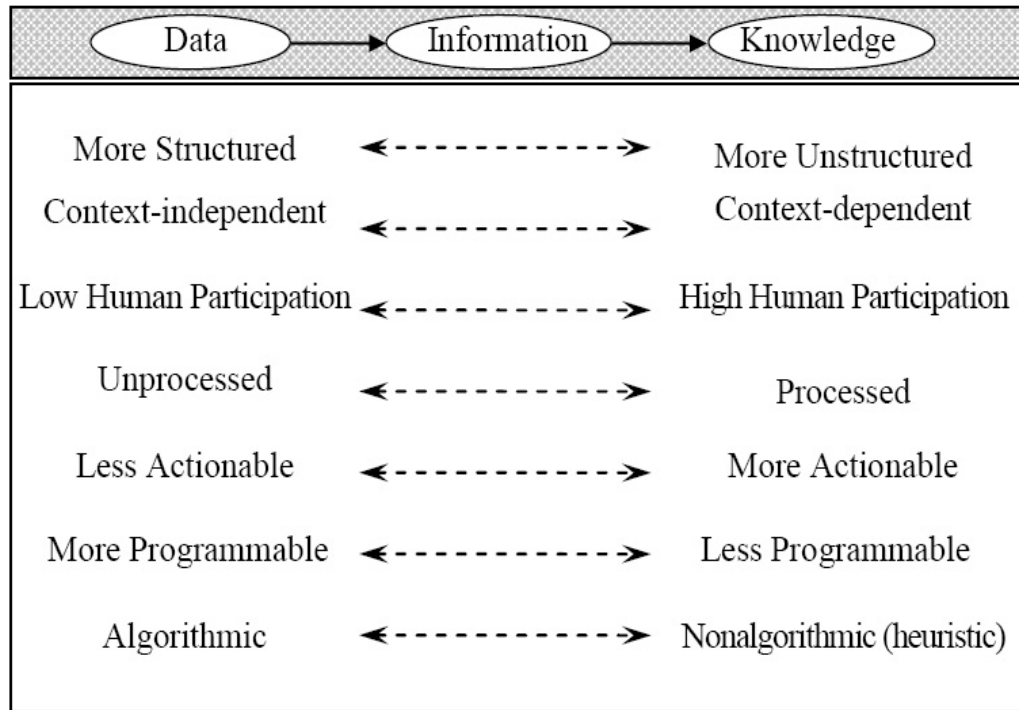
Figure 1.1: Data, Information and Knowledge Attributes (Awad & Ghaziri, 2004)

Data refers to raw facts without any processing, organizing or analysis, so it has little meaning and few benefits to managers and decision-makers. According to Data is un-interpreted material on which a decision is to be based and depends on facts which may include anything known to be true or exist.

Information refers to data that has been processed and shaped to be of more meaning to users. Argues that information results from the interpretation of data in a given context. So, a single content of data may produce different information contents if the context is different. Information comprises facts that are organized in a structured way, whereas knowledge incorporates values, beliefs, perspectives, judgments, and know-how.

Knowledge is the most useful form of contents for problem solving and decision making since it has more meaning than data and information. Therefore, knowledge is more than data and information in that it combines information with experiences to show methods and procedures used by others, which can be reused in the future to solve similar problems.

Studies found that a useful way to differentiate between the three concepts is by representing them in a hierarchy where knowledge is represented at the top with the most value and meaning for the end-users, and data is represented at the bottom with the least value and meaning to the end-users but with the most availability and programmability in the organization this can be represented as shown in Figure 1.2.
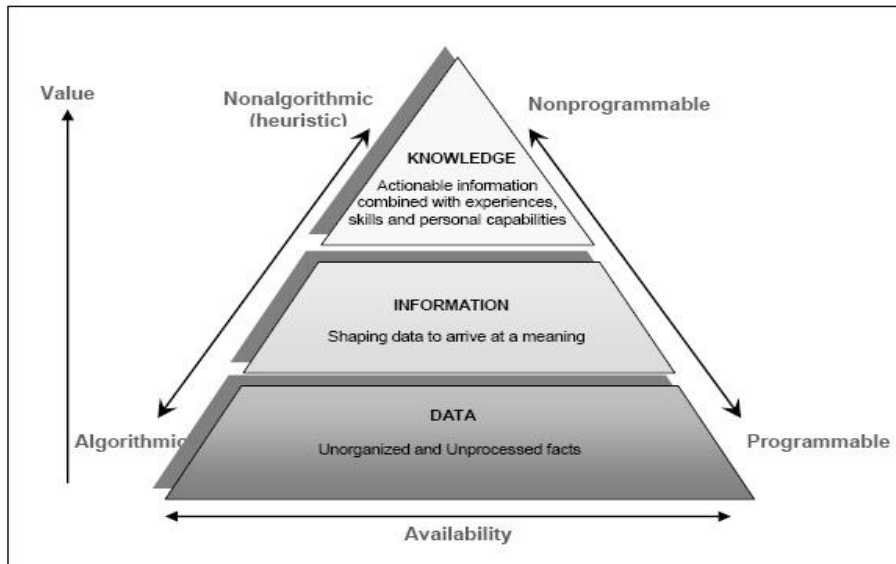

Figure 1.2: Data, Information and Knowledge (Bierly et al., 2000)

1.2.3 Knowledge Classification Methods

Knowledge can be considered in a variety of ways. Classifying knowledge helps organizations to identify the different types of knowledge with different nature that may need different procedures, tools and activities to process and manage. Hence, classifying knowledge is an important issue to help the organizations to manage important and available knowledge resources successfully.

1.2.3.1 Explicit and Tacit Knowledge

Explicit knowledge can be expressed in formal and systematic language, and shared in the form of scientific formulae, specifications, manuals and such like. Explicit knowledge is easy to be captured, retrieved, shared and used because it can be expressed in words and numbers that can be managed more easily. In project contexts, explicit knowledge may include project-related contents such as specifications, contracts, reports, drawings, changing orders and data. Explicit knowledge as being "readily available", recorded, codified and/or structured in a way that makes it easily transmissible and available to be retrieved and used, which can be found in a range of diverse sources, such as human resources data, meeting minutes and the Internet.

Tacit knowledge is the most valuable type of content since it combines information with experiences, skills and understanding of people, which can help people to find best solutions and reduce opportunities of repeating mistakes. In project contexts, tacit knowledge may include work processes, problems faced, problems solved, expert suggestions, know-how, innovations and experiences.

Tacit knowledge is highly personal and hard to be managed, shared or formalized since it includes experiences, know-how and perceptions, which normally reside in individuals" heads and memories. According to tacit knowledge cannot be easily articulated with formal language since it is a personal knowledge that is embedded in people experiences and involves intangible factors such as personal beliefs, perspectives, and values. The best way for utilizing tacit knowledge is by using methods and tools that encourage and facilitate collaboration and knowledge sharing among the people of the organization, such as applying e-messaging and e-meeting tools .However, some tacit knowledge can be captured, mobilized and turned into explicit knowledge by using KM tools, such as knowledge capturing, publishing, categorizing and editing tools. These help to transfer knowledge into more available and accessible forms that may help the organization to progress rather than requiring its members to relearn from the same stage all the time.

Although a complete tacit-explicit split cannot be achieved, it is a useful way to understand the different characteristics and nature of different types of knowledge that require different processing, procedures and tools to be managed and dealt with. Figure 1.3 represents a hierarchy that has been developed to provide a useful way to understand the differences and relationships among data, information explicit knowledge, tacit knowledge and wisdom. This representation helps to understand the different characteristics and values of the different types of contents and how these contents can be transformed from one type to another. Blumentritt and Johnston suggested that in order to gain competitive advantages, organizations need to enhance the information-knowledge balance through

the implementation of IT-based improvements to enhance information management and socially-based mechanisms to enhance knowledge management.
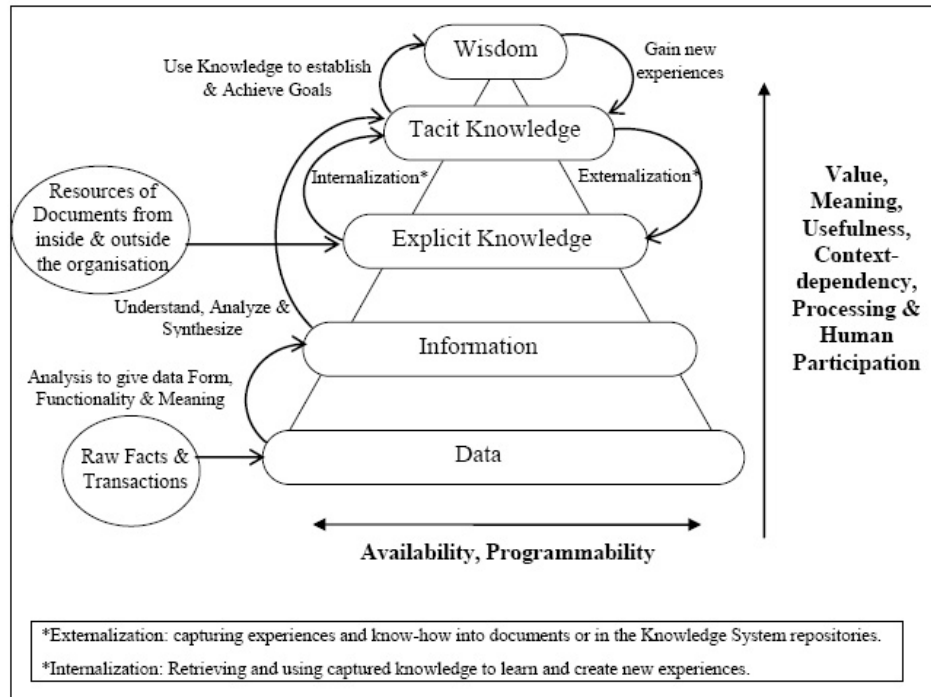

Figure 1.3: Data, Information, Explicit Knowledge, Tacit Knowledge, and Wisdom (Bierly et al., 2000; NDR, 2003)

Tacit knowledge according to Nonaka and Takeuchi (1995) can be further categorized into technical knowledge and cognitive knowledge. Technical knowledge depends on the experiences of individuals, which has been developed with time, so it can be captured in the form of "know-how", while cognitive knowledge depends on mental models, perspectives and beliefs therefore cannot easily be articulated. Technical knowledge contains many shapes of knowledge, such as descriptions of problems and solutions,

experience notes and procedures. Cognitive knowledge includes ideas, viewpoints and innovations.

Although tacit knowledge is difficult to capture simply by normal tables, they can be captured and stored in forms similar to articles including those attached descriptions, pictures and videos that provide more details and clarifications to the knowledge contents. Another useful method is by encouraging sharing such knowledge through direct contacts, such as face-to-face meetings, e-chatting, video conferencing, etc., and indirect contacts, such as e-messaging, e-discussions, e-commenting, etc. Although these methods have been proven more convenient in the collection and sharing of tacit knowledge, it needs more effort to follow procedures that encourage people to capture and share their knowledge, and to provide classification and searching techniques that facilitate knowledge retrieving and reusing.

1.2.3.2 Explicit, Implicit and Tacit Knowledge

Although many studies have used the terms tacit and implicit knowledge synonymously, some other studies have differentiated among three knowledge dimensions, including explicit, implicit and tacit, emphasizing that tacit and implicit knowledge have significant differences and cannot be used interchangeably. Nickols (2003) introduced a representation that provides a useful way to distinguish among explicit, implicit and tacit knowledge as shown in Figure 1.4.

Explicit Knowledge consists of knowledge that has already been articulated or codified in the form of text, tables, diagrams, drawings, photos, audios, videos, etc., so they can be directly and completely captured, used or shared,

such as documented articles, books, reports, best practices, manuals, specifications and standards.

Implicit Knowledge is the knowledge identified that it can be articulated and turned into explicit in the future but has not yet been articulated. This can be caused by various reasons such as if the codification or capturing process has not been completed or even started yet, if the company has not decided to capture this form of knowledge yet or if the company has decided that they do not currently need to capture this form of knowledge.

Tacit Knowledge refers to knowledge that people have, but they cannot articulate, express using language or make explicit, because articulating them will fail to capture its essence. Examples include people skills and experiences that cannot be easily described, such as how to deal with different people and read the reaction on their faces or the ability and speed to work under time pressure, solve problems, provide ideas and innovate.
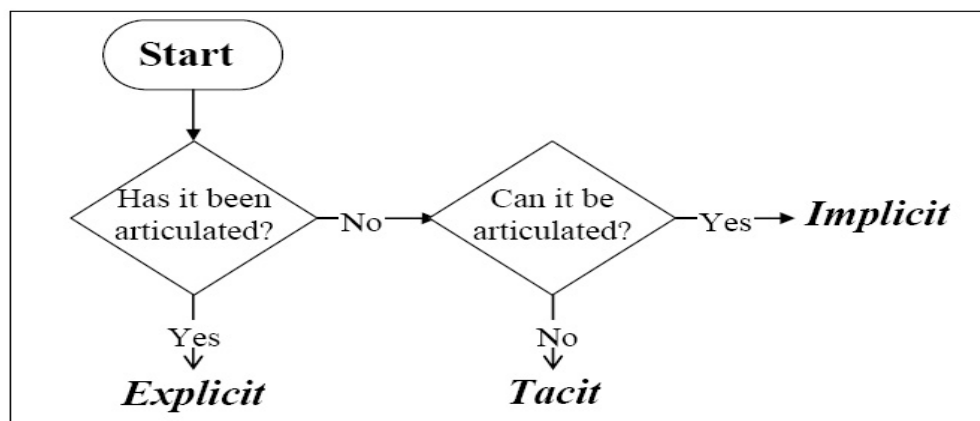

Figure 1.4: Distinguishing among Explicit, Implicit and Tacit Knowledge (Nickols, 2003)

Embodied Tacit Knowledge relates to the movement of the body, such as knowing a craft or how to use a tool, and the five human senses such as

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knowing the quality of a material or a finished work from its appearance. This kind of knowledge can be learned through practicing and behavior skill training and through time it becomes embedded in memory and retrieved automatically when needed.

Intuitive Tacit Knowledge is the knowing that may affect decisions and actions that comes from the individuals" sense and the actor cannot explain (unconscious) the reason for taking this action". Source Intuitive knowledge has developed in people's minds as a result of continuous learning through meaningful experiences that can be built up by practicing making decision and actions, collecting feedback on these decisions and actions, and interpreting this feedback. These practices will help people to develop intuitive skills such as developing the ability to evaluate situations quickly and to predict the consequences of such situations.

Affective tacit knowledge refers to people feelings that may have impact on behaviors, thoughts and responses. Thus, affective tacit knowledge is related to other types of knowledge because feelings as a form of knowledge can influence decisions and actions, such as feeling fear or upset that could prevent the decision-maker from taking an action.

Finally, spiritual tacit knowledge can be described as the animating principles of human life such as its moral aspects, the emotional part of human nature and mental abilities, which may affect thoughts and actions.

1.3 Problem Identification

Construction projects are in knowledge-intensive environments where many of interrelated components are working together in a complex manner. In many circumstances, knowledge in the building projects is mostly tacit knowledge and highly based on individuals" experiences and perceptions, which increase the difficulty of capturing and reusing it. These situations call for a method for managing knowledge to solve problems and achieve higher quality construction projects.

Various KM models have been developed to support KM activities. However, many of the existing KM models only provide a communication platform or a repository for data and/or explicit knowledge, and much KM efforts still lack structured methods of implementation and alignment with business objectives and strategies of the organizations.

Most recent literature classifies knowledge within an organization into two categories, i.e. explicit knowledge and tacit knowledge. Explicit knowledge is normally easy to capture, retrieve, share and use because it can be expressed in words and numbers that can be managed more easily, while tacit knowledge is personal and exists in the individuals" memories in the form of experiences and know-how that is not easy to capture, share and manage. However, tacit knowledge can be captured, mobilized and turned into explicit knowledge, which can be accessible to others in the organization to enable the organization to progress, rather than requiring its members to relearn from the same stage all the time and repeating mistakes that have been learnt how to solve and avoid in previous project.

Many studies have confirmed that tacit knowledge plays the most important role of KM in the organizations. However, many of the existing KM techniques and tools can only deal with explicit knowledge. Knowledge generated in construction projects, especially tacit knowledge, can be lost from the company due to many reasons, such as when people with experiences leave the company or when knowledge saved in unsearchable filing systems. This represents a lost opportunity for the organization, in that if its competitors succeed in sharing and leveraging similar knowledge efficiently, then they may gain competitive advantages.

These challenges and barriers that may affect the successful management of knowledge cause the need for a more coherent and structured approach for utilizing knowledge in construction organizations. Therefore, it is essential to develop a new KM model which can be used to satisfy the needs of the industry to successfully manage organizational knowledge. This study addresses this problem by developing a KM model that can deal with knowledge more efficiently and effectively in construction projects.

1.4 Goals and Objectives of the Research

The specific objectives of the research are as follows:

I. To review current practices of KM in the construction industry. A critical review of important KM literature is carried out to highlight technological, cultural and managerial aspects of KM implementation and application in the context of construction projects and organizations.

II. To analyze and evaluate existing models of managing knowledge in the construction industry, and discuss problems those negatively affect the

successful implementation and application of KM in the construction context.

III. To develop a new KM model that enables ideas and suggestions of employees to be captured and shared, and deals with creating value from construction operations.

IV. To develop a guidance that can help organizations to identify important KM resources, processes, tools and procedures for successful implementation and application of KM System in the building organizations.

V. To validate the proposed KM model by applying a chosen research methodology. Questionnaire surveys and interviews approaches are used to enhance the proposed KM model and case studies are conducted to evaluate the final developed model in terms of its ease of use, usefulness, importance and credibility to the construction industry.

VI. To provide recommendations for the future development of KM implementation and application at both organizational and industrial levels within the building project.

1.5 Research Hypotheses

I. There is no pacing features and unified knowledge management in building projects.

II. In this research has been directing some companies to implement knowledge management.

III. This research seeks to develop various knowledge management techniques to support the project activities.

ɪᴠ. This research aims to develop method of knowledge management in order to avoid problems and provide an effective and highly efficient knowledge management in building projects.

1.6 Research Methodologies

A combination of quantitative and qualitative research methods has been adopted in this research to investigate KM critical success factors, tools and activities, and KM implementation and application in the construction industry, in order to develop, enhance and evaluate the proposed KM model. The main methodologies adopted in this research are:

ɪ. Literature Review

The research depends on the understanding and analysis of various recent KM literatures to provide a foundation for this study. Review of literature helps to support the research work with other research on the KM domain to provide more understanding and strength to the research topic and provide other examples of KM models to make the research more credible. Existing KM models in the construction industry and some other general models will be reviewed and analyzed. The advantages and disadvantages of the current KM models will be studied in order to search for appropriate solutions of problems. This provides a theoretical basis for developing a new KM model that fills gaps of other KM models and present enhanced KM model for the building projects.

ɪɪ. Interviews

The interview is probably the most common research method in qualitative research, because it provides an easy flexible method that can be used to

capture important ideas and detailed opinions to enrich the research (Bryman & Bell, 2003).

Interviews with KM academics and practitioners in the building projects and in-depth study of the initial proposed model will help to modify and improve the KM model to enable the developed version to be used more effectively and efficiently in the building organizations. Interviewees will be asked to provide general opinions and important aspects that need to be considered when developing a KM model, and also to evaluate and discuss the components of the proposed KM model and provide opinions and suggestions.

The interviews follow semi-structured approach, which means that a procedure, shown in Appendix 1, will be used in the interviews, but the interviewees will be given flexibility to refer to and discuss their opinions and interests in the KM field. This also means that questions that are not included in the questions" list can be asked regarding details and description on things mentioned by the interviewees (Bryman & Bell, 2003). This method may help to encourage the interviewees to provide more important, valuable and detailed responses to the interview questions (Kendall & Kendall, 2002).

III. Questionnaire Survey

A questionnaire survey has been conducted to capture the initiatives for KM and investigate the critical success factors for implementing KM in the building projects. The questionnaire seeks the importance of KM activities, procedures and tools for successful implementation and use of KM System, and investigates which activities and methods are currently used in building organizations to manage their knowledge. The questionnaire survey helps

the research to reach to a final enhanced version of the KM model that can help to successfully manage knowledge in the building projects.

The questionnaire survey is one of the tools used by researchers to confirm, deny or enhance what was already believed or known. Survey methodology is important and popular because of its ability to define and detail various characteristics of key issues that can be important and interesting for certain readers and organizations (Chauvel & Despres, 2002). A questionnaire survey also has the ability to provide results that can be quantified and so can be easily treated and analyzed statistically. It provides the ability to extend the results obtained from a sample of respondents to a larger population when it is not practical and efficient to work with the entire population. It also provides fast and straightforward results compared with other research methods to allow researchers and practitioners to act in a relatively quick and intellectually respectable manner (Chauvel & Despres, 2002).

1.7 Limitations

Building and implementing a new KM System in an organization is a complicated task because it can involve fundamental changes, such as organizational culture, work practices and technological infrastructure. This requires a considerable amount of time (perhaps years) to be accomplished, and substantial courage from organizational management. Thus, this cannot be achieved within the limited time extent of this research.

Another limitation to the research is that most of the employees in the building projects feel they lack the time to provide details about the existing knowledge system in their organizations due to the limited time of projects and the pressure to finish projects before specific deadlines. Furthermore,

some employees feel they lack the authority to provide such details due to the restrictions of privacy and confidentiality regulations. The details related to the design and implementation processes of the KM System cannot be effectively investigated in the building organizations because most of these processes are normally provided by external IT specialized companies. (Company in Sudan, 2012-2014).

1.8 Layout of the Study

Chapter one is the introduction of knowledge management and knowledge classification, problem identification, Goals and Objectives of the Research, research hypotheses, Limitations. This purpose of this chapter to help the redder to understand why this need to written.

Chapter Two is literature review, Definition of Knowledge Management (KM), Knowledge Management Importance and Motivations, Challenges and Factors Affecting Knowledge Management, Knowledge Management Methods and Techniques, knowledge model.

Chapter Three is interviews and questionnaires, aim and objective of interview, analysis responses, and questionnaire survey.

Chapter four contain the result and analysis of the collect data .this chapter aim to present the collected data as objectively and completely as possible for each for the research question.

Chapter five contains the conclusion, recommendation of the study, references and appendices .

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Definition of Knowledge Management Systems (KM System) The term "System" is normally used in different disciplines to refer to a group of interrelated components that work together by way of some driving process that can often be visualized or modeled as component blocks that have connections drawn between them.

The term of "Knowledge Management System" (KM System) has been used in different meanings through the literature. In KM literature, the terms of KM System and knowledge systems are used synonymously to refer to the technological or software components of the KM. For example, Alive and Leander (2001) defined KMSs as "IT-based systems developed to support and enhance the organizational processes of knowledge creation, storage/retrieval, transfer, and application". Furthermore, Gupta et al. (2000) defined it as "A class of information systems applied to managing organizational knowledge, which helps organizations to find, select, organize, disseminate and transfer important information and expertise necessary for activities such as problem solving, dynamic learning, strategic planning and decision making".

However, other researches have expanded those definitions by incorporating strategy, services, processes and users" components to the KMS, not just the IT components. Because, as mentioned previously, the term" System" should include all the interrelated components with their driving processes

and relations, then all the components, processes and relations important for successful implementation and application of KM should be included in the KMS definition of this study. So, the terms of KM System and knowledge system in this research are used to refer to the technological and/or non-technological components of KM that may include KM software, hardware, networks, individuals, groups, organizations, resources, tools, services, activities, procedures, methods and other environmental factors and activities that may compose, relate to or affect KM in an organization.

2.2 Knowledge Management (KM)

2.2.1 Definition of Knowledge Management (KM)

There are many definitions and interpretations of the term ''Knowledge Management'' (KM) that have been used in the literature. However, KM is defined in this thesis in a way that copes with the aim of this study of developing a KM model that presents structured procedures, methods and techniques, important and useful for successful management of knowledge in the construction projects.

The term of KM used in this thesis is defined in general as a set of distinct and well-defined processes and techniques, which include systematic procedures based on technologies and practices, that motivate effective creation, capturing, organization, distribution, use and sharing of both useful tacit and explicit knowledge, to enable individuals of the organization to be more effective and productive in their work in order to generate value for the projects and the organizations. KM provides the tools and services for end-users to capture, share, reuse, update, and create new experiences, problem solutions and best practices to aid employees in processes such as problem

solving, decision making and innovation without having to spend extra time, effort and resources on reinventing solutions that have already been invented elsewhere in the organizations .

2.3 Knowledge Management Importance and Motivations

Knowledge management (KM) is now becoming more vital for successful management of construction projects and a complement to the business activities of organizations. With the new economy increasingly becoming a more knowledge-based economy, knowledge is becoming the most important asset for organizational success among other assets such as capital, materials, machineries, and properties. The research by Gupta et al. (2000), which discusses practices and challenges of KM in a number of selected organizations, argues that KM is the only competitive advantage for companies in the 21st century.

Building projects are in knowledge-intensive environments where many interrelated components work together in a complex manner. A main benefit by adopting KM System in building work is to enable the industry companies to complete the projects with reduced cost and time while improving quality of projects. By reusing and sharing previous experiences and knowledge, employees can find solutions for their problems without spending extra time, efforts and resources on reinventing solutions that have already been invented elsewhere in the organization.

With the successful capturing, sharing, and creation of useful knowledge, industrial companies can improve the process of organizational learning to enhance performance and create more possibilities to gain competitive advantages for the organization. Li and Gao (2003) argue that industrial

companies can enhance organizational learning through knowledge generation combined with successful knowledge sharing, which will not only lead to enrich the knowledge of employees and organizations, but also will lead to more strategic innovations. Improving organizational learning means enhancing the ability of the organizations to collect and use knowledge so that members exploit it to improve the organizations" performance. Organizational learning can create possibilities to gain competitive advantages, which involve the ability of a company to perform projects and activities at lower cost and time combined with higher quality of projects than other competitors. The benefits from the application of KM in an organization which have been discussed previously can be summarized and represented as shown in Figure 2.1.
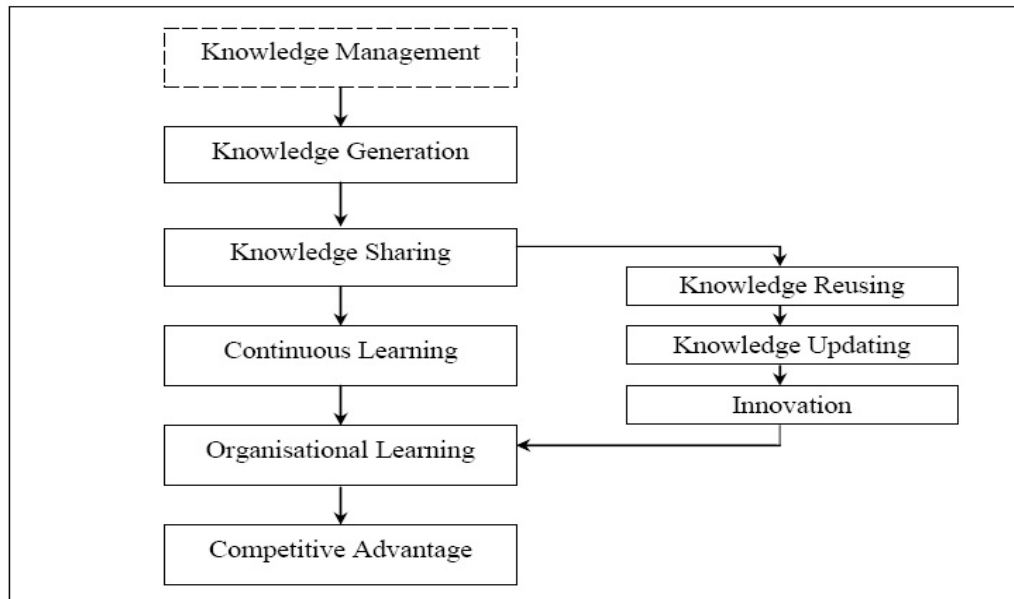

Figure 2.1: Knowledge Generation and Sharing Leading to an Organizational Competitive Advantage (Li & Gao, 2003)

The current interest in KM has been motivated by the need for continuous changes and improvements to enhance the construction process that has benefited from the remarkable developments in computer technology which provide people with ability to digitally capture, Search and transmit knowledge and electronically contact other people. The building organizations have shown an increased awareness of KM as a necessary prerequisite for improved quality, innovations, business performance, efficiency of project delivery, and relationships with partners, suppliers and clients to gain competitive advantages. KM System provide the tools and services for end-users to capture, share, reuse, update, and create new experiences, problem solutions and best practices to aid employees in processes such as problem solving, decision making and innovation, and so to enhance the total performance of the organization.

2.4 Challenges and Factors Affecting Knowledge Management

Many challenges to KM implementation in the building projects , for example, the complexity of building , diversity of work players, adversarial relationships encouraged by the strategy of contracting and the project nature with pressure to complete and non-repetitive nature of work, are all causes for much "knowledge wastage" and difficulties in accessing important knowledge. The complex nature of knowledge and buildings context increases the difficulty for organizations to plan and implement formal KM initiatives.

While much of the literature has been concerned with discrete projects, project integration proved to be a major challenge for construction management that goes beyond conventional systems integration, which is

largely concerned with technical integration of software, hardware and communication protocols etc., to the coordination and management of the different activities necessary for the successful completion and delivery of the project as a whole.

The research indicated that some individual behaviors (cultural frictions) can negatively affect the KM process. They suggested a set of solutions to reduce the influence of these factors and encourage knowledge creation and sharing in the organizations by applying some procedures and approaches such as providing incentives, accepting and rewarding creative errors, providing times and places for learning, meeting and sharing knowledge, and encouraging relationships and trust among employees (see Table 2.1).

Table 2.1:: Examples of cultural frictions and the solutions (Davenport & Prusak, 1998)

Frictions	Possible Solutions
Lack of trust	Build relationships and trust through face-to-face meetings.
Different cultures, vocabularies, and frames of reference	Create common ground through education, discussion, publications, teaming, and job rotation.
Lack of time and meeting places; narrow idea of productive work	Establish times and places for knowledge transfers: fairs, talk rooms, and conference reports.
Status and rewards go to knowledge owners	Evaluate performance and provide incentives based on sharing.
Lack of absorptive capacity in recipients	Educate employees for flexibility; provide time for learning; hire for openness to ideas.
Belief that knowledge is prerogative of particular groups, not-invented-here syndrome	Encourage non-hierarchical approach to knowledge; quality of ideas more important than status of source.
Intolerance for mistakes or need for help	Accept and reward creative errors and collaboration; no loss of status from not knowing everything.

An& Ahmad (2010) discussed and represented the influence of environmental factors and the way they affect the ability of KM methods, tools and activities in delivering desirable outcomes for individuals and organizations, as shown in Figure 2.2, to simplify understanding their effects and enhance awareness of their importance in KM implementation and application.

Knowledge Management
Motivation, Training, Support, and Methods; Tools and Activities for Knowledge Capturing, Retrieving, Sharing and Generation.

Environmental Factors
Personal and Organisational Culture, Management & Leadership; Strategies, Technology Support, Competencies, Structure, Operations, Evaluation, Finance, Security and Privacy Issues.

Results & Outcomes
Learning, Growth, Innovation, Performance Enhancement, Cost Reduction, Profits Increase, Customer Satisfaction, Business Processes Improvement, Capabilities & Competitiveness.
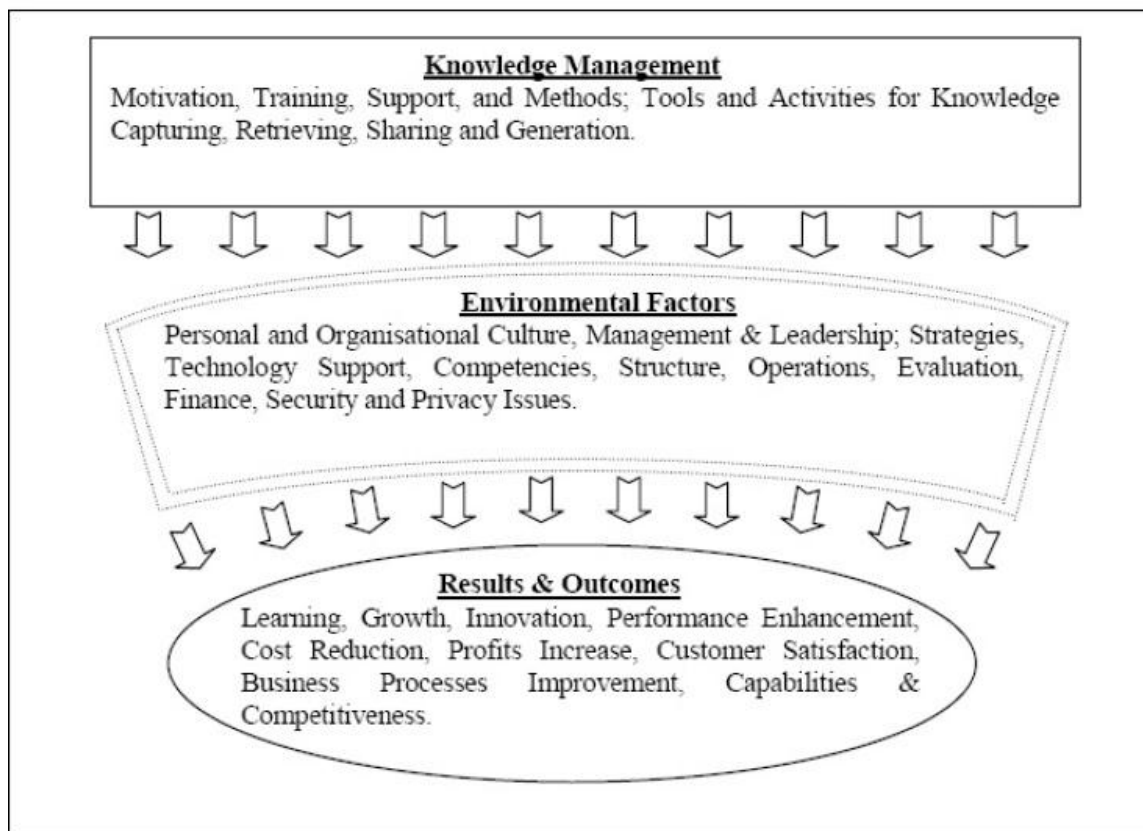
Figure 2.2: Influence of Environmental Factors on KM Outcomes (An & Ahmed, 2010)

The challenges and barriers discussed earlier that may affect the successful management of knowledge cause the need for a more coherent and structured approach for utilizing and managing knowledge in building

organizations. Therefore, it is essential to develop a new KM model which can be used as a navigation aid for managing knowledge to satisfy the needs of the industry. This study addresses this problem by developing a KM model that can deal with available and important knowledge in the building projects more efficiently and effectively. Case studies conducted in the building project are used to demonstrate how the proposed KM model can be useful to improve the building KM performance.

2.5 Knowledge Management Methods and Techniques

Many techniques have been developed and used in the building organizations to enhance KM implementation and reduce the effect of knowledge barriers. For example, by using network knowledge maps, users can improve their ability to discover what knowledge exists and what knowledge is missed in a certain area or project.

Dynamic knowledge maps proposed by Woo et al. (2004) is a technique that facilitates searching for experts with relevant knowledge and communicating with them by using instant messaging, e-mail, telephone, Internet conferencing or other internet technologies.

Another technique is the use of modeling methods that can be used to develop and manage KM System. Models are used to help people to understand the complexity of real systems by representing the main features and dividing the large systems into its parts, to simplify understanding and managing .

A successful technique in construction KM is the use of Activity-Based KM System where information and knowledge from projects are categorized and

saved in units related to the projects" activities so that these information and knowledge can be easily retrieved and reapplied.

Another technique of knowledge categorization and organization is the use of Ontology-based systems. Ontology is an explicit specification that provides formal representation to show what knowledge of a domain exists in a knowledge-based system, which enhances searching capabilities, enabling the segregation of knowledge and reducing the overlapping topics between different discussion groups. Ontology-based systems provide a mechanism to classify domain knowledge items into inter-related components, in the form of hierarchical structure and semantic relationship, in which knowledge can be accessed based on meaning, better enabling computers and people to exchange.

The research by Gupta et al. (2000), which discussed practices and challenges of KM in selected organizations, shows that the two major trends currently used when applying KM are measuring the intellectual capital by developing measurement ratios and benchmarks, and mapping knowledge that includes capturing and disseminating knowledge of individuals, mainly through information technology. This research also shows the importance of data mining tools in transforming the organization's existing data into "answers-knowledge" available to employees, anywhere in the organization at any time.

Many of the existing KM techniques and ongoing research need a more structured coherent approach to KM and a better alignment of KM to business goals in the building organizations. Although, many of the existing KM techniques and tools can only deal with explicit knowledge, many

studies have approved that tacit knowledge is playing an important role of KM in the organizations. Therefore, it is essential to develop a new KM model that can be used as a navigation aid to explicit and tacit knowledge to satisfy the needs of the industry. This study addresses these problems by developing a new KM model which provides a structured method for KM that can deal with both explicit and tacit knowledge and align with the specific characteristics of construction projects.

2.6 Knowledge Management Evaluation Methods

To convince senior management to undertake the decision of implementing or enhancing KM in their organizations, business benefits and competitive advantages compared to cost of implementation of KM need to be demonstrated. Many researches have studied the relationship between KM and supply chain management (SCM) to show how KM affects the performance of organizations and how it can improve the speed of learning, improving and decision making for players in the supply chain. Burgess and Singh (2006) argued that knowledge, infrastructure and corporate governance, can work together to produce innovations that lead to desirable improvements in the organization performance, only if the social environment support this transformation.

Most of the organizations normally use general business performance management models to evaluate their KM System and to assess the influence of the KM System on their business performance. Carlucci et al. (2004) reviewed the role of KM in the business performance management models such as the Balance Scorecard, the Business Excellence Model (EFQM, 1999) and most recently the performance. The study depended on the

classification of knowledge assets , using a method developed by Marr and Schiuma (2001), into four asset groups (i.e. knowledge of human resources, management or stakeholder relationships, physical infrastructure and virtual infrastructure) to conclude that KM processes will lead to enhancements in competencies, effectiveness and efficiency of organizational processes, business management abilities and business performance. That will finally lead to an increase in value generation for the whole organization.

Measuring the value of intellectual capital can also be assessed by using tools and techniques such as "cause-and-effect map" that measures contribution of KM initiatives to the strategic objectives of the organization, "evaluation roadmap" which is an interactive tool that guides users to select the most appropriate technique based on a set of structured questions to measure the impact of each KM initiative on the user business performance, "cost and benefit checklists" that compare costs of each KM initiative to its potential tangible and intangible benefits, and "priority matrix" that prioritize KM initiatives of users based on effectiveness and efficiency of performance (Robinson et al., 2004).

Other KM evaluation methods used in the construction industry are by using "verification tests" that use questionnaires to collect users" feedback to determine whether the system operates according to the required design and specifications, and "validation tests" that use questionnaires to collect users" feedback about the usefulness of the system (Lin et al., 2006).

Furthermore, Gupta et al. (2000) suggested that two major trends which can be used in evaluating KM System in the organizations are by developing measurement ratios and benchmarks. Although there were various measures

in practice, the research argued that there was still no absolute measurement matrix in the literature to measure the success of a KM effort. The research recommended that there is a need to develop accounting procedures for valuing intangible assets of organizations. The research suggested that evaluating KM efforts can be achieved through evaluating aspects related to KM, such as customer satisfaction, financial outcomes, effectiveness of business processes, ability to sustain innovations and changes, improvements resulting through enhancing organizational learning, and finally through quantifying critical success factors (Gupta et al., 2000).

Although all of these methods can help organizations to obtain better views of the performance and usefulness of their KM System, there are still no precise ways to evaluate the return on investment in knowledge and the impact of KM on business performance. This study will help to provide a practical and structured method to evaluate the existing KM System of an organization and suggest important modifications and enhancements.

2.7 Definition and Importance of Knowledge Management Modeling

KM modeling is a technique that uses graphical and textual presentations to describe the real system of KM in order to describe the KM System features, components, inputs, outputs, tools, processes, practices and other factors that can impact the organizational knowledge and/or the KM System. KM models are used in organizations to provide guidance for implementing and applying KM efficiently and effectively. It can provide a procedural and structured plan that directs KM efforts through the stages of designing, building, evaluating and enhancing the KM System of organizations.

KM models can be used to evaluate successfulness of existing KM System in organizations and help to decide and achieve required improvements. It can also help to coordinate the work of the different people and/or groups who work on developing the KM System or applying various activities of the KM processes, by providing details about the different work phases and activities to be implemented and the roles of the people who apply these activities.

KM models help to enhance awareness of organizations, management and people about KM and its activities, tools and procedures, which may encourage management and employees to apply KM more successfully. It helps organizations to decide the overall objectives of applying KM and required strategies to achieve them. Using modeling techniques in KM to help people understand the complicated large systems leads to reducing the implementation and development costs of KM System .This thesis presents a proposed KM model that addresses these issues and provides an effective and efficient way for managing knowledge in the construction industry.

Models are used to help people to understand the complexity of real systems by representing the main features and dividing the large systems into its parts, which will simplify understanding and managing. Models help to provide a more structured approach to understand, implement, apply and evaluate KM System. Many researchers have developed KM models to help organizations in implementing and applying KM successfully. However, it can be argued that most of those models have disadvantages that limit the organizations to achieve successful KM in the building projects.

2.8 General Knowledge Management Models

Many methods, techniques and tools have been developed in the literature to enhance the management of knowledge and reduce the effect of KM barriers. Examples can include knowledge maps, SECI model, KM models, Activity-Based KMSs and Ontology-Based KM System. However, these KM techniques and many other ongoing researches need a more structured, coherent approach to KM and a better alignment of KM to business goals in the building organizations.

Nonaka and Takeuchi (1995) suggested that knowledge is created through continuous interactions between tacit and explicit knowledge to form four modes presented in the SECI (Socialization, Externalization, Combination and Internalization) model as shown in Figure 2.3argued that to create new knowledge there should be a non-stop process to re-create the company and everyone in it by making the creation of new knowledge a non-specialized activity where everyone in the organization acts as a knowledge worker. He explained that new knowledge always begins with the individual and that individual's personal knowledge can be transformed into valuable organizational knowledge, such as when an employee uses his experiences to enhance work processes or provide innovations.

2.9 Research Stages

The methodologies and stages followed during the research life-cycle are represented in Figures 2.3 and 2.4.

Figure 2.3: Research Model

Figure 2.4: Research Stages and Methodologies

As shown in Figure 2.3, the KM model has been developed and enhanced from its first version into a final improved KM model through continuous reviewing of literature and projects, conducting questionnaire survey with KM practitioners, organizing interviews with people from the KM domain and building projects, and presenting and publishing the achieved results in scientific journals and at conferences.

These methods have been used to investigate KM tools, processes, methods and environmental factors, and to collect experts" and practitioners" feedback and ideas for further improvement of the proposed KM model. This helped the research to identify key parts of the KM model, evaluate the appropriateness of the proposed KM model, identify important characteristics that should be included in the development of the model, and finally to decide required amendments and improvements that might be useful to enhance the developed KM model.

Examples of the various versions of the KM model proposed, developed and evaluated during the life-cycle and stages of the research are shown in Figures 2.5 to 2.6. The first developed version of the KM model depended mainly on the review of existing KM modeling techniques and KM models, especially those developed for building projects. These include KM models and techniques that developed by Abdullah et al. (2002), Nonaka and Takeuchi (1995), McInerney (2002), Wetherill et al. (2002), O"Dell and Grayson (1998), Tserng and Lin (2004), Lin et al. (2006), Robinson et al. (2004), Jashapara (2004), Wiig et al. (1997), IDEF0 (1993), Tiwana (1999), Davenport and Prusak (1998) and Wong and Aspin wall (2004).

Every KM model version went through an evaluation process through extensive study of the model details, an in-depth review of recent KM literature and capturing feedback from the research participants. Therefore, limitations of the developed versions and recommendations to enhance them were concluded and applied.

In general, while the research was developing the KM model from one version to a more enhanced one, the research started to receive more positive feedback, less negative comments and less required improvement to the proposed KM model. Chapters 3 and 4 provide more details of how the adopted methodology of the research helped to develop and improve the KM model to be more practical and useful for KM implementation and application in building projects.

Figure 2.5: Version 1 of the KM Model Developed during the Research
Stages (Lin et al., 2006; Robinson et al).

Figure 2.6: Version 2 of the KM Model Developed during the Research
Stages (Details are available in Appendix 4.1)

Figure 2.7: Version 3 of the KM Model

Figure 2.8: Version 4 of the KM Model Developed During the Research
Stages

Figure 2.9: Version 5 of the KM Model Developed During the Research
Stage

Table 2.2 Definition of Models

Version 1 in Figure 2.5	KM model as interesting and informative, and stated that it addressed the important issues of KM within the construction management research. The graphical presentation of the model is difficult to understand and follow, and needs to be improved and explained better.
Version 2 in Figure 2.6	Version 2 was found by respondents to be easier to understand and applied than the previous version.
Version 3 in Figure 2.7	Was developed to provide better details for KM adoption in building projects.
Version 4 in Figure 2.8	Version 4 was found by respondents to be easier to understand and applied than the previous version.
Version 5 in Figure 2.9	Version 5 was found by respondents to be easier to understand and applied than the previous version.

. Researcher chose Version 3 figure 2.7 for easy implementation and understanding.

2.10 Summary

This chapter highlighted the importance and need to conduct more research to pinpoint and improve the application of KM in modern building organizations. KM modeling is an important method that can help to manage knowledge within the complex environment of building projects. However, more research work is needed to fill gaps and solve problems of existing KM models. The research aims at developing a KM model that fills the gaps of previous models to better deal with tacit knowledge, provide structured methods of KM implementation and application, and ensure alignment of KM System with business objectives and strategies of the building organizations.

Interviews with academics and practitioners of KM in the building projects were conducted to evaluate and improve the proposed KM model of the research. Furthermore, a questionnaire survey was used to investigate critical success factors, activities and tools for KM implementation and application in the building projects. This helps to highlight important KM practices in order to evaluate and enhance the proposed KM model.

CHAPTER THREE

INTERVIEWS AND QUESTIONNAIRES

3.1 Introduction

The effective implementation and application of KM in organizations is controlled and facilitated by KM activities, methods, tools, and environmental factors. Organizations need certainly to encourage the application of KM activities, the use of KM System tools, and the improvement of environmental factors (or what is described in literature as Critical Success Factors (CSFs)), in order to apply KM more effectively and ensure a more successful competitive performance .

CSFs include factors for the successful implementation and application of KM such as the alignment of KM to business strategy, the appropriateness and flexibility of system architecture, the support and motivation of management, the support of knowledge-friendly culture, the adequacy of technology and infrastructure, the desire and ability of learning, and the efficiency of KM activities and tools.

Although previous studies have tried to study KM processes, tools and CSFs, most of these studies do not consider the special characteristics and features of building projects that can affect KM efforts. Furthermore, many of these studies lack the adoption of a systematic way and suffer from a lack of empirical studies for the particular business sector of the building projects. This chapter studies KM activities, methods, tools and environmental factors in a systematic way to enhance the proposed KM model so that it can be easily and effectively used by building organizations for successful KM implementation and application.

Firstly in this chapter, the aims and objectives of the interviews conducted for this research are discussed. Then, the responses of the participants are reviewed and analyzed. Secondly, the objectives and design of the questionnaire survey used in the research are presented. The findings from the questionnaire survey are analyzed and presented.

3.2 Interviews

3.2.1 Aim And Objectives of Interviews

As part of the research effort to evaluate and improve the KM model to develop a more comprehensive and appropriate version of the model interviews were conducted with experts of KM in the building projects. The aim of the interviews is to investigate respondents" evaluation and understanding of the KM model in terms of its ease of use, usefulness, comprehensiveness, applicability, feasibility and structure.

Many people, including practitioners and academics from the building projects known for having experience and/or published work in the KM domain, were chosen and asked to participate in interviews for the purpose of this research. A description of the KM model, combined with general questions about KM and the participants" backgrounds (see Appendix 1), were sent to the people who showed interest in participating in the research.

Interviews were conducted with six people who agreed to participate in the research. The interviewees include two academics with wide experiences in KM research and publishing, two KM managers with more than seven years' experience in IT and KM System applications, one knowledge worker with more than 5 years' experience and 1 senior manager with more than 12 years' experience in the construction projects and a wide experience in the KM domain. The interviewees were chosen regarding their experiences and

background in the KM domain and their willing and interests on participating.

However, the responses and results were filtered to insure the exclusion of unnecessary irrelevant outcomes. Also, the respondents were given the opportunity to review their responses in order to edit contents and provide comments. In some occasions, opinions from respondents were discussed with other respondents to collect feedback, refine results and improve outcomes. Also, some face-to-face discussions were arranged to encourage discussion and solve problems.

Adopting semi-structured interviews with questions of an open-ended nature was the method adopted by the research interviews to encourage respondents to provide useful detailed opinions and ideas, and to identify and discuss important topics, which enabled the research to identify issues that can be important for the development of a KM model for building projects.

3.2.2 Analysis of the Responses

The comments and discussions provided by the interviewees reflect their opinions, perspectives, ideas and evaluations about the proposed KM model in terms of its characteristics, such as ease of understanding and use, comprehensiveness, applicability, feasibility, structure, usefulness, etc. In general, the respondents gave positive comments, and agreed that the developed KM model is useful, relatively comprehensive and appropriate, especially for the latest versions. The comments given by the respondents are discussed in the following paragraphs.

The comments received in the early stages of the development of the KM model (Version 1 in Figure 2.5) described the KM model as interesting and informative, and stated that it addressed the important issues of KM within the construction management research. However, the graphical presentation

of the model is difficult to understand and follow, and needs to be improved and explained better. This motivated the author to enhance and develop the KM model into a clearer version (Version 2 in Figure 2.6).

Version 2 was found by respondents to be easier to understand and applied than the previous version. However, respondents found some difficulties in following the different stages of the proposed KM model. Respondents suggested improving the proposed KM model by dividing it into its main components, where every component can be represented and explained more clearly. By using this method, an enhanced KM model (Version 3 in Figure 2.7) was developed to provide better details for KM adoption in building projects.

Version 3 divides the KM method into five major components and provides details for each component. All of the respondents agreed that the proposed KM model is properly developed, looks relatively simple, easy to understand and follow, and includes the elements needed for the successful implementation and application of KM System. They stated that the proposed KM model successfully shows the relationships and the flow of knowledge among the different components. Respondents believed that the proposed KM model makes the implementation and application of KM in building projects easier, more structured and more effective. However, some concerns were raised by respondents regarding modifying and adding more details to the proposed KM model.

Suggestions were given to add more details about the influential factors that affect KM adoption by presenting procedures or activities to deal with them successfully. Some cultural frictions were referred to by interviewees, such as unwillingness to share knowledge and a belief that sharing knowledge means losing the power accompanied with it. Environmental activities were

recommended by interviewees to deal with cultural frictions such as rewarding knowledge sharing, encouraging trust among employees, and providing time and places for employees to learn. Privacy, confidentiality and copyright issues are also examples of the influential factors that have been referred to by the interviewees to be dealt with in the development and application of KM System.

Concerns were given about the effort and cost required to capture and share explicit and tacit knowledge by the KM System users. Recommendations were provided about exerting more efforts to identify knowledge resources of high importance to the organization to decide what knowledge needs to be captured, to be shared, and what needs to be ignored in the KM System.

An important issue discussed with the interviewees was the need to review and approve captured knowledge by experts and/or KM team members before making it available to the users of the KM System. Some of the interviewees recommended that a successful KM System should be open, where everyone in the organization can add and edit the knowledge contents. They argued that the existence of processes to review and approve knowledge before making it available for the KM System end-users delays the participation of many of the employees and causes a loss of opportunities to view important content and gain valuable knowledge.

 The interviewees stressed the importance of allowing any participation from people in the company to encourage adding to the system Other interviewees recommended that the existence of rules, restrictions and reviewing processes protect the system from being overloaded with too many contents that may confuse the searchers and negatively affect the system's performance. They argued that it is important to filter knowledge and exclude unimportant contents from the system before overloading it with

unrelated and low quality contents. An interviewee gave an example from his experience of a leading   company where KM System had the problem of having too much knowledge in its repositories that caused the low performance of the system and complexity in finding required knowledge. This caused a very low level of usage for the system.

A mechanism to review, adapt, edit and approve captured knowledge was suggested and encouraged in the proposed KM model. However, the proposed KM model suggests finding a balance in the process of reviewing and approving the knowledge contents. Too much reviewing of the contents will result in delays, and discourage knowledge capturing and sharing, while overloading the system with too many unimportant contents. This will negatively affect the performance of the users and the system. Hence, it is important to define the required purposes and roles of the KM System to align with the strategy of the organization.

Comments were also provided by interviewees on enhancing the effectiveness of the proposed KM model in dealing with tacit knowledge. The interviewees suggested adding more details to the KM model to better deal with the special characteristics of tacit knowledge. This suggestion was dealt with by categorizing knowledge resources into more types that require different procedures, methods and tools to manage and deal with them, as will be described in the final version of the developed KM model.

The development of the final KM model will take into consideration the useful comments and suggestions provided by the interviewees, combined with other results of the questionnaire survey that will be detailed and discussed in the following section.

3.3 Questionnaire Survey

KM researchers have applied survey methodology in the building projects to investigate a variety of objectives. Egbu and Botterill (2002) conducted a questionnaire survey in order to investigate the role of IT for KM in the building projects. The results revealed that traditional technologies, such as the telephone, are used more frequently to manage knowledge, than other knowledge sharing tools, such as Groupware or video conferencing. The researchers recommended a greater implementation of knowledge sharing tools supported by sufficient training and education to achieve more potential benefits for KM.

Carrillo et al. (2004) conducted a questionnaire survey on the building organizations to examine the importance of applying KM in these organizations, to investigate the resources used to implement KM strategies and to investigate the main barriers to implementing KM strategies. The results showed that the main motive for implementing KM is the need to share the tacit knowledge of employees" experiences and best practices. The resources allocated for KM by the respondent companies, in terms of staff and budget, were investigated. The research found that the main barrier for implementing KM in the building organizations is the lack of a standard work process.

Robinson et al. (2005) carried out an exploratory questionnaire survey to investigate the perception of KM in the leading building organizations. The findings indicated that over 75 % of respondents are aware of the importance of KM and intended to apply KM in the future, while over 45 % intended to appoint a person or group with responsibilities for KM.

Lin et al. (2006) applied the questionnaire method to evaluate an existing KM System by collecting the feedback of its users. The questionnaire aimed

to investigate whether the system operated according to design specifications and to assess the usefulness of the system. The results showed that the KM System helps to find required knowledge easily and effectively. The results also highlighted the primary benefits of using the KM System, such as identifying key knowledge that is most strategic and critical to the projects, and providing assistance for users to find the required knowledge easily and effectively.

3.3.1 Aims and Objectives of Questionnaire Survey

The main aim of the research survey is to capture the initiatives for KM and investigate the critical success factors for implementing KM in the building projects. The questionnaire includes four main sections as shown in Appendix 2.1.

Section 1 asks for general information about the participants and their companies. These will be used to describe characteristics of the questionnaire respondents. Section 2 is dedicated to investigate both the usage and importance of activities, procedures and tools of KM in the participating companies. Section 3 investigates KM environmental activities and factors (Critical Success Factors, CSFs) by listing statements that relate to the CSFs. Respondents are asked to provide their opinions regarding how much those statements describe the KM System in their organizations and the importance of the different statements for a successful implementation and application of KM in the building projects. Also, motivations, challenges and required specifications to KM will be investigated in terms of their importance and influence on the organizations according to the participants" opinions. Section 4 of the questionnaire is for non-knowledge adopters to investigate the reasons of not applying KM in some of the construction companies.

The responses of the questionnaire represent respondents" opinions that depend on their judgments and affected by their own experiences in the building and KM domains. By involving practitioners and those with knowledge of KM implementation and application from the building projects in the survey, important perceptions and results will be gained to strengthen the proposed KM model and achieve more accurate and comprehensive results.

The second aim of the questionnaire survey is to investigate the importance and applicability of the different parts of the KM model in order to identify the areas and subjects that need further investigation and improvement. For example, if the results show that specific areas or activities have received high importance but low levels of application in the organizations, this indicates a need to provide details in the KM model to improve awareness and encourage application in the required areas. So the questionnaire helps to evaluate the proposed KM model and encourage applying improvements and providing details to reach to a final KM model for building projects.

The results of the questionnaire help to build sets of important KM activities, tools and environmental factors in the KM model to enable organizations to plan and manage their KM efforts successfully. The results evaluate importance and influence of different KM issues in order to help organizations manage resources and efforts successfully to obtain required results and potentials. Hence, addressing the results of the questionnaire into the KM model is necessary in helping building organizations to identify the key factors, that if effectively adopted can make the implementation and application of KM more successful.

3.3.2 Questionnaire Design and Development

The questionnaire was designed to investigate the KM methods, procedures, activities, tools and environmental factors which are important to shape a more useful and comprehensive model for successful and effective KM implementation and application in the building projects. During the research stages, the questionnaire has been developed and enhanced in shape, design and content. The contents of the questionnaire relied on the developed KM model (mainly on version 3 in Figure 2.7). The questionnaire was checked and evaluated through a pilot study and so were corrected and enhanced in terms of structure, content and format.

The questionnaire was designed to search opinions from KM or IT managers, workers and team members, senior and junior engineers, or any employee who may have good experience in implementing or applying KM System in building organizations. The questionnaire asks participants to provide their evaluation for the importance of different components, characteristics and activities of KM and KM System according to their experiences and perceptions.

The questionnaire was split into four main sections as shown in Appendix 2.1. Section 1 seeks general information about the respondents and their companies, such as the profession of the respondent, the size of the company, the type of the company's business and the year the company started to implement KM. The responses for this section will be used to define the characteristics of the respondents and their companies.

Section 2 asks respondents to evaluate, according to their experiences and opinions, the extent of application and the level of importance of activities for KM implementation (building and development) and application (use), and KM technological tools (see Table 3.1).

In Section 3, the respondents were asked to provide their evaluation about the importance of statements that describe environmental factors and activities that affect KM and to indicate how much these statements describe the KM environmental activities in their companies (see Table 3.2). Furthermore, section 3 investigates the importance of drivers, system specifications and challenges that may affect KM efforts in the building projects, and asks respondents to indicate how much these statements describe the KM application in their companies (see Table 3.2).

Sections 2 and 3 were designed to provide a tool for evaluation of statements that describe activities, procedures, tools and factors that may affect KM implementation and application in building projects. The statements used in Sections 2 and 3 were carefully formulated and categorized on the basis of the preceding research work that includes reviewing and analyzing of relevant KM literature, interviewing KM experts and practitioners, and developing, evaluating and modifying the KM model. Participants were asked to provide two responses for each statement organized into two columns as shown in Appendix 2.1.

Means extremely important. The respondents were asked to leave boxes blank if they did not know or were unsure of the response, or if their companies did not practice KM.

Two other questions were included in section 3 of the questionnaire, asking the participants to give their evaluation of the KM System in their organizations and to evaluate the success of the activities, methods, tools and factors listed in sections 2 and 3 of the questionnaire. Comparing results of the two questions can be used to indicate the usefulness of applying the activities, tools, and procedures included in the questionnaire. Since the questionnaire statements depend on the contents of the KM model developed

at that stage of the research (Version 3 in Figure 2.7), the comparison of the responses to the two questions provides a general evaluation for the contents of the KM model and their usefulness to implement and improve KM System in the building organizations.

Finally, Section 4 asks non-adopters of KM to give their opinions about the main reasons for not applying KM in their organizations to date and whether or not they intended to implement a KM System in the future. A feedback section was included at the end of the questionnaire to encourage respondents to participate in other stages of the research. This section allows respondents to provide comments about the questionnaire survey and invites more opinions and suggestions on how to improve KM in the building projects.

Table 3.1: KM implementation activities, application activities and technological tools investigated in the questionnaire survey

SECTION 2: KM ACTIVITIES AND TOOLS

KM Implementation Activities	**A1. System Analysis** 1. Conducting questionnaires and/or interviews with employees 2. Identifying business processes and procedures 3. Identifying data & knowledge available and important for the organization 4. Identifying what tools are appropriate for KMS **A2. System Design** 1. Defining aims and objectives for KM 2. Using KM models to represent KM activities, methods, and components 3. Preparing an action plan and guidelines for KM implementation **A3. System Implementation** 1. Implementation of a Prototype before applying wide range KMS 2. Appointing KM offices to provide training and support to employees 3. Embedding KM activities into employees' work processes and activities **A4. System Maintaining and Monitoring** 1. Collecting feedback from end-users regarding improvement requirements 2. Observing the differences in operations after implementing KM 3. Monitoring the system performance and showing bottle necks 4. Monitoring the environmental factors such as management strategy, employees culture and technological factors **A5. System Evaluation** 1. Investigating business process improvements 2. Evaluating the system correctness and Alignment with design specifications 3. Evaluating the system usefulness, ease of use, and applicability
KM Application Activities	**A6. Knowledge Capturing and Storing** 1. Recording problem solutions & experiences in electronic repository 2. Referring knowledge to its sources (experts, books, articles or websites) 3. Recording new ideas and perceptions of experts and engineers 4. Attaching pictures, videos, and text files to clarify knowledge contents **A7. Knowledge Reusing and Sharing** 1. Using the intranet to share and transfer knowledge 2. Using searching tools to find required knowledge 3. Showing contact details and experiences of the employees **A8. Knowledge Reviewing and Approving** 1. Using the intranet to publish and edit knowledge 2. Reviewing knowledge contents by experts or a knowledge team 3. Classifying knowledge to facilitate knowledge searching functions **A9. Using Databases to create Knowledge** 1. Capturing data and information of projects in electronic repository 2. Using Data Mining, Data Analysis, and Reporting tools 3. Recording knowledge and information concluded by using previous tools
KM Technological Tools	**A10. System Tools** 1. User manuals and help desk 2. Data Mining, Analysis and Reporting 3. Document Management 4. Photos and/or Videos Management 5. Training and Support (E-learning) 6. Knowledge Searching 7. Knowledge Map (graphical presentation provides overview and sometimes links to existing knowledge and domain experts) 8. Yellow Pages and/or Contact Details 9. Subscribing and/or Password Interring to define authority level 10. E-Meeting, Messaging, Chatting and Discussion board/forum 11. Decision support systems and/or Intelligent agents

Table 3.2: KM environmental factors, drivers, system specifications and
challenges investigated in the questionnaire survey

SECTION 3: KM Influential Factors	
Environmental Factors and Activities	**F1. Culture** 1. A culture that values knowledge seeking and problem solving 2. Providing time to employees to perform knowledge related activities 3. Encouraging collaboration and teamwork among employees 4. Updating employees and other users about the changes in KMS 5. Building up awareness and providing training on use of the KMS **F2. Management leadership and support** 1. Management establishes the necessary conditions for KM 2. Leaders encourage and support knowledge creation, sharing and use 3. Knowledge managers constantly search for new approaches to KM 4. Development of a KM strategy with clear objectives and goals 5. Sufficient financial resources for building up a technological system **F3. Information technology** 1. Matching the KMS with KM objectives and user's needs 2. Utilisation of the intranet and internet 3. Ease of use of the technology 4. Protecting knowledge from unauthorised exposure or being stolen 5. Ability of the system to capture and store tacit knowledge 6. Appropriate categorization and updating of knowledge 7. Application of technological tools (collaborative tools, searching tools, indexing, document management etc) **F4. Measurement** 1. Measuring benefits per unit of investment 2. Monitoring the system performance and showing bottle necks 3. Developing indicators for measurement of KM **F5. Organizational infrastructure** 1. Appointing of a knowledge leader and/or knowledge team or workers 2. Ensure of sufficient human resources to support KM initiatives 3. Specifying activities, tasks and processes for performing KM 4. Specifying roles and responsibilities for performing KM tasks 5. Recruiting and hiring of employees to fill knowledge gaps
KM Drivers	**F6. Drivers for KM** 1. Building up and maintaining employees' expertise and skills 2. Sharing employees' expertise and perceptions 3. Identifying internal and/or external best practices 4. Reducing cost and/or time to solve problems in projects 5. Enhancing work quality of projects 6. Providing competitive advantages to the company 7. Helping senior engineers and managers to avoid many problems' causes 8. Presenting accurate and timely knowledge to facilitate decision making 9. Providing an effective tool to train junior engineers 10. Enhancing relation and coordination with customers, partners and suppliers 11. Encouraging continuous improvement and/or new products and services 12. Reducing rework and save time of solving repeated problems
KMS Specifications	**F7. Specifications of the KMS** 1. The knowledge system is easy to use

	2. It is easy for users to find useful information for problem solving 3. The system Collects knowledge that is important for the organization 4. The system Ignores knowledge that is not important for the organization 5. The system facilitates knowledge sharing between company's employees 6. The system maintains good relationships with customers and other partners 7. The role of knowledge team and knowledge workers is very important
KM Challenges	**F8. KM Barriers and Challenges** 1. The nature of construction projects (e.g. non-repetitive work, no standard procedure for activities, pressure to complete on schedule, changing employees in different phases, etc.) 2. Lack of organizational culture for knowledge creation and sharing (e.g. build trust among employees, establish times and places for knowledge transfer, provide incentives, accept and reward creative errors, etc.) 3. Lack of structured procedures and processes to implement KM 4. Lack the adoption of well formulated KM strategies and implementation plans 5. Lack of knowledge manager or a team to implement KM strategy 6. Lack of awareness of the importance of KM in construction organizations 7. Lack of training and support 8. Lack of technology and techniques for knowledge capture and sharing 9. Lack of leadership support 10. Lack of resources in term of a budget, staff, and IT infrastructure 11. Employee resistance to share their knowledge 12. Lack of post-project reviews and project documentation

3.3.3 Characteristics of Selected Construction Companies

In order to select construction companies for the survey, the fame (financial analysis made easy) database was used to generate a list of the Sudan construction companies. this list contains construction companies" names, latest number of employees, last turnover, contact details, web sites and e-mail addresses, which provides useful information for the questionnaire survey.

a method recommended by the national science foundation (NSF, 2006) is used to classify organizations into 10 groups based on the total number of employees. The NSF method is used in the research to ensure that the chosen list of companies is homogeneous and diverse, i.e. it is distributed in the different size categories and so provides better representation of the existing construction companies in the Sudan.

Another method widely used in the Sudan survey-based researches recommendations that classify organizations into four groups based on the

number of employees and turnover. The recommendations are used in the analysis of the questionnaire responses to simplify understanding the results of the respondents" characteristics (Section 1 of the questionnaire).

The two methods are compatible and can be used together in the questionnaire. Figure 3.1 shows similarities in the two methods, where small and micro companies groups according to Groups 1 and 2 of NSF, the medium companies group relates to Groups 3 and 4, while the large companies group includes Groups 5 to 10. Appendix 2.2 shows an example of the Sudan construction companies" population lists that was generated by using the FAME database and categorized in separate sheets for the different size groups based on the NSF recommendations for size categorization.
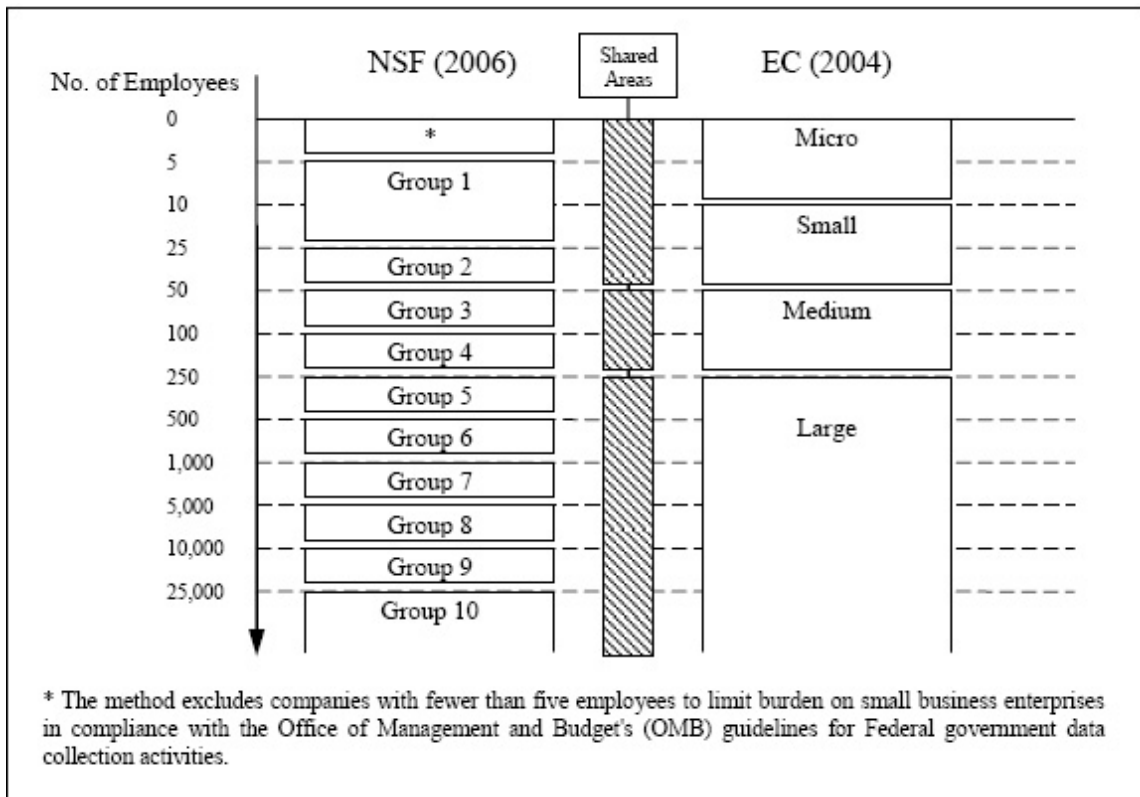

Figure 3.1: The Classification Methods of Companies Adopted by the Research (NSF, 2006; EC, 2004) .

Companies were randomly selected from the list of the Sudan building organizations, from each of the different size groups, especially those for which the web-site and/or e-mail address are provided, and those who provided details about a selected director or contact whose position is related to KM, IT or construction domain as shown in Appendix 2.1. The data of the chosen companies were carefully checked to ensure they are correct and up-to-date. E-mail addresses of employees whose positions are related to KM were also searched through the companies" web-sites to ensure that the questionnaire survey can reach people with required experiences and knowledge. Finally, e-mail messages were sent to a total of 100 construction companies inviting the targeted people to participate in the questionnaire survey, explaining its purposes and importance, providing link to the questionnaire web-site, and asking to forward the message to any employee in their organization who may have useful experiences for the purposes of the research. Follow-up messages were also sent to the companies in order to improve the response rate. Example of the sample message used to contact the construction companies and the Follow-up message are shown in Appendices 2.4 and 2.5.

CHAPTER FOUR
ANALYSIS OF QUESTIONNAIRES

4.1 Reliability and Validity of the Questionnaire Results

Testing the reliability and validity of the questionnaire results is very important before conducting any further analysis. Reliability tests are used to provide an indication of the degree to which the measures used to evaluate the same thing are homogeneous and consistent.

In order to assess the reliability of empirical measurements, \the internal consistency method.

Examples of reliability results shown in Appendix 2.6. The analysis was performed for each activity or factor separately recalculated if any of the items were deleted from the sub-sections as shown in Appendix 2.6.

4.2 Analysis of the survey responses

In order to define the response characteristics and to evaluate the importance and level of implementation of KM activities, tools and procedures in the participating construction companies, the responses to sections 1, 2, 3 and 4 of the survey need to be analyzed. The response characteristics are investigated by calculating the numbers and percentages of occurrence of responses from Section 1 in the questionnaire. The level of implementation and importance of KM activities, tools and factors are investigated in Sections 2 and 3 of the questionnaire through calculating the mean scores and the number and percentage of occurrence for the respondents" ratings. Calculating numbers and percentages of occurrence of the responses in Section 4 investigates the reasons of not adopting KM in some of the participating companies.

4.2.1 Section 1: Response Characteristics

From the 100 companies contacted, a total of 34 questionnaires were received, representing 11.3% response rate. However, only 27 of them confirmed that their companies have implemented and practiced KM, representing a usable 9% response rate which is adequate to satisfy the survey objectives and acceptable when compared to surveys carried out in the KM field.

The response rate for the survey was 9 percent of the population. The results of that research indicated that a strong relationship exists between KM technologies and organizational culture.

An example is a study by De Pablo's (2002) that used a questionnaire survey to investigate areas of KM strategies, organizational learning and organizational performance in the Spanish manufacturing industry. The questionnaire survey was sent to 2,136 firms and the perceived response rate was about 6 percent. The results of the questionnaire showed that different KM strategies have different effects on organizational learning, performance, capabilities and competitive advantages.

Furthermore, a study by Wong and Aspin wall (2004) applied a questionnaire survey to investigate the critical success factors (CSFs) for adopting KM in small and medium-sized enterprises (SMEs). The questionnaires were distributed to a total of 100 SMEs in the Sudan and 50 contributors from academics, consultants and practitioners in the KM field. The response rates were 8.7 percent and 18 percent respectively from the two groups. The survey aimed to integrate the results of the two groups of respondents in order to generate a prioritized list of CSFs in order of their importance for implementing KM.

Finally, the numbers of respondents and/or response rates of the surveys of KM in the building projects reviewed earlier are: 40 respondents from the building projects for the study conducted by Egbu and Botterill (2002); 53 respondents, giving a response rate of 31.2 percent for the study conducted by Carrillo et al. (2004); and 15 respondents to evaluate an existing KM System in the study conducted by Lin et al. (2006).

It is difficult to evaluate the percentage of companies in the building projects that can be classified as KM adopters. There is a lack in the literature for a precise definition that can differentiate KM organizations from non-KM organizations. Although some construction companies have announced that they adopt formal KM System in their organizations, some research shows that these companies may only apply some KM tools that cannot insure successful application of KM System (Axelsson & Landelius, 2002).

In this research, the items and practices included in the proposed KM model and in the developed questionnaire survey, shown in Tables 3.1 and 3.2, which refers to the important KM implementation, application and environmental activities and KM technological tools, will be used to define the characteristics of KM organizations.

Figure 4.1 shows the percentages of responses that indicate large scale implementation for the KM practices and tools proposed in the questionnaire survey. The results show, for example, that about 50% of the respondent companies only apply less that 10% of the items proposed in the research.

These results are affected by the fact that most of the respondent companies are from large construction companies who already have interests in KM, and the fact that the questionnaires were sent and more contacting were conducted to organizations that were recognized, through their contacts and web-sites, of being interested with computer systems.
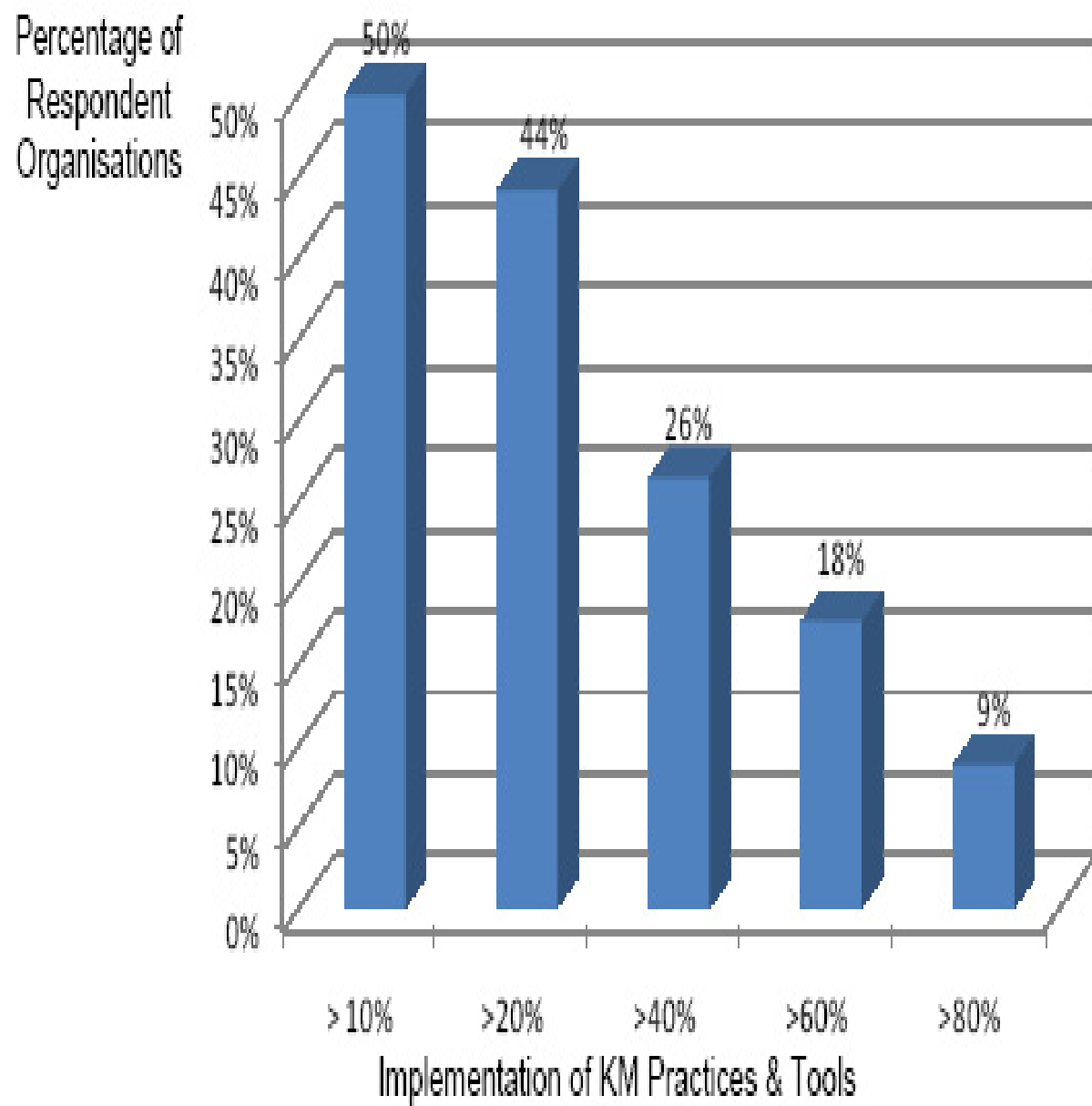
Figure 4.1: Percentages of Companies Implementing KM Practices and Tools

The research confirms that KM adoption is still new and in its early stages in most building organizations (Carrillo et al., 2004). This research only addresses the use of KM practices in the Sudan leading building organizations and does not address the difficulties often associated with managing tacit knowledge (Carrillo et al., 2004). Another survey by Martin (2002) that investigated KM practices across leading companies in all industrial sectors showed that the majority of organizations fall in the "add hoc" level and only 9% can be considered as having "managed" KM.

4.2.2 Section 2 (A1 to A5): KM Implementation Activities

The results of sub-sections A1 to A5 are analyzed to evaluate the importance and level of implementation for activities of KM implementation in the respondents" building organizations. The activities in sub-sections A1 to A5 are proposed in the developed KM model of the research to define activities and processes of KM implementation in the building projects. The average rating of importance for the activities listed in sub-sections A1 to A5 are summarized and represented in Figure 4.2. As can be seen, 88.1% of the responses indicate that the KM implementation activities are important, very important, and extremely important. This indicates that, in general, the activities included in sections A1 to A5 are of high importance for the successful implementation or building of KM System in the construction companies.
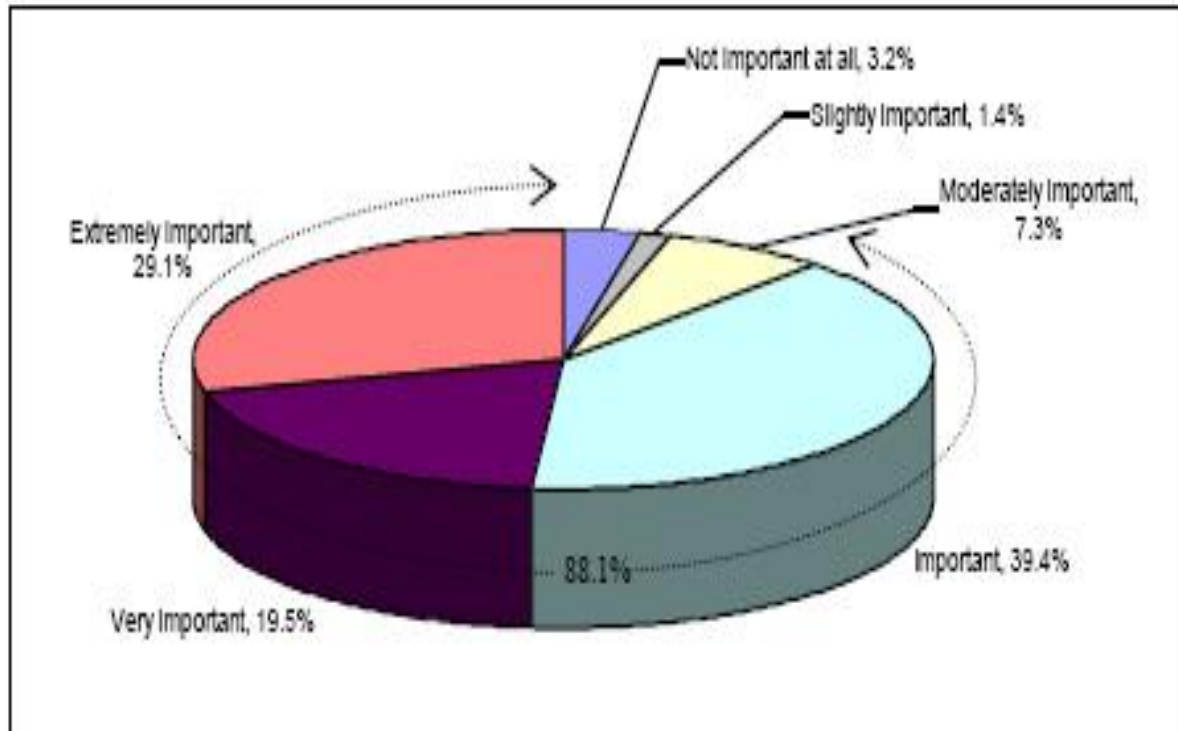
Figure 4.2: Evaluation for Activities of KM Implementation Presented in the Research

The average of the rating values for each activity in sub-sections A1 to A5 are calculated and represented to create a comparison among the perceived importance of the activities in the opinions of the questionnaire participants as shown in Figure 4.3. The mean values are in the range from 3.81 to 5.27 that fell within the range of „Important" and „Very important" activities with a total average of 4.59 for all the KM implementation activities. So, it can be concluded that all of the KM activities included in the questionnaire sub-sections A1 to A5 were perceived by the respondents as playing a key role in KM implementation.

The highest scores were provided for system evaluation activities with an average score of 4.96. Receiving higher importance levels for system evaluation, system analysis and system monitoring activities refer to the high involvement of the employees in the building organizations in these activities. That shows the importance of capturing feedback from end-users in the early and late stages of the development of the KM System in an organization in order to implement the required KM System. Lower importance levels for the design and implementation activities refer to the fact that employees of the building organisations have less involvement in these processes compared to other activities where most of these activities are carried out by specialized IT companies.

Figure 4.3: Importance Analysis of Sub-sections A1 to A5

4.2.3 Section 2 (A6 to A9): KM Application Activities

In order to evaluate the activities of using KM System in building projects, the questionnaire survey includes questions to rate these activities. The percentages of the responses are calculated for all of the KM application activities. The results show that about 94.1% of responses believe the activities included in sub-sections A6 to A9 to be „Important", „Very important" or „Extremely important". This demonstrates that the adoption of the listed activities is important for a successful application and use of KM System in building projects as shown in Figure 4.4.
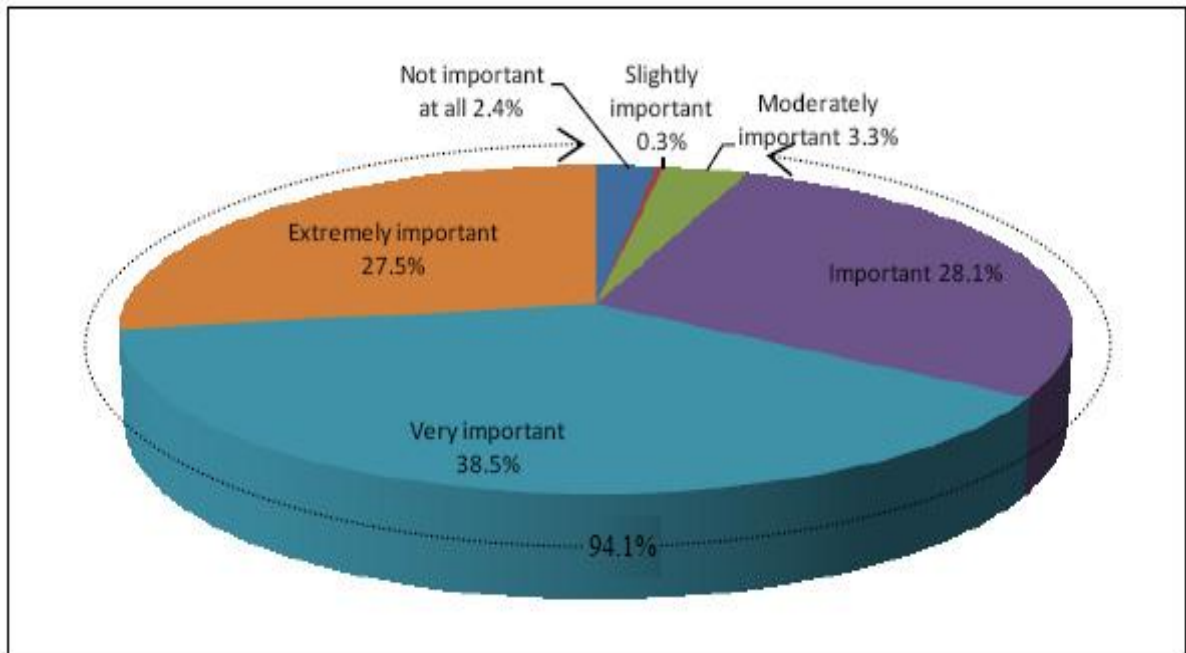

Figure 4.4: Importance Evaluation of Activities of KM Application
Proposed in the Research

In order to provide an overview about the perceived importance of each proposed KM application activity, the averages of the rating values are calculated and represented in Figure 4.5. As can be seen, the averages of the

perceived importance fell in the range of 4.08 to 5.19 with a total average of 4.75 for all the activities. This shows that all of the KM application activities proposed in the research are perceived by the respondents as key activities for the successful application of KM. The results also show that the most important group of activities of KM application are the activities of knowledge reviewing and approving with an importance average rate of 5.09.

The most important activity within the groups, and perhaps the main reason for people to practice and use KM System, is the use of the company's intranet and collaborative tools to share and transfer know-how and experiences among employees. Furthermore, the lowest importance of the activity groups of KM application is the activities of using the companies'' databases to create knowledge, with an average of 4.49. The least important within this group is the activity of capturing and recording the knowledge concluded by using the company''s databases and data mining tools, with an average importance rate of 4.08. This shows the need to enhance the awareness of people and organizations in the building project about the important role of data and information in creating knowledge as will be discussed in the final proposed KM model of the research. For example, a captured problem solution, best practice or innovation may need to be supported with data and information to show that it is cost efficient, time efficient and practical, before it is made available for the KM System end-users.

The total average rate for the proposed KM application activities is 4.75, which is higher than the total average of KM implementation activities of 4.59. This can refer to the fact that for a successful adoption of KM in an organization, it is not enough merely to have a well designed and

implemented KM System, but it is also important to follow procedures and processes to encourage and enhance the use of the KM System.

Figure 4.5: Averages of the Perceived Values of Importance for the KM Application
Activities

4.2.4 Section 2 (A10): KM Technological Tools

An analysis to a list of KM technological tools (section A10) was carried out to investigate the implementation of these tools in the construction companies and to evaluate their importance for the successful application of KM. The percentages of the responses for each importance level for the proposed tools are represented in Figure 4.6. The results show that 81.1% of the responses indicate that the KM technological tools are „Important", „Very important" or „Extremely important", which shows that the adoption of such tools is a key issue for a successful application and use of KM.
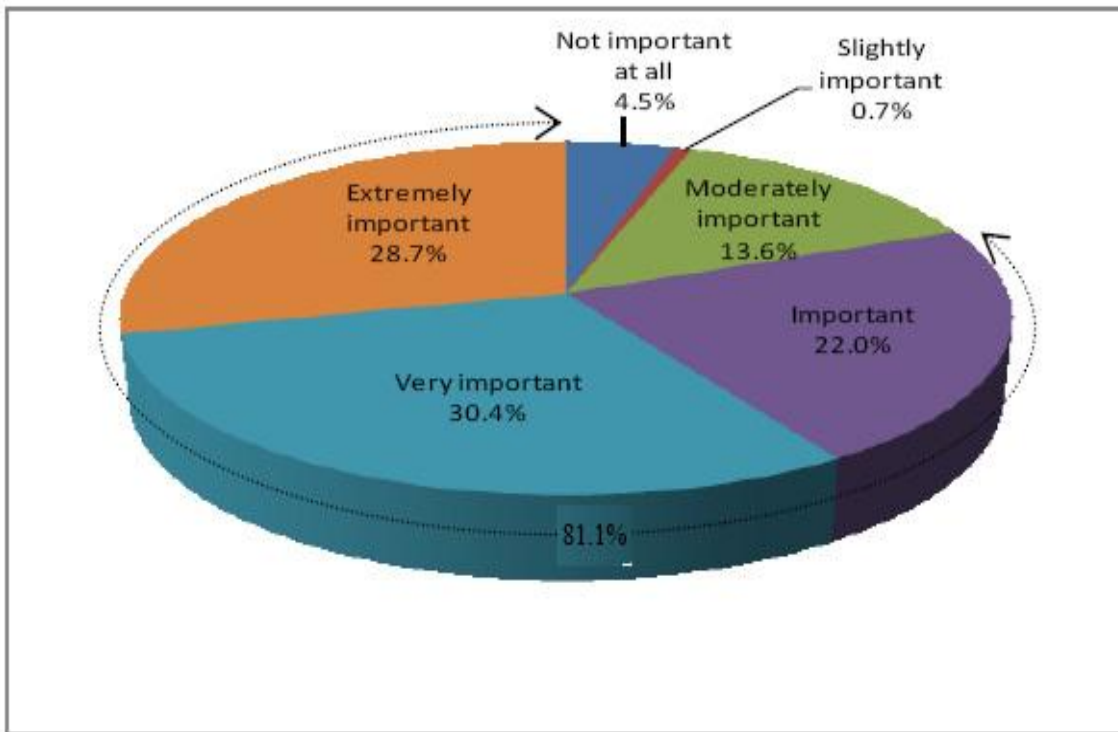

Figure 4.6: Evaluation of Importance of KM Technological Tools Proposed in the Research

The averages of the rating values for each KM technological tool are shown in Figure 4.6. Average ratings fall in the ranges of „Important", „Very important", and „Extremely important" with a total average of 4.59. This indicates that those tools are very important for a successful adoption of KM in the building organizations.

The results also show that the technological tools of capturing and retrieving explicit knowledge, such as documents, drawings, photos and videos management tools, received the highest importance ratings among other KM technological tools. Other tools, such as knowledge maps and yellow pages, which can help users to navigate and find required contents and people, are known to be very useful in processes such as problem solving and decision making. However, these tools received the lowest importance rating values. This shows that there is still a need from the construction companies and KM literature to enhance the awareness of people about the importance of applying and using such tools, and to encourage providing more support and motivation to use them.

Figure 4.7: Average Rates of Importance for Proposed KM Technological

Tools

4.2.5 Section 3 (F1 to F5): Environmental Factors and Activities

Subsections F1 to F5 in the questionnaire survey are to investigate the opinions of KM practitioners in the building projects about the importance and the level of implementation of KM environmental activities. The aim is to examine key activities to deal with environmental factors that may affect the successful implementation and application of KM in the building projects. The results are represented in Figure 4.8. It should be noticed that 88.8% of the responses refers to the high importance of the proposed activities according to the opinions and experiences of the questionnaire respondents. As can be seen, the environmental activities in the proposed KM model have been ranked as highly important for a successful adoption of KMSs in the construction companies.
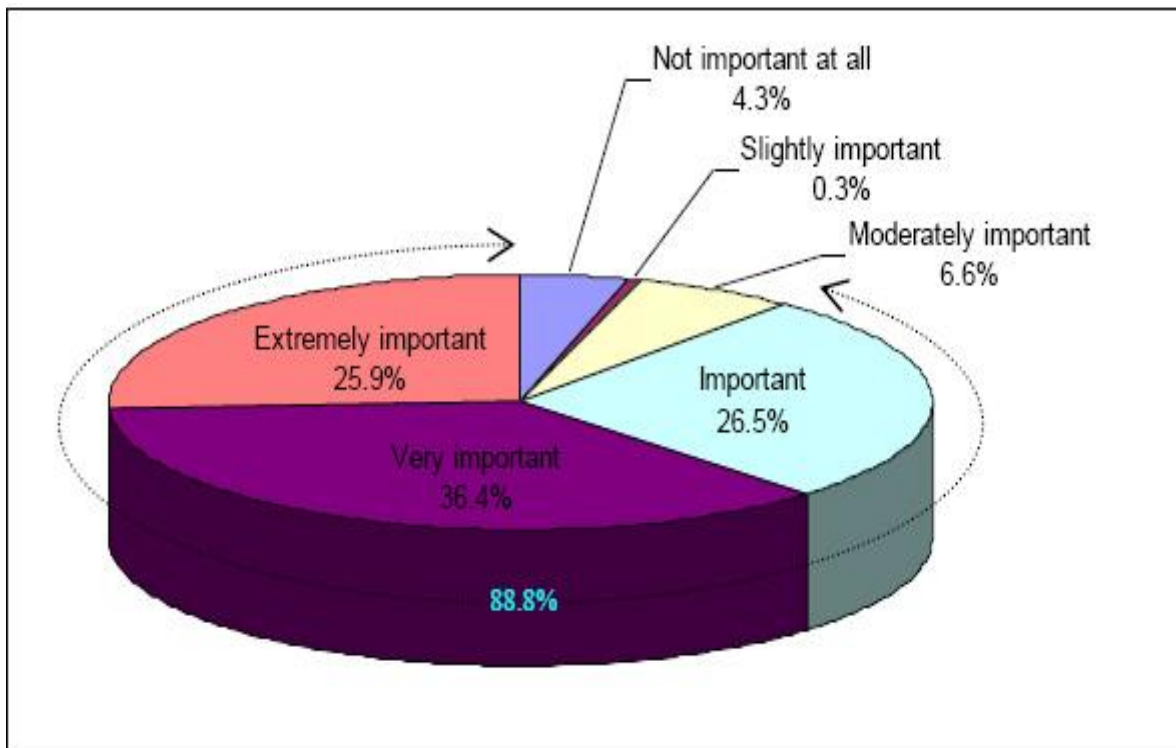

Figure 4.8: Evaluation for Environmental Activities of KM Adoption
Proposed in the Research

The average rating values for the subsections F1 to F5 and for the activities within each subsection, as represented in Figure 4.9, fell in the range from 4.07 to 5.41, as „Important" and „Very important". The overall average was 4.68, which indicates that the activities included in the proposed KM model to define the environmental activities are highly necessary to deal with KM environmental factors and play key roles for the adoption of KM in the building organizations. The highest evaluation averages are given regarding the activities and procedures related to information technology. This indicates that KM System should be easy to use; be available for end-users through intranet and internet; include tools and components that satisfy organizational and individual needs; and allow users to capture, share, retrieve, reuse, update and protect knowledge. Although the environmental activities are evaluated to be very important for a successful adoption of KM in the building projects, those activities cannot work successfully if the existing KM System is not easy to use, lacks the required components, does not consider privacy and copyright regulations, and lacks effective and efficient performance.

Figure 4.9: Importance Evaluation of Environmental Activities

4.2.6. Section3 (F6 to F8): KM Drivers, Specifications and Challenges

Subsections F6, F7 and F8 are designed in the questionnaire survey to ask for respondents" opinion about the importance of drivers, specifications and challenges that may encourage or hinder the efforts for adopting KM in the building organizations. Figure 4.9 shows the results of these sections, which indicate that "Important" to "Extremely important" responses are 93.1% for KM drivers, 92.6% for KMS specifications, and 96.0% for KM challenges. This indicates the need of construction organizations to investigate drivers that encourage their KM efforts, specifications that are required to support their KM activities, and challenges that they need to avoid and deal with by applying special KM methods and procedures.
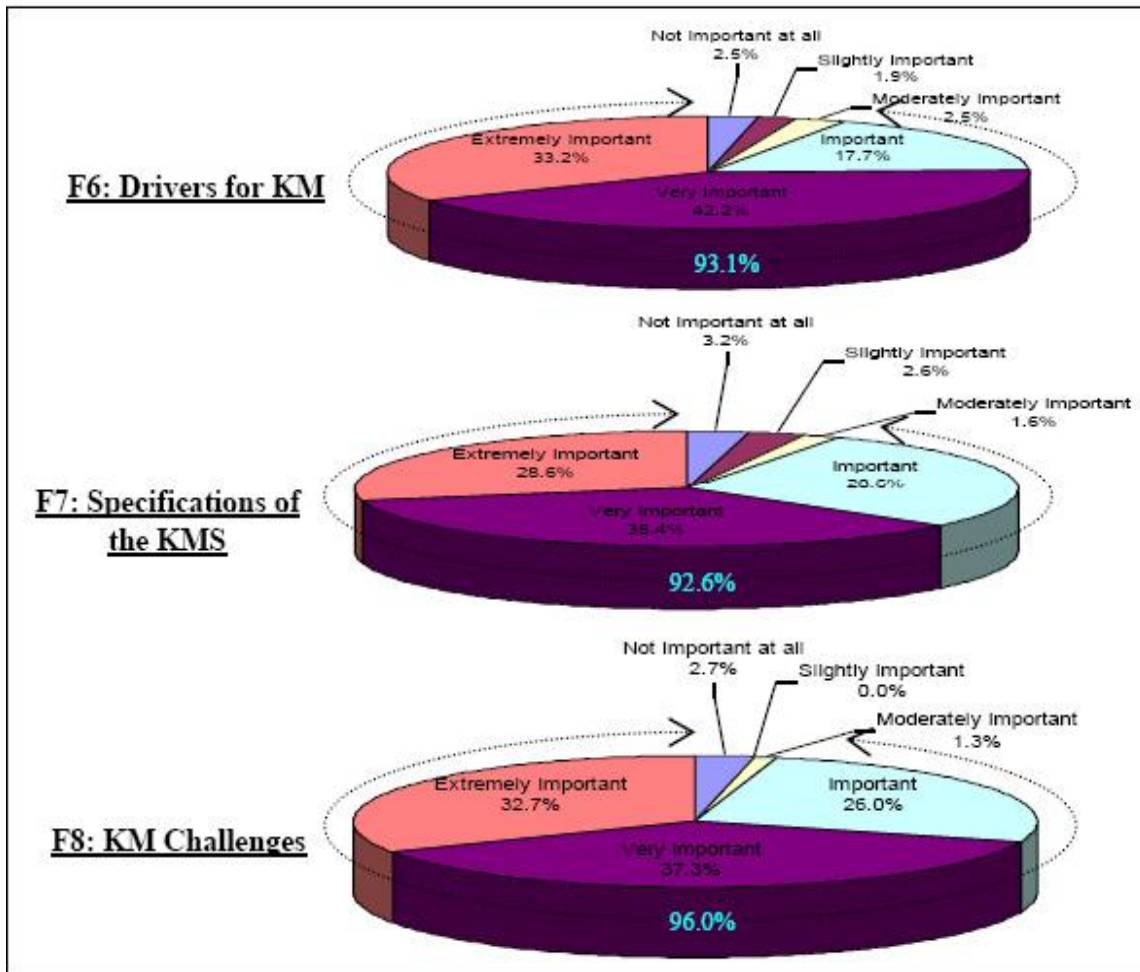
Figure 4.10: Evaluation for KM Drivers, Specifications and Challenges

Figures 4.11 show the responses" results in terms of mean ratings of importance and average percentages of implementation of each item used to describe KM drivers, system specifications and KM challenges. It should be noted from Figures 4.10, that all importance means are in the range from 4.07 to 5.52 which refers to the „Important", „Very important" and extremely important" evaluation levels. This indicates that all the factors in the questionnaire are crucial for a successful adoption of KM in the construction projects. Therefore, for successful implementation and

application of KM, these factors should be investigated, managed and dealt with effectively in the building organizations.

As can be seen in Figures 4.11, the most important driver that encourages the building organizations and people to adopt and apply KM is to enhance the quality of work processes and products in the building projects. Other factors that received high importance levels include enhancing relations with customers, partners and suppliers; and reducing time, money and efforts required to find problem solutions, best practices and decisions.

Figure 4.11: Importance Evaluation of KM Drivers

The results of subsection F7, shown in Figure 4.12, demonstrate the most important specifications required for a successful adoption of KM System. These include KM System characteristics such as providing services and knowledge to partners, suppliers and customers; appointing KM teams and/or workers; providing user friendly services and interfaces, and ensuring the collection and availability of useful and valid knowledge.

Figure 4.12: Importance Evaluation of KM System Specifications

Figure 4.13 shows that the most important challenge to the success of KM in the building organization is the lack of knowledge teams or KM roles to deal with KM processes, activities and strategies. However, this challenge does not widely describe what actually exists in the responding companies.

Figure 4.13: Importance Evaluation of KM Challenges

4.2.7 Sections 2 and 3: Comparison of Results

Figure 4.13 shows a comparison among KM implementation activities (sub-sections A1 to A5), KM application activities (sub-sections A6 to A9), KM technological tools (sub-section A10) and KM environmental activities (sub-sections F1 to F5) in terms of the perceived importance and the evaluation of their implementation.

The results show that the KM application activities (subsections A6 to A9) have the highest importance rates among other activities and tools. However, the results show that the KM application activities have a lower implementation percentage than for the KM implementation activities. This indicates that there is still a need to encourage adopting KM activities that enhance the use and application of KM System in the building organizations. An effective method to achieve that is by embedding KM activities into the routine work procedures of the people in the organization. The results also show high levels of importance and implementation of the environmental activities in the respondent construction companies. This emphasizes the need to apply procedures and methods that deal with environmental factors to encourage the useful factors and reduce the negative influence of KM barriers.
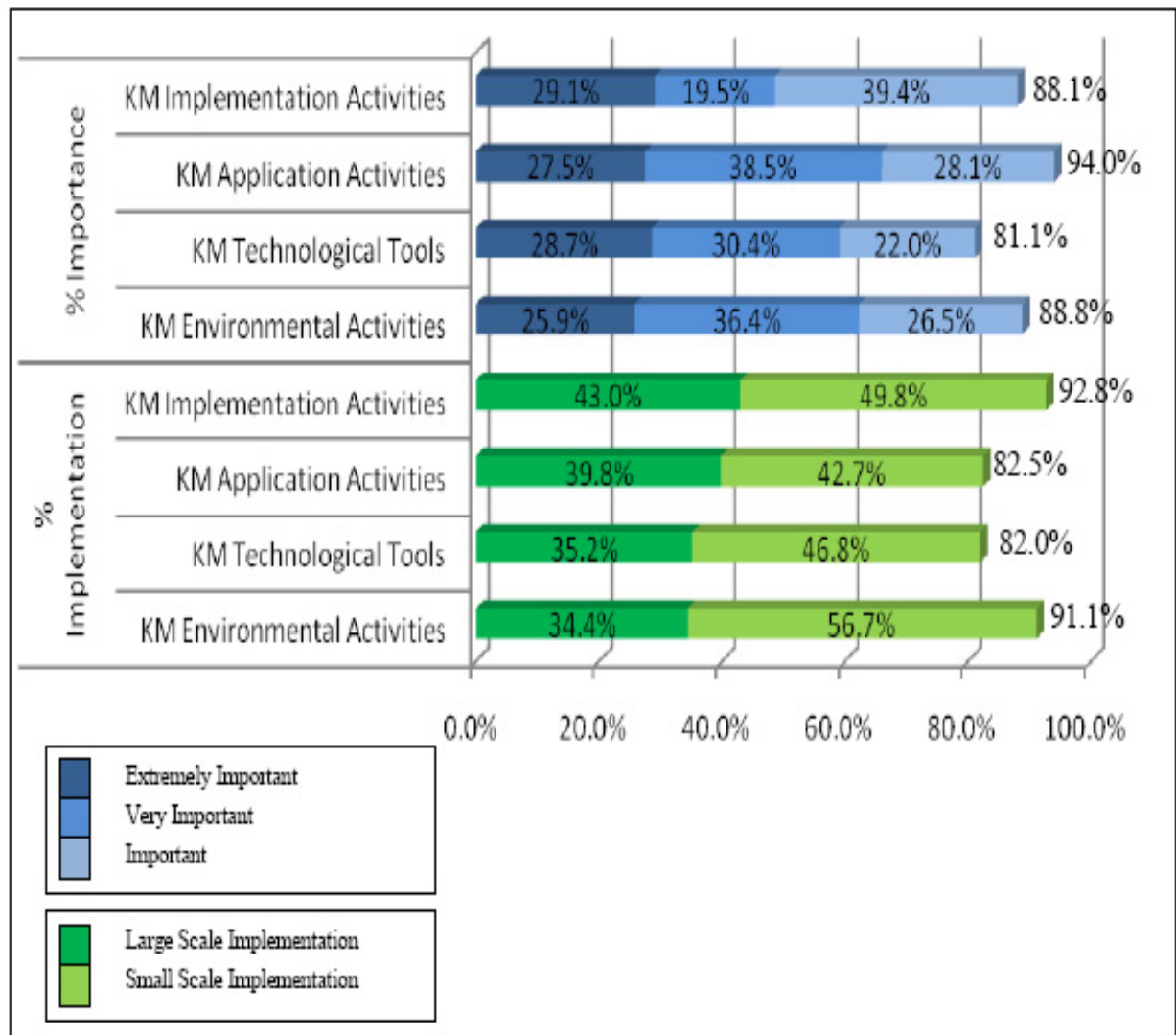
Figure 4.14: Comparison of Importance and Implementation Evaluation for
KM Activities and Tools Proposed in the Research.

4.2.8 Section 4: KM Barriers for Non-KM Adopters

This section investigates the reasons of not adopting KM in the building organizations. The section requires respondents from organizations that do not adopt KM to choose one or more of the main reasons for not adopting KM in their organizations. The number of respondents to this section is 7 respondents provided 19 responses. The results represented in Figure 4.15 show that the main reason for not adopting KM is the lack of financial and human resources to implement and apply KM. Other major KM barriers are the lack of awareness about KM benefits and the lack of methods to evaluate the actual benefits of KM System in the building organizations. More barriers to KM implementation are described by respondents. A major barrier described by the respondents is that the organizations planning to adopt KM need to apply major changes in terms of work procedures and organizational culture which require considerable time, effort and managerial courage to be implemented and applied.
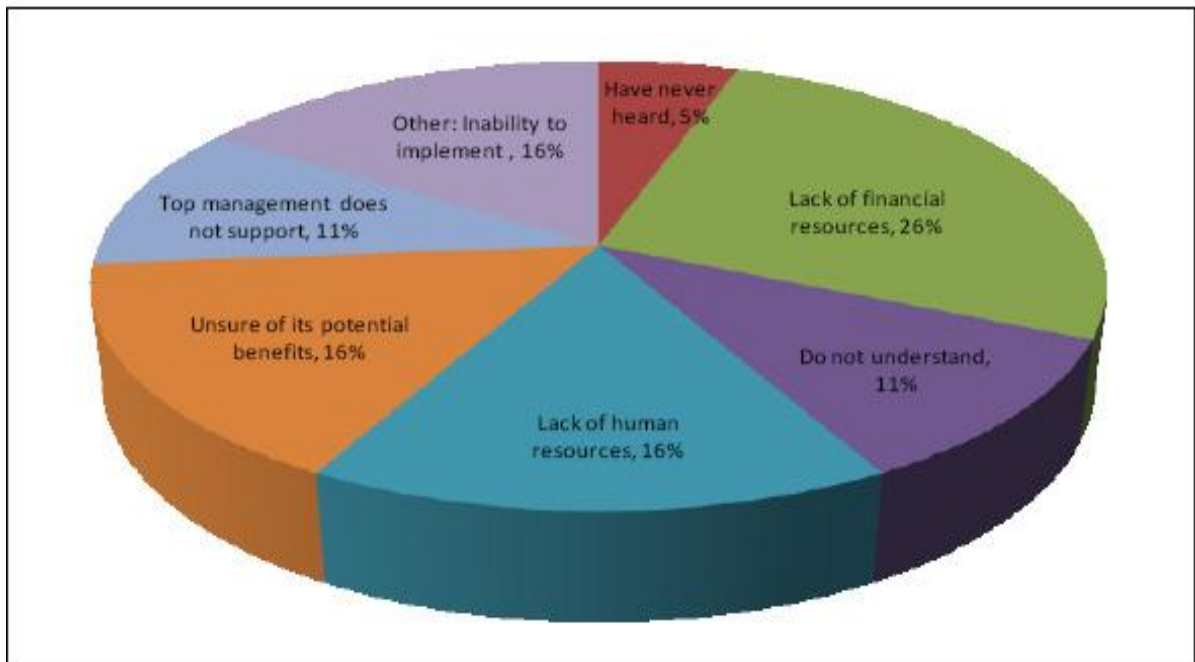

Figure 4.15: Response Rates of KM Barriers for Non-KM Adopters

4.3 Summary of Findings

The suggestions, recommendations, opinions and experiences provided by the respondents to the research interviews and questionnaires had a great effect on the development and enhancement of the KM model of this study in order to achieve a final version of a KM model for KM implementation and application in the building projects. The results of the interviews and the questionnaire survey have been supported by a continuous review of recent KM literature and projects" reports to develop a practical KM model that is useful in the context of building projects. The final results of the interviews and questionnaires have important effects on the research developed KM model and encourages for more development and refinement of the model to achieve the desired consequences. The final results concluded from the conducted interviews and questionnaires which have positive impact on the development of the KM model can be summarized as follows:

• The results of the interviews and questionnaires have shown a high importance of the contents proposed in the KM model and their usefulness for a successful adoption of KM in the construction organizations. However, the results highlighted the importance of developing the KM model in a way that is easy to understand and follow.

• The results of the interviews have shown that it is very useful to provide enough details and descriptions to the proposed KM model that may help to simplify its understanding and adoption.

• It has been found from the results of the interviews and questionnaires that it is highly important to include details in the KM model about the environmental factors that may affect KM efforts in the building organizations. It is also important to provide and suggest procedures and

methods that can be useful in reducing the negative influence of the environmental factors and encouraging successful KM efforts. The results of the questionnaires and interviews showed the importance of environmental factors that relate to information technology, people culture and leadership support, and that it is important to deal with these factors for successful applications of KM System.

- The results of the interviews and questionnaires have shown the importance of applying more efforts during the early KM implementation and development stages, such as in the analysis and design stages, in order to achieve a system design that better aligns with business objectives and procedures and to reduce time and effort wastage caused by design errors and reworks.

- It can be concluded from the interviews" results that it is important to find a balance in the process of reviewing and approving captured knowledge before making it available for end-users in order to encourage the processes of knowledge capturing and sharing without overloading the KM System with unimportant, unrelated or outdated contents. Furthermore, the results of the questionnaires showed a high importance of adopting procedures for knowledge reviewing and approving to ensure that the knowledge stored in KM System repositories is useful, searchable and applicable.

- Since many of existing KM models do not provide sufficient details to successfully deal with and manage tacit knowledge, and because the building projects are in knowledge intensive environments where most of the important knowledge is tacit knowledge, recommendations were provided by interviewees to include more details in the proposed KM model

to better deal with the special characteristics of tacit knowledge in the construction projects.

- The results of the questionnaire responses showed the importance of applying evaluation and monitoring mechanisms by using techniques such as capturing end-users" feedback about the system use, or developing evaluation measures to ensure a continuous process of system maintenance and improvement. However, the results showed a low level of implementation for evaluation methods in the building projects. This indicated the need to develop more evaluation methods to help organizations to better estimate the success of their KM efforts and the effect on business performance.

- The results of the questionnaire survey showed that it is not enough to implement a KM System with its technological tools to ensure a successful adoption of KM in an organization, but it is more important to follow procedures and methods to encourage successful use of the system to capture and share experiences and know-how.

- The results of the questionnaire showed a need to enhance the awareness of the people and organizations in the building projects about the importance of using data and information of the organizational database to create new knowledge and to show efficiency and practicality of captured knowledge.

- The results of the questionnaires showed the importance of the KM technological tools provided in the research, especially those that can help to capture knowledge and retrieve it from the systems" repositories.

- The results of the questionnaires showed a need to enhance awareness of people and organizations in the building projects about the importance of applying knowledge maps and yellow pages to help in categorizing captured

knowledge, finding required knowledge and people, and providing idea of available and missing knowledge in the system repositories.

• According to the questionnaires results, the most important drivers that may encourage building organizations to adopt KM are to enhance work processes and products in the building projects, maintain relationships with customers, partners and suppliers, and saving time, cost and effort of rework and solving repeated problems.

• The results also showed that the most important specifications for KM System required by end-users includes characteristics such as allowing the organizations to maintain good relationships with customers, suppliers and partners, availability of knowledge teams and/or knowledge workers to handle some KM tasks and to provide training and support for other users, providing easy to use interfaces and services, and finally allowing end-users to easily collect and share important knowledge.

• Finally, the questionnaire results showed that the most important challenges that negatively affect KM application include factors such as lack of a knowledge manager or a team to implement KM strategies, lack of structured procedures for KM implementation and application, lack of sufficient training and support, lack of management support, and lack of financial, human and IT resources. However, the results showed that the most important challenge that describes the actual condition in the construction companies is the lack of a structured method for KM implementation and application, which will be dealt with in this research by developing a KM model that provides a structured method for KM adoption in the building projects.

This chapter has discussed the application and results of methodologies used in this research to develop and enhance a KM model for KM implementation and application in building projects. The next chapter will present the final enhanced version of the developed KM model proposed in this research to help to achieve successful adoption of KM System in the building organizations.

CHAPTER FIFE
CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The research has achieved its main goal of developing an integrated comprehensive KM model by following a process of research methodologies. The research has proved that the proposed KM model can successfully help building organizations to enhance KM adoption. The achievements of this research can be summarized as follows:

o The objective of providing required background to simplify understanding and developing the KM model of the research and to identify the various areas of KM that may require more research and investigation has been achieved. This has been accomplished through conducting an extensive review of KM literature that highlights KM concepts and discusses technological, cultural and managerial aspects of KM implementation and application in the context of building projects. The research has started with an investigation of important KM principles, methods, tools and techniques. Then the research has investigated the unique features of building projects and discussed the associated motivations and challenges affecting KM adoption in the knowledge-intensive environment of building projects.

o The objective of investigating shortcomings of existing KM models has been accomplished through an extensive review of sufficient number of KM models in the literature. This has helped the researcher to investigate problems of existing KM models and identify opportunities for improvements. The results have shown that, although many KM models have been developed to enhance the adoption of KM in organizations, those models still have many shortcomings that prevent them from being used

successfully in building projects. For example, many of these KM models may lack necessary components and processes of KM or may not consider the special characteristics and situations of the project-oriented building organizations. Most KM models fail to provide a structured method for KM adoption, while others lack successful methods and procedures for dealing with the different types of knowledge and fail to fulfill the requirements of end-users and organizations in the building projects.

o A preliminary KM model has been developed on the basis of reviewing and analyzing KM literature to identify the main components required in the proposed KM model. The review and analysis of previous KM models has helped to address the key characteristics required in the KM model in order to overcome shortcomings of other models and to provide a useful method for KM in building projects.

o A final enhanced KM model has been developed to fulfills the research objectives of providing a structured and practical method for KM implementation and application in building projects. It includes all important components with sufficient details required for a successful adoption of KM in the building organizations. It can solve problems of previous KM models, such as the lack of important KM activities, technological tools or influential factors; the non-alignment with characteristics and requirements of the building projects; the lack of an appropriate method for knowledge identification and categorization; the absence of the required roles of KM teams, workers, end-users and Communities of Practices (CoPs); and lack of providing methods for KM System evaluation and feedback collection. The proposed KM model provides a classification of knowledge resources that shows more types of knowledge resources and provides clearer process for

managing them. The KM model provides a clearer map and useful guideline for appropriate KM processes and tools in building projects.

o In order to fulfill the aim of the research to evaluate and validate the developed KM model in terms of its usability and usefulness, an extensive investigation of KM System through two case studies has been conducted in the building projects . Evaluation results obtained from an adequate number of KM practitioners and experts in the case studies have shown that the KM model is favorably recommended for its applicability and usefulness in building projects.

o From the 100 companies contacted, a total of 34 questionnaires were received, representing 11.3% response rate. However, only 27 of them confirmed that their companies have implemented and practiced KM, representing a usable 9% response rate which is adequate to satisfy the survey objectives and acceptable when compared to surveys carried out in the KM field.

5.2   Recommendations for Future Research

The proposed KM model of the research is designed to provide a useful structured method that solves problems of other models, and facilitates and encourages KM initiatives to help to successfully adopt KM in the building projects. However, as with any other research, recommendations and suggestion for further investigation, improvement and refinement of the proposed KM model are provided in order to improve the implementation and application of KM in the building organizations.

This study provides a platform for further development and modification of the KM model so that the proposed KM model can be used in practice more efficiently and effectively. More efforts can also be conducted to enhance

the awareness of SMEs in the construction industry about the importance of KM to encourage more implementation and application of KM System in this sector.

5.3 Recommendation to Company

○ Implementation knowledge management it most important in construction company because it is reduce the cost overrun and losses time, Daly duo to unknown reasons, also reduce the cost for maintenance equipment.

○ Recommend to implement knowledge management model in Construction Company in Sudan to save time, cost, equipment, material, and make Construction Company more provisional.

○ in future research there must be development in the model used to implementation knowledge management in building projects in Sudan.

REFERENCES

1. Abdullah, M.S., Benest, I., Evans, A. and Kimble, C. (2002)"Knowledge Modeling Techniques For Developing Knowledge Management Systems", Proceedings of the 3rd European Conference on Knowledge Management, Dublin, Ireland, September, pp.15-25.

2. Ahmad, H. S., An, M. and Gaterell, M. (2007) "Development of KM model to simplify knowledge management implementation in construction projects", Proceedings of the 23rd Annual ARCOM Conference, Association of Researchers in Construction Management, Belfast, UK, 3-5 September, pp.515-525.

3. Ahmad, H. S., An, M. and Gaterell, M. (2008) " KM model to embed knowledge management activities into work activities in construction organisations", Proceedings of the 24th Annual ARCOM Conference, Association of Researchers in Construction Management, Cardiff, UK, 1-3 September, pp.309-318.

4. Ahmad, H.S. and An, M. (2008)"Knowledge management implementation in construction projects: a KM model for Knowledge Creation, Collection and Updating (KCCU)", International Journal of Project Organisation and Management, Vol. 1, No. 2, pp.133–166.

5. Ahmad, H.S., An, M. and Gaterell, M. (2009) " Web-based knowledge management method to enhance knowledge capturing, sharing and creation in construction projects", Proceedings of the 4th eServices Symposium in the Eastern Province: eServices Integration, Khubar, Saudi Arabia, 9–11 March, pp.51–62.

6. Albaum, G. (1997) "The Likert scale revisited: an alternate version", Journal of the Market Research Society, Vol. 39, No. 2, pp.331-348.

7. Alavi, M. and Leidner, D.E. (2001) "Knowledge management and knowledge management systems: Conceptual foundations and research issues", MIS Quarterly, Vol. 25, No. 1, pp.107-136.

8. Alderman N., Ivory C. J., Vaughan R., Thwaites A., and McLoughlin I. P. (2001) "Knowledge management for projects integration: case studies of capital investment programmes", Managing Knowledge: Conversations and Critiques Conference, University of Leicester, http://www.ncl.ac.uk/labs/Leicester.doc.

9. Alonderiene, R., Pundziene, A. and Krisciunas, K. (2006) "Tacit Knowledge Acquisition and Transfer in the Process of Informal Learning", Problems and Perspectives in Management, Vol. 4, No. 3, pp.134-145.

10. Amo, B.W. (2006) "What motivates knowledge workers to involve themselves in employee innovation behaviour?", International Journal of Knowledge Management Studies, Vol. 1, No. 1/2, pp.160-177.

11. An, M. and Ahmad, H.S. (2010) "Knowledge management in construction projects: a way forward in dealing with tacit knowledge", International Journal of Information Technology Project Management (IJITPM), Vol. 1, No. 2, pp.16-42.

12. Antony, J., Leung, K., Knowles, G. and Gosh, S. (2002) "Critical success factors of TQM implementation in Hong Kong industries", International Journal of Quality & Reliability Management, Vo1. 19, No. 5, pp.551-566.

13. Awad E.M. and Ghaziri H.M. (2004) " Knowledge Management, Printice Hall.

14. Axelsson, M. and Landelius, H. (2002) "An Information System as an Enabler of Knowledge Transfer - A case study of the Skanska

Knowledge Network at Skanska AB, A Master"s thesis, Department of Civil Engineering and Architectural Management, Chalmers University of Technology, Gothenburg, Sweden.

15. Badri, M., Davis, D. and Davis, D. (1995) " A study of measuring the critical factors of quality management", International Journal of Quality & Reliability Management, Vol. 12, No. 2, pp.36-53.

16. Baker, M., Barker, M., Thorne, J. and Dutnell, M. (1997) " Leveraging human capital", Journal of Knowledge Management, Vol. 1, No. 1, pp.63-74.

17. Berners-Lee, T., Hendler, J. and Lassila, O. (2001) " The Semantic Web", Scientific American Magazine, May 2001, www.sciam.com/article.cfm?id=the-semantic-web&print=true, Accessed on 25-03-2009.

18. Bryman, A. and Bell, E. (2003) Business research methods, Oxford University Press Inc., New York.

19. Buckley, M. and Carter, M. (2001) "Knowledge management in global markets", Strategic Direction, Vol. 17, No. 1, pp.7-10.

20. Burgess, K. and Singh, P. (2006) "A proposed integrated framework for analysing supply chains", Supply Chain Management: An International Journal, Vol. 11, No. 4, pp.337–344.

21. Cannon, J.T. (1968) "Business Strategy Policy, Harcourt, Brace and World, New York.

22. Carlucci, D., Marr, B. and Schiuma, G. (2004) "The knowledge value chain: how intellectual capital impacts on business performance", International Journal of Technology Management, Vol. 27, Nos. 6/7, pp.575-590.

23. Contextual Issues", Construction Informatics Digital Library, http://itc.scix.net/paper w78-2000-155.content.

24. Carrillo, P.M., Robinson, H., Al-Ghassani, A. and Anumba, C. (2004) " Knowledge Management in UK Construction: Strategies, Resources and Barriers", Project Management Journal, Vol. 35, No. 1, pp.46-56.

25. Carrillo, P.M. and Chinowsky, P. (2006) "Exploiting Knowledge Management: The Engineering and Construction Perspective", Journal of Management in Engineering, Vol. 22, No. 1, pp.2-10.

26. Chauvel, D. and Despres, C. (2002) "A review of survey research in knowledge management: 1997-2001", Journal of Knowledge Management, Vol. 6, No. 3, pp.207-223.

27. Davenport, T.H., De Long, D.W. and Beers, M.C. (1998) "Successful knowledge management projects", Sloan Management Review, Vol. 39, No. 2, pp.43-57.

28. Davenport, T. H. and Prusak, L. (1998) "Working Knowledge: How Organizations Manage What They Know, Boston: Harvard Business School Press.

29. Davis, R. and Buchanan, B. (1997) "Meta-level knowledge: overview and applications", Proceedings of the 5th international joint conference on Artificial intelligence, Cambridge, USA, Vol. 2, pp. 920-927.

30. Debowski, S. (2006) " Knowledge Management, Australia, John Wiley & Sons.

31. De Pablos, P.O. (2002) "Knowledge management and organizational learning: typologies of knowledge strategies in the Spanish manufacturing industry from 1995 to 1999", Journal of Knowledge Management, Vol. 6 No. 1, pp.52-62.

32. EC, European Commission (2004) "Internationalization of SMEs", Observatory of European SMEs 2003, No. 4, EIM, Luxembourg.

33. EC, European Commission (2005a) "ICT and Electronic Business in the Construction Industry: ICT adoption and e-business activity in 2005", Report of the European e-Business Market Watch, e-Business Sector Study on the Construction Industry, www.ebusiness-watch.org ("resources"), Sector Report No. 08-II, September 2005.

34. EC, European Commission (2005b) " the new SME definition: user guide and model declaration, European Commission, Brussels.

35. Egan, J. (1998) "Rethinking construction", Report of the Construction Task Force on the Scope for Improving the Quality and Efficiency of the UK Construction Industry, Department of the Environment, Transport and the Regions, London.

36. Egbu, C. and Botterill, K. (2002) "Information Technologies for Knowledge Management: Their Usage and Effectiveness", ITcon, Vol. 7, pp.125-137.

37. Egbu, C. (2004) "Managing knowledge and intellectual capital for improved organizational innovations in the construction industry: an examination of critical success factors", Engineering, Construction and Architectural Management, Vol. 11, No. 5, pp.301-315.

38. Egbu, C., Hayles, C., Anumba, C., Ruikar, K. and Quintas, P. (2004) "Knowledge Management for Sustainable Construction Competitiveness", Final Report, Partners in Innovation Project, supported by the Department of Trade and Industry, UK.

39. EI-Diraby, T.E. and Kashif, K.F. (2005) "Distributed Ontology Architecture for Knowledge Management in Highway Construction",

Journal of Construction Engineering and Management, Vol. 131, No. 5, pp.591–603.

40. Ferneley, E., Wetherill, M. and Rezgui, Y. (2002) "Toward the construction knowledge economy: The e-COGNOS project", Proceedings of ECIS 2002, Gdansk, Poland, 6-8 June.

41. Fong, S. W. and Wong, K. (2005) "Capturing and Reusing Building Maintenance Knowledge: A Socio-Technical Perspective", In: Kazi, A.S. (ed.), Knowledge Management in the Construction Industry: A Socio-Technical Perspective, London: Idea Group Publishing.

42. Fuchs, M. (2002)"Changing employment relations, new organizational models and the capability to use idiosyncratic knowledge", Journal of European Industrial Training, Vol. 26, Nos. 2-4, pp.154-165.

43. Gore, C. and Gore, E. (1999) " Knowledge management: the way forward", Total Quality Management, Vol. 10, No. 4&5, pp.554-560.

44. Lima, C., El-Diraby, T. and Stephens, J. (2005) "Ontology-based optimization of knowledge management in e-construction", ITcon, Vol. 10, pp.305-327.

45. Lin, Y., Wang, L. and Tserng, P. (2006) "Enhancing knowledge exchange through web map-based knowledge management system in construction: Lessons learned in Taiwan", Automation in Construction, Vol. 15, No. 6, pp.693-705.

46. Logan, R.K. and Stokes, L.W. (2004) " Collaborate to Compete: Driving Profitability in the Knowledge Economy, Wiley.

47. Love, P., Edum-Fotwe, F. and Irani, Z. (2003) "Management of knowledge in project enviorments", International Journal of Project Management, Vol. 21, pp.155-156.

48. Merriam Webster"s Collegiate Dictionary (2009) " hhtp://www.m-w.com/egi-bin/dictionary, Accessed January 11, 2009.

49. Moffett, S., McAdam, R. and Parkinson, S. (2003) "An empirical analysis of knowledge management applications", Journal of Knowledge Management, Vol. 7 No. 3, pp.6-26.

50. NDR, No Doubt Research (2003) "Data, Information, and Knowledge", March 2003, Auckland, New Zealand, www.nodoubt.co.nz/articles/data.pdf.

51. Neely, A., Adams, C. and Kennerley, M. (2002) " The performance prism: the scorecard for measuring and managing business success", Financial Times, Prentice Hall, London.

52. Nickols, F. (2003) "The Knowledge in Knowledge Management" [Internetsiteon22-01-2006]:

   http://home.att.net/~OPSINC/knowledge_in_KM.pdf

53. Nonaka, I. (2007) "The Knowledge- Creating Company", Harvard Business Review, Vol. 85, No. 7&8, pp.162-171.

54. NSF, National Science Foundation, Division of Science Resources Statistics (2006) "Research and Development in Industry: 2003, project officer: Raymond M. Wolfe, Arlington, VA.

55. OECD-APEC (2006) "Removing Barriers to SME Access to International Markets", Global Conference Keynote Paper, Joint report for OECD (Organisation for Economic Co-operation and Development, APEC (Asia Pacific Economic Cooperation and Hellenic Republic (Ministry of Development), 6-8 November 2006, Athens, Greece.

56. Oxford English Dictionary (2009) " http://dictionary.oed.com, Accessed January 14, 2009.

57. Robinson, H., Carrillo, P., Anumba, C. and Al-Ghassani, A. (2005) "Knowledge management practices in large construction organizations", Engineering, Construction and Architectural Management, Vol. 12, No. 5, pp.431-445.

58. SBS (2001) " Small and Medium Enterprise (SME) Statistics for the United Kingdom, 2000, Research and Evaluation Unit, Small Business Service, UK.

59. Skanska (2007) "Skanska Annual Report 2006, Skanska AB, Stockholm.

60.. Tserng, H. and Lin, Y. (2004) "Developing an activity-based knowledge management system for contractors", Automation in Construction, Vol. 13, No. 6, pp.781-802.

61. Trochim, W.M. (2006) "Likert Scaling", Research Methods Knowledge Base, Vol.2, http://www.socialresearchmethods.net/kb/scallik.php, Retrieved June 15, 2009.

62. Woo, J., Clayton, M.J., Johnson, R.E., Flores, B.E. and Ellis, C. (2004) "Dynamic Knowledge Map: reusing experts" tacit knowledge in the AEC industry", Automation in Construction, Vol. 13, No. 2, pp.203– 207.

63. Woods, E. (2005) "Collaboration Software: Evolution and Revolution", In: Knowledge Management Tools and Techniques-Practitioners and Experts Evaluate KM Solutions, Ed. Madanmohan Rao, Elsevier Inc., Oxford, UK.

64. Yin, R.K. (2003) "Case Study Research: Design and Methods, Sage Publications, London.

.

65. Zboralski, K. and Gemünden, H. (2006) "The Impact of Communities of Practice", pp. 218-223, In: Encyclopedia of Communities of Practice in Information and Knowledge Management, by: Coakes, E. and Clarke, S. (2006), London, Idea Group Inc.

BIBLIOGRAPHY

1. Bhatt G. D. (2000) "Information dynamics, learning and knowledge creation in organizations", The Learning Organization, Vol. 7, No. 2, pp.89-98.

2. Busby, J.S. (1999) "An Assessment of Post-Project Reviews", Project Management Journal, Vol. 30, No. 3, pp.23-29.

3. Carrillo, P.M. and Anumba, C.J. (2002) "Knowledge management in the AEC sector: an exploration of the mergers and acquisition context", Knowledge and Process Management, Vol. 9, No. 3, pp. 149-161.

4. Carrillo, P.M. (2005) "Lessons learned practices in the engineering, procurement and construction sector", Engineering, Construction and Architectural Management, Vol. 12, No. 3, pp.236-250.

5. Coakes, E., Bradburn, A. and Blake, C. (2005) "Knowledge Management in a Project Climate", Chapter 8 in: Jennex, M.E. (2005) Case Studies In Knowledge Management, Idea Group Inc.

6. Cranfield Business School (1998) "Europe"s State of the Art in Knowledge Management", Information Strategy, The Economist Group, London, p.17.

7. DiBella A. and Nevis E. (1996) " How Organizations Learn: An Integrated Strategy for Building Learning Capability, John Wiley & Sons.

8. Donk, D.P. and Riezebos, J. (2005) "Exploring the knowledge inventory in project-based organisations: a case study", International Journal of Project Management, Vol. 23, pp.75–83.

9. Egbu, C., Kurul, E., Quintas, P., Hutchinson, V., Anumba, C. and Ruikar, K. (2003) „Techniques and technologies for knowledge

management", Report in the Knowledge Management Web Site, www.knowledgemanagement.uk.net/ resources/WP3%20Interim%20Report.pdf.

10. Gimenez, A.O. and Rincon, M. (2003) "Knowledge management in the developing countries: an empirical approach in search of limitations and opportunities", Proceedings of the Fourth European Conference on Knowledge Management, Oxford University, pp.703-711.

11. Guizzardi, R.S. (2006) " Agent-oriented Constructivist Knowledge Management, PhD thesis, University of Twente, The Netherlands.

12. Hibbard, J. (1997) "Knowing what we know", Information week, Vol. 653, pp.46-54.

13. Hill, O. (2008) "Increasing the value of SharePoint as a knowledge management tool to an Engineering consultancy", Dissertation submitted to the University of Birmingham, for the Master Degree in Construction Management.

14. Kazi A. (2002) "Knowledge Management for the Construction Industry: The E-COGNOS Project", ITcon, Vol. 7, pp. 182-196.

15. Kazi A. and Hannus M. (2002) "Editorial: ICT Support for Knowledge Management in Construction", ITcon, Vol. 7, pp.56-61.

16. Knauseder, I. (2004) "The Client"s Project Manager - a Key-Role for Knowledge Management in Construction Projects", Proceedings of I-KNOW "04, Austria, pp.106-114.

17. Koch, C. (2002) "The Emergence of Second Generation Knowledge Management in Engineering Consulting", Conference Proceedings – distributing knowledge in building, International Council for Research and Innovation in Building and Construction 12 – 14 June.

18. Marwick, A.D. (2001) " Knowledge management technology", IBM Systems Journal, Vol. 40, No. 4, pp.814-830.

19. Narasimha, S. (2000) "Organizational knowledge, human resource management, and sustained competitive advantage: toward a framework", Competitiveness Review, Vol. 10, No. 1, pp.123.

20. Nonaka I., Konno N., and Toyama R. (2001) "Knowledge emergence: social, technical, and evolutionary dimension of knowledge creation", Oxford University Press.

21. Nonaka I., Krogh G. V., and Ichijo K. (2000) "Enabling Knowledge Creation: New Tools for Unlocking the Mysteries of Tacit Understanding", Oxford University Press.

22. Ribiere, V. (2001) " Assessing knowledge management initiatives" success as a function of organizational culture, PhD dissertation, George Washington University, Washington, DC, available at: www.km.gwu.edu .

23. Rungasamy, S., Antony, J. and Ghosh, S. (2002) " Critical success factors for SPC implementation in UK small and medium enterprises: some key findings from a survey", The TQM Magazine, Vo1. 14, No. 4, pp.217-224.

24. Shavelson, R. and Townes, L. (2002) "Scientific research in education", National Academy Press, Washington, DC.

25. Sijing L. (2002) "Analysis and Design of Knowledge Management System: A Case Study — Analysis and Design of Knowledge Management System in SDIC/CAAS, (SDIC) Scientech Documentation and Information Centre, (CAAS) Chinese Academy of Agricultural Sciences", Proceeding of Third Asian Conference for Information Technology in Agriculture, Beijing China, pp.172-178.

26. Weiser, M. and Morrison, J. (1998) "Project memory: information management for project teams", Journal of Management Information Systems, Vol. 14 No. 4, pp.149-66.

27. Wenger, E.C. (2004) "Knowledge management as a doughnut: Shaping your knowledge strategy through communities of practice", Ivey Business Journal, Vol. 68, No. 3.

APPENDICES