

MODELING THE KNOWLEDGE MANAGEMENT PROCESSES FOR  
PLANNING AND SCHEDULING OF CONSTRUCTION PROJECTS BASED ON  
STATE-OF-THE-ART TECHNOLOGY

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## ABSTRACT

Construction management is an information intensive industry. In construction projects, knowledge is usually buried in unread reports and arcane filing systems, or lost because people move on, leads to wasted activity of reinventing the wheel and impaired project performance. The application of Knowledge Management (KM) has been identified to be lagging in the area of construction project. Previous developments for KM in the construction industry are focused on traditional project management philosophy of focusing on tasks. Based on high focused research on construction management by Lean practitioners and researchers it is evident that breakthrough improvements in construction can be achieved by focusing on flows. This study focuses on modelling the technology enabled KM process using a re-engineered Last Planner System (LPS) that focuses on flows and Integrated Production Scheduler (IPS) process. Taking an action research approach, a case study was documented to map out the information flow and the KM mechanism. The KM process was modelled based on systematic cyclical observation and analysis. A questionnaire survey was carried out to understand the current practice of information flow management and identify the KM mechanism as well. The result revealed that currently, the construction practitioners applied the traditional approach of project management practice and there are inefficiencies of the current practice. Questionnaire result also had identified KM mechanism that currently being practiced in Planning and Scheduling (P&S) activities. Hence, a proposed system was developed to enhance the current construction management process that performs the role of KM mechanism. At the end of this study, a working model for KM in P&S was developed. The initial feedback of system evaluation on functionality, applicability and effectiveness was gained and will be used in future research work.

## ABSTRAK

Pengurusan pembinaan merupakan industri yang mempunyai maklumat yang banyak dan teliti. Dalam sesuatu projek pembinaan, pengetahuan biasanya tersimpan rapi dalam timbunan sistem pemfailan tradisional atau hilang disebabkan organisasi sementara, menyebabkan pengulangan proses kerja yang mengakibatkan penurunan prestasi projek. Dalam bidang pengurusan projek, aplikasi Pengurusan Pengetahuan (PP) adalah sangat terhad. Kajian terdahulu berkaitan PP dalam industri pembinaan adalah berfokuskan pada konsep tradisional pengurusan projek yang menumpukan pada sesuatu aktiviti. Berdasarkan kajian terperinci oleh penyelidik 'Lean', telah terbukti peningkatan dalam pengurusan projek boleh dicapai dengan menumpukan pengurusan terhadap aliran maklumat atau pengetahuan. Untuk itu, kajian ini bertujuan memodelkan aplikasi teknologi bagi proses PP dengan menggunakan proses kejuruteraan semula yang mengambil kira konsep *Integrated Production Scheduler (IPS)* dan *Last Planner System (LPS)* yang menumpukan pada aliran. Menggunakan kaedah *Action Research*, satu kajian kes telah didokumenkan untuk memetakan aliran maklumat dan mengenalpasti mekanisma PP. Dengan ini, proses PP telah dimodelkan berasaskan kitaran pemerhatian dan analisis yang sistematik. Satu kaji selidik telah dijalankan untuk memahami praktis semasa bagi pengurusan aliran maklumat dan untuk mengenalpasti mekanisme PP. Keputusan kaji selidik mendapati, pihak pengurusan pembinaan masih menjalankan pendekatan tradisional dimana terdapat ketidakcekapan dalam praktis semasa. Dengan itu, kajian ini telah mencadangkan satu sistem untuk meningkatkan kecekapan praktis semasa dan turut dapat menjalankan mekanisma PP. Diakhir kajian ini, satu model kerja proses PP dalam aktiviti perancangan dan penjadualan telah dibangunkan. Maklumbalas awal penilaian sistem prototaip berkaitan kebolehfungsian dan keberkesanan dikumpul diakhir kajian ini dan akan digunakan untuk kajian seterusnya bagi menambah nilai kajian ini.

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## LIST OF ABBREVIATIONS

<i>3D</i>	-	3 Dimension
<i>4D</i>	-	4 Dimension
AEC	-	Architecture Engineering and Construction
AR	-	Action Research
BIM	-	Building Information Modeling
CPM	-	Critical Path Method
DFD	-	Data Flow Diagram
IDEF	-	Integrated Definition for Function
IE	-	Internet Explorer
<i>IPS</i>	-	Integrated Production Scheduler
IS	-	Information System
IT	-	Information Technology
<i>KM</i>	-	Knowledge Management
<i>LP</i>	-	Last Planner
<i>LPS</i>	-	Last Planner System
<i>P&amp;S</i>	-	Planning and Scheduling
P&SKM	-	Planning and Scheduling Knowledge Management System
PPC	-	Plan Percent Complete
<i>SDLC</i>	-	System Development Life Cycle
SA	-	System Administrator
<i>WBS</i>	-	Work Breakdown Structure

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# CHAPTER 1

## INTRODUCTION

### 1.1 Introduction

Management is increasingly aware that knowledge resources are essential to the development of their organizations. Various writers have indicated that knowledge is an organization's best sustainable source of competitive advantage (Issa and Haddad, 2007). Knowledge Management (KM) is central to this and is increasingly recognised as an integral part of an organisation's strategy to improve business performance (Carillo *et al.*, 2003). KM is becoming more important in construction industry than ever before since knowledge sharing and reusing can reduce project time and cost, improve quality, and provide a major source of competitive advantage for the construction participants. It is recognized that in the construction project, the project knowledge is lost dramatically between project phases, such as concept phase, design phase, construction phase and occupancy phase (Wenfa, 2008).

The knowledge gurus, Nonaka and Takeuchi (1995) define Knowledge Management (KM) as a capability of an organization to create new knowledge, disseminate it inside the organization and embody it in products, services and systems. The general purpose of KM is to make knowledge usable for more than one individual, e.g. for an organisation as a whole; that is, to share it. According to Scarborough *et al.* (1999) KM is “any process or practice of *creating, acquiring, capturing, sharing* and *using knowledge*, wherever it resides to enhance *learning* and *performance* in organizations”. Generally speaking, this has to include the identification of the current state, the determination of needs, and the improvement of affected processes in order to address these needs.



Nicolas (2004) claims that KM is generally viewed as a systematic process for *creating, acquiring, disseminating, leveraging* and *using knowledge* to retain competitive advantage and to achieve organizational objectives. Whilst, Tserng and Lin (2004) view KM as a process that involves *creating, securing, capturing, coordinating, combining, retrieving* and *distributing knowledge*.

To fit with this research objectives, definitions from several existing work has been combined to create a working definition of KM specifically for this research purpose of modeling knowledge management process in the construction industry. As such, the KM can be viewed as a task of managing a systematic process of *creating, securing, capturing, coordinating, combining, retrieving* and *distributing knowledge* to retain competitive advantage and achieve the construction contracting organization's objectives.

## **1.2 Research Background**

This section discusses the research background that provides the context to this study and the justification for the research focus. There are three (3) sub-sections that provide the justification for undertaking KM research in the construction industry namely:- (i) Knowledge Driven Economy, (ii) Nature of Construction Industry, and (iii) Information Technology (IT) Advantage.

### **1.2.1 Knowledge Driven Economy**

The construction organization is recognized as a knowledge-intensive organisation. It is noted by Egbu and Robinson (2005) that knowledge intensive organisations rely on professional knowledge or expertise relating to a specific technical functional domain. The rise in knowledge intensity is being driven by the combined forces of the information technology revolution and the increasing pace of technological change. The Malaysian Construction Industry is no different in this respect, although

it has been described as lagging in terms of leveraging on technological advances. According to Houghton and Sheehan (2000), the rise in *knowledge intensity* of economic activities, and the increasing *globalisation* of economic affairs are two defining forces of the current knowledge economy. They also noted that, the issue of knowledge production, transmission and transfer are important facets of the knowledge economy, and undoubtedly the knowledge economy involves rapid change, uncertainty and turbulence.

In Malaysia's Knowledge-based (K-based) Economy Master Plan (2000), many definitions of K-based economy are provided, all revolving around the notion of an economy based on the production, distribution and utilisation of knowledge, which constitutes the primary engine of growth and wealth creation in the economy. Hence, in this economy status; knowledge, creativity and innovation play an ever-increasing and important role in generating and sustaining growth. In this sense, Asoh *et al.* (2002) point out that there is a tendency to define the new economy in terms of the new tools and technologies that permit us to manage data and information faster and better than ever enabling us to discover if not create, knowledge. During the early stages of the K-based economy, traditionally we have always been concerned with mainly managing data and information in order to improve organizational efficiency and effectiveness. However, today the Internet and related global networking technologies have enabled us to make data, information and even knowledge available to anyone at anytime.

### **1.2.2 Nature of Construction Industry**

The issue of Knowledge Management (KM) is relevant to all industries. However, the construction industry and its peculiarities provide a more challenging opportunity to develop clear understanding of the fundamentals and possible unique problems related to KM. Hence, the nature of construction industry had become a catalyst for this research as well as from an economic perspective the activities of the construction industry have great significance for the achievement of national socio-economic development goals of providing infrastructure, sanctuary and employment

(Raza Ali Khan, 2008). This industry has a broad definition and means differently to different people. The term construction is generally used to describe the activity of the creation of physical infrastructure, superstructure and related facilities (Fadhlin Abdullah, 2004). Whilst Egbu and Robinson (2005) note that construction is an industry that is not made by a single party, but being made up of different organisations, consultants and professionals providing a range of services for clients, customers and the wider community.

It is noted by Zhu (2009), that the construction industry being a big and complex industry inevitably brings a bigger challenge to the aspect of knowledge management. Hence, traditionally, the precious knowledge and the experience management obtained was not valued or accumulated, causing the massive intelligence achievement not to be reused, but also not to become the competitive advantage of the organization. In view of this, Koskela *et al.* (2002), pointed out that the construction industry needs a rapid change of improving their business process by adapting new management theories in nurturing the KM practice inside the projects communities as well as promoting the use of technology in project management. Koskela (2000) identified the construction industry to have three (3) peculiarities; on-site production, temporary organization and this is a major reason for the complex issues faced by the industry. Amongst the complex issues facing the industry, is that of communication and coordination of work that requires greater attention for research. KM has the potential to contribute not only to enhancing communication and coordination of work, more importantly providing the opportunity for enhancing productivity.

Realizing the complex issues facing the construction industry, construction practitioners, notably comprising mainly from developed countries have created a research group for implementing the principles of Lean Construction. The main idea initially was to apply, translate and adapt lean manufacturing principles and practices to the end-to-end design and construction process. However, unlike manufacturing, construction is totally project based and is currently mainly concerned with non-standardized production process (Koskela *et al.*, 2002). Hence, the theories derived from manufacturing have been adapted to suit construction environment and further developed with the production perspective based on increased standardization and reduction in variation. These theories have provided new ways of performing the

business process and this research clearly provides the confirmation that the focus on the Transformation-Flow-Value (TFV) approach at the same time allows knowledge to be managed more systematically.

This study however focuses its research lens only on the planning and scheduling activities of a construction project. As the construction industry is large and involves various disciplines who form a *temporary organization*, this research assumes that the 'Planning and Scheduling' department has the potential to be the focal point for information and KM mainly due to it being a core coordination task. Hence, it is appropriate to view construction planning and scheduling as a managerial process that is closely related to the aim of improving the holistic effectiveness of delivering construction projects on time, within budget/cost and expected quality.

#### **1.2.2.1 Planning and Scheduling Activities via Information and Knowledge Management**

Planning and scheduling activity is known for its focal point that touches all other processes in construction projects (Prince, 2007). This activity is one of the most important functions in a supply chain to achieve high quality products at lower cost, lower inventory and high level of performance. Solving the problem is essential for the generation of flexible process sequence with resource selection and for the decision of the operation schedules that can minimize makespan (Chiung *et al.*, 2008).

According to Weber (2005), planning is the way in which the planner organizes and sequences the tasks needed to accomplish a goal while scheduling is one component of the plan and aids in visualizing the plan. Construction projects are subject to the uncertainties of weather, soil conditions, disputes, availability of labour, material and plant, and so on. These uncertainties, by their very nature frequently result in unanticipated extra cost and in the worst case scenario, can cause delays in project programmes (Ng *et al.*, 2004).

These uncertainties have become a major concern for planning and scheduling, where every task is not certain until the accomplishment of it. These uncertainties can happen whether before, while or after the task is carried out. Even though it is the nature of construction industry, numerous researches have attempted to tackle this issue by proposing new construction methods and have yet to find appropriate solutions to address this in a structured, practical and cost effective manner. Ibrahim *et al.* (2010), emphasizes that this industry needs to prepare for paradigm shifts to improve its competitiveness that can be achieved by using good practices, advanced construction techniques and optimise resource utilization. Egbu and Botterill (2002) argued that KM is about mobilising the intangible assets of an organization, which are of greater significance in the context of organizational change than its tangible assets, such as Information Technology (IT).

They emphasize that IT should be understood less in its capacity to store explicit information and more in its potential to aid collaboration and co-operation between people. In considering the above arguments, however this research argues that the intended change requires a systemic focus that can only be delivered by re-engineering the process of P&S from the traditional transformation view to the Transformation-Flow-Value (TFV) view. In this research, through extensive literature review it was concluded that the Last Planner (LP) approach using the Integrated Project Scheduler (IPS) provided the basis for structuring information flow to enable reliable and efficient P&S. Hence, this research views the role of the Planner working for the main contractor as a key knowledge worker collaborating with fellow knowledge workers rather than just information suppliers and processors.

Systematic capture and coordination of knowledge makes it easier to disseminate and use knowledge that can improve interaction and iteration between knowledge workers. Through augmentation by appropriate technology, knowledge is effectively amplified from being tacit and individual into a form that is more widely used throughout the organisation on an ongoing basis. Although this research does not focus on tacit knowledge it is acknowledged as a form of knowledge that can be made explicit as described by Nonaka (1995).

It is without doubt that with there is increasing awareness of the potential of KM for enabling organization's to increase their competitiveness and ability to

increase the value of their services. Egbu *et al.* (2005), had identified various potential benefits of KM as follows:

- 
- Improved ability to sustain competitive advantage;
- Immediate results in solving organisation-wide problems;
- Improved organisational productivity in delivering services to clients;
- Improvements in the quality of an organisation's work force, through capacity building and upskilling;
- Formalised knowledge transfer system can be established (best practices, lessons learned).
- Improved capture and use of knowledge from outside the firm;
- Improved integration of knowledge within the firm;
- Better on-the-job training of employees;
- Fostering Innovation and services.

### **1.2.3 Technology Advantage**

According to Carneiro (2000), 'Knowledge' and 'Information Technology' (IT) are critical success factors for strategic formulation. Along with economic globalization and science and technology's rapid development, the scale of modern engineering construction projects are growing bigger, the project's content is more and more complex and construction client's request are more and more demanding (Zhu, 2009). From a strategic point of view, hence KM that is technology-enabled can provide the capacity to deal with growing challenges faced by the construction industry.

It is widely accepted that technology is one of the key enablers of KM (Tanriverdi, 2005). Song and Teng (2006) emphasize that, this enabler supports various KM activities through providing efficient storage, retrieval, and transfer mechanisms and it is thus essential to the success of KM initiatives. However Mustafa (2007) points out that there are some construction practitioners who believe that information technology has made communication worse rather than better,

because of the incompatibility of systems used by individual disciplines which can create artificial barriers that did not exist before. However, research focuses on developing a model for KM based on integrated system in which the system requirements will be identified.

Malaysia's Construction Industry Master Plan (CIDB, 2007) also stresses that leveraging on information and communication technology in the construction industry as being one of the strategic thrust in order to achieve the vision and mission of the construction industry. From a national initiative perspective, there is strong support for leveraging on technology. The Malaysian Industrial Development Authority (MIDA, 2009) has identified the use of high technology as one of the characteristics that need to be fulfilled in order to be granted incentives for deduction in the computation of their income tax. Hence, with the use of advanced technology, the management function can be enhanced by additionally incorporating new management theories in current practice and using technology as its enabler.

### **1.3 Problem Statement**

The world is experiencing an era which has been termed the “knowledge age” or the “knowledge economy” (Sunassee, 2000). The importance of knowledge is seemed to be appreciated the extent to which it is being managed to generate value, however this is questionable, especially within the construction industry. The ability of current industry players to leverage on technology in the construction industry sector in order to enhance management functions is not encouraging. Below are the problem statements that are identified during the background study.

#### **1.3.1 Reinventing the Wheel in Planning and Scheduling Activities**

In current planning and scheduling practices, input from fellow construction players becomes knowledge to the planner to plan the logical sequence of task, predicting

project duration and to make a reliable plan in order to avoid extra cost and project delay. Inefficiency does happen, and is not really being managed in which the need to value knowledge at this level is the key, so that the industry does not continuously reinvent the wheel which leads to time and cost wastage (Govender and Pottas, 2007). Often the focus on KM for planning and scheduling is overlooked.

Based on preliminary case study of this research, it is observed that, the construction practitioner is comfortable with the act of taking corrective action and reinventing the wheel in doing his job, this contributes to time and cost wastage. The acceptance of this phenomenon is evidenced by, the practice of project timeframe buffer that is intentionally fixed in for confronting the unexpected condition. According to Mohamed and Anumba (2006), KM can help management to prevent repeating past errors; by capturing best practices, lessons learned, and especially, the solutions to problems that arise allow, similar situations in the future to be dealt with efficiently and effectively, which can also be applied to a planner or project manager in managing a construction project.

However, planners and project managers in construction contracting companies are often not allowed to prioritize and develop their own requirements and resources for KM as most other information intensive work organization often do. There is a tendency to use generic KM systems and applications that often are not synchronized with the existing flow of information on projects. Additionally, key construction processes such as planning and scheduling are very information intensive and current systems tend to work on complex functionalities and operations that are cross-linked and hamper the ability to achieve effective knowledge management as the scope is rather extensive.

### **1.3.2 Inadequate Theories of Planning and Scheduling**

Duncan (1996) has criticized traditional construction planning and control system in terms of insufficiency of its underlying theories and ineffectiveness of its techniques. This is due to insufficient data from one activity to other, and also negligence of physical flow between activities in the traditional conversion model (Koskela, 2000).



Whilst Sriprasert and Dawood (2002), have summarized the shortcomings in this area in terms of: (i) unrealistic role of planning and poor short term planning, (ii) lack of systematic way of managing execution; and (iii) narrow view of control as measuring and taking corrective action rather than as a process of learning. Formosa *et al.* (1998) identified the main problems during the diagnosis stage of a project as:

- Development of the planning process on a very informal basis;
- Lack of accomplishment of the schedule;
- Schedule preparation based on the experience of the site engineer and not on the firm's own data;
- Lack of a systematic short term plan;
- Lack of resource scheduling.

Recently, new theories and techniques have been introduced in order to enhance the process of planning and scheduling. It involves the enhancement of information flow, managing knowledge in collaborative environment and the Last Planner concept to support more reliable planning (Ballard, 1999).

### **1.3.3 Negligence on Technological Advantage**

Although Computer-Integrated Construction (CIC) paradigm has evolved as a tool of information technology (IT) integration in the construction industry, with the aim to effectively managing construction information (Sanvido, 1990). Construction industry is still seen by many as backward in deploying technology, not least information technology. Application of IT has been quite piecemeal and only very few contractors have a comprehensive and integrated information system for its core business (Mak, 2001). This has become a barrier to the industries to achieve a state where knowledge becomes a main competitive advantage asset.

According to Kazi (2005) experience shows that most tools need to be built and customized to the needs and culture of an organisation. A tool that is developed based on conceptual theory sometimes differ from the real practice which will lead to the failure of system implementation either being rejected due to human-factors or

the infrastructure support itself. Lots of attempt had been made by previous KM researchers, on using technology as an enabler to manage knowledge. These attempts mostly focus on the explicit type of knowledge and the tacit part of it is usually being neglected or overlooked as technology capabilities itself that has limited access to manage something inside the human minds. However, technologies present a number of potentials as a medium of communication, reducing time and distance constraint and, in addition, having the potential to add value to communications processes (Quintas, 2005). This ability can accelerate the KM process and its efficiencies can double up the management effectiveness by only taking advantage of the explicit knowledge.

#### **1.4 Research Scope**

This research is focused on G7 Class 'A' Malaysian construction firms who act as main contractors in construction projects. The area that was explored and tested is planning and scheduling of construction projects as it touches every task in a project and in every phase from project conceptual planning to completion. The targeted respondents were construction project planners and project managers who are crucial in the planning and scheduling of activities. The reason for choosing Class A construction firms is because it is anticipated that they would require a more systematic infrastructure for construction management that provides the opportunity for exploring the issues of knowledge management based on data provided by practitioners who are within a more information and knowledge intensive environment.

#### **1.5 Research Objectives**

In order to address the statement of problems and research question above, the objectives of the research are as follows:

- i) To do an analysis of current practice in the planning and scheduling of construction industry on the management of information flow.
- ii) To identify the mechanism for knowledge management that is currently being practiced within planning and scheduling activity of construction project organization.
- iii) To develop a working model for knowledge management, incorporating state-of-the-art technology specific to the requirements of planning and scheduling activities of construction management.
- iv) To develop knowledge management mechanism as a web-based-system for enabling collaborative construction project management with a focus on structuring the knowledge management process.

## 1.6 Research Methodology

An applied research approach was used in this study, as this study deals with ‘fuzzy’ issues, aimed at addressing the generation of a solution in a “messy” or uncontrolled environment (see Bickman and Rog, 1998) as is a predominant feature of construction project environments. A well-known process for guiding applied research work is action research (Page and Mayer, 2000). As such action research methodology was used in carrying out this study. **Figure 1.1** shows the simple action research model used in this study.

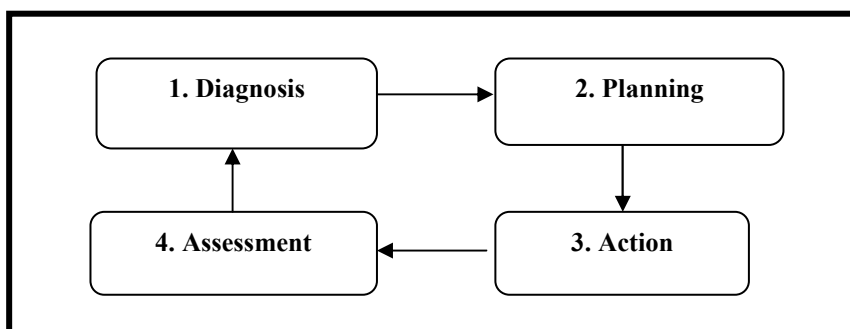


Figure 1.1: Action Research Model (Eden and Huxham, 1996)

In each phase or process in the model, other methodologies were incorporated, such as; case study methodology, qualitative research method, quantitative research

methodology and prototype system development in order to accomplish the objectives of this research.

### **1.6.1 Data Collection**

The data collection activity started with data collection from secondary sources such as journals, books, reports etc. The data was studied and reviewed to find out underlying theories previously proposed on the subject of KM, as well as being applied models for KM either being implemented or other relevant theories currently being proposed.

For the purpose of achieving objective one and two, an exploratory case study methodology was applied as initial steps in undertaking this study. According to Davey (1991), exploratory case study is normally undertaken before implementing a large-scale investigation as it helps identify questions, select measurement constructs, develop measures and also safeguard investment in larger studies. However, in this study, the exploratory approach was combined with an attempt to conduct an in-depth study as a non-participant observation technique which was undertaken by the researcher. Additionally, a key practitioner-researcher provided further credibility to the data obtained from the case study.

The study was scoped only within the area of planning and scheduling. In order to obtain more specific data regarding the user requirements for having a web-based KM system, a questionnaire survey was undertaken to collect data from the practitioner-researcher, who is the contractor's planner and project managers was undertaken. The quantitative approach was undertaken as it is possible to give precise and testable expression to qualitative ideas.

The researcher as the non-participant observer, gathered data regarding the requirements for having in place a KM System. A prototype system design was undertaken and the collection on system feedback was done at the end of the research phase. The evaluation notes were distributed to the planner who used the prototype system and the proposal to conduct a focused evaluation was made as the further research scope.

### 1.6.2 Data Analysis

Data gained from the case study is documented and presented, and important elements and points were considered in the development of the questionnaire based on the results of the literature review. The analysis of data is made using these approaches (Creswell, 2009 and Elliott, 2005):

- i. Narrative approach
  - a. The description method was used for analysing the case study.
  - b. A chronological process mapping will be done as a result of a case study.
- ii. A descriptive quantitative data analysis
  - a. To analyse the questionnaire survey and feedback from the KM system implementation.
  - b. For each question, a graph is generated and a simple description of every question is made (Babbie, 2010).

### 1.7 Significance of the Research

The description and representation of the current practice of information flow management for achieving the first research objective expose the disadvantages of poor management of information flow. The analysis acquired from this objective reveals how the information currently flows in and out of the planning and scheduling activities specifically and flows within construction projects generally. According to Santos *et al.* (1998), when construction is viewed as a flow many factors that before were considered unimportant come to the surface and become very important to the effectiveness of production. By identifying these flows, it can enhance the current shortcomings that are being neglected inside the flow.

The attempt to accomplishing objective two exposes the knowledge management activity that happens in managing the daily planning and scheduling activities. As the construction environment is built by temporary organization, currently most of specialist knowledge is not managed in any realistic sense. Hence,

the knowledge that is input by these temporary specialists can become permanent corporate asset as they are paid to provide the specific information and knowledge regarding the project as part of their work coordination efforts KM system. Without proper management, the waste of knowledge flow within construction project scan be visualized as being directly proportional with also temporary specialists which also leave after the project. As the mechanism of KM is successfully identified and applied, the approach of making knowledge a permanent asset for the construction contracting organization will be much easier.

The working model of KM process that is to developed as an outcome of this research is based on reviewing and matching current available technology and ensuring that it is closely tied in with a real practice of Malaysia's construction industry and not just 'importing' models from other industries. As the model is developed based on current technological status, the elements inside the model have been designed after every critical aspect had been considered, especially with regards to attempting to incorporate state-of-the-art technology. Based on this model, it is intended that technology aspect be regarded as an effective means for enhancing information and knowledge management. In addition by focusing on the work process in modelling the ICT-enabled KM, significant improvements in communication, reducing time and distance constraint can be achieved.

The web-based KM system is expected to improve decision making, improve strategic and reliable planning, provide a faster and more robust problem solving infrastructure and also to reduce cost of employee training. All these advantages are stated by Long *et al.* (2005) as benefits that can be attained by applying a KM system.

## **1.8 Thesis Writing Organization**

The writing organization explains the transition of research progress according to chapters. Below is the brief explanation of the content of each chapter in this thesis.

### **1.8.1 Chapter 1: Introduction**

In this chapter, the background of research title is elaborated and discussed. As the understanding of research background is cleared, the problem statement is identified from the gaps that exist in the Research background, research questions are formulated and relevant research objectives are presented. The suitable methodology was selected in order to achieve the objectives.

### **1.8.2 Chapter 2: Knowledge Management**

This chapter reviews the aspect of Knowledge Management (KM), to give a clear knowledge of relevant research regarding this research topic. It consists of introduction to knowledge, understanding KM, previous work on KM, and current concepts, tools in handling KM issues.

### **1.8.3 Chapter 3: Planning and Scheduling**

This chapter reviews the aspect of Planning and Scheduling (P&S) as it is crucial to understand the case to implement KM. It consists of; i) issues of P&S, ii) current technological status, iii) new management concept of P&S and iv) previous proposed application of KM in P&S. At the end of this chapter, a gap of previous research is discussed and the action plan to overcome the gap is described in Chapter 4.

### **1.8.4 Chapter 4: Research Methodology**

This chapter details the action plan on how the research is conducted. The approach is mixed method of initially doing descriptive qualitative research, prototype system

development and finally using a descriptive quantitative research methodology. System and user requirements for web-based mechanism for KM using the case study approach is described and justified using a questionnaire analysis. Description of the conceptual KM model is presented and how it is used as a guide for developing a prototype web-based mechanism of KM. The proposed web-based mechanism and its testing process based on using an action research approach is documented as a case study. The descriptive quantitative research process is described as a means to acquire more reliable data to support the key components of the KM system.

Waterfall model of system development life cycle used in designing and developing a prototype system for this study is described. The logical and physical view of system development is provided to give a clearer view on how this mechanism works. The database and knowledge base logical view is also provided. Also, the tools that are used in the system development as well as the launching process are described. The prototype system that was tested and evaluated are presented, whilst the analysis of the evaluation presented in the Findings and Discussions Chapter.

### **1.8.5 Chapter 5: Findings and Discussions**

The description method of qualitative analysis in this study of current practice of KM is presents in this chapter as well as the conceptual working model that is tested using the action research approach. The analysis of case study and preliminary interview used in constructing the working model is presented.

Development of prototype system presents the system functionality is described in this chapter so as to tie in the functionality with analysis result of the qualitative approach. A questionnaire survey, to assess the applicability of the prototype and the findings of the data analysis is presented together with brief discussions.



### **1.8.6 Chapter 6: Conclusion and Recommendation**

The developed prototype web-based mechanism of knowledge management and its findings are evaluated in the context of achieving the intended objectives. Additionally, the limitations and usefulness of the KM system based on practitioner feedback is evaluated and concluded in terms of a brief comparison with current models and recommendations for future work are proposed. The focus of this chapter is to provide a conclusive comparative analysis and identify the possibility of developing the system for the whole construction project.

### **1.9 Chapter Summary**

The importance of Knowledge Management (KM) is now being realised and businesses are starting to formulate strategies to invest in systems that will enable them to manage their corporate knowledge. This is a relatively new concept for construction organisations, which have a fundamental need to manage knowledge as they move from one project to another, working with different partners and supply chains (Carillo *et al.*, 2000).

This research intends to incorporate KM practice in the planning and scheduling activities of construction industry to enhance the effectiveness of managing project and achieve a competitive edge in the context of the knowledge era. The action plan in undertaking this research are as follows: i) to assess the existing and current work on KM in terms of state-of-the-art technologies focusing on information flow, ii) identification of KM mechanisms from the previous work and presentation of a case study, iii) developing a conceptual model based on the element, iv) developing a prototype web-based mechanism of KM and evaluating its usage. At the end of this study, a working model will be developed by incorporating latest management concept that is proven to be effective in previous research.

## **CHAPTER 2**

### **KNOWLEDGE MANAGEMENT**

#### **2.1 Introduction**

Throughout the 1980s and 1990s a new range of business improvement philosophies, approaches and methodologies have been continuously developed. Knowledge Management (KM) started to emerge as an area of interest in academia and organisational practice. Literature reveals a rapidly increasing body of knowledge relating to KM which covers many different disciplines and areas of interest to academia and practitioners. This chapter presents the literature review on elements of the research which was carried out to provide the background knowledge related to the problem statement, determine the important areas requiring further research and to support as well as to structure the focus of this study in order to achieve the research objectives stated in Chapter 1. In this respect the existing work related to the research topic is discussed. Hence, this chapter on literature review chapter provides the basic knowledge associated with KM concept for project-based organisations, specifically that of construction. This research study additionally serves as a basis for further future work that needs to address the issue of organizational KM for construction contracting organizations.

Human activity is inconceivable without knowledge. It was noted by Quintas (2005) that knowledge provides the basis of whole industries, or that it plays a

crucial role in the functioning of organisations, and indeed is the source of innovation and competitive advantage. Knowledge is neither data nor information, and people speak of a ‘knowledgeable individual’ and mean someone with a thorough, informed and reliable grasp of subject, someone both educated and intelligent (Davenport and Prusak, 1998).

### **2.1.1 Differentiating of Data, Information and Knowledge**

Some authors address the question of defining knowledge by distinguishing it among knowledge, information and data. Numerous previous researches have been concerned with managing data and information in order to improve organizational efficiency and effectiveness (Asoh *et al.*, 2002). The literature reveals an established hierarchical relationship among data, information and knowledge. Data can be defined easily as “raw” facts, strings of elementary symbols, such as digits or letters (Meadow, 2000). Data becomes “information” when it is put into some context, with respect to relevance and purpose but not specific skill or experience, as according to Drucker (2001), information means ‘*data endowed with relevance and purpose*’. Whilst, knowledge is stated by Wiig (1999) as “*the data and information made meaningful through a set of beliefs about the causal relationships between actions and their probable consequences, gained through either inference or experience*”.

Knowledge differs from information in that it is predictive and can be used to guide action while information merely is data in context which have the static characteristic (Bouthillier and Shearer, 2002). For example, thirty thousand is the data, when this data is put into context such as project loss, it becomes information, whilst when the context is put into it such as cause of project loss, the knowledge is generated in which the information receiver now has the knowledge of what is the cause of thirty thousand project loss. Hence, as noted by Wiig (1999), knowledge contains more than combination of static information, it contains set of truths and beliefs, perspectives and concepts, judgements, expectations and know-how.

### 2.1.2 Defining Knowledge

In the domain of KM, multiple attempts to categorizes, classify and define knowledge and related terms have been undertaken in the past (Davenport and Prusak, 1998). Knowledge is defined by the Oxford English Dictionary (2009) as (i) expertise, and skills acquired by a person through experience or education; the theoretical or practical understanding of a subject, (ii) what is known in a particular field or in total; facts and information or (iii) awareness or familiarity gained by experience of a fact or situation. However, the definitions differ catering to the research objective. According to McInerney (2002), in the journal paper titled *Knowledge management and the nature of knowledge*, knowledge is referred to “as the awareness of what one knows through study, reasoning, experience or association, or through various other types of learning”. Morrissey (2005) defines knowledge as something that can be thought of as “information combined with experience, context, interpretation, reflection and is highly contextual. It is a high-value form of information that is ready for application to decisions and actions within organizations”.

The examination of existing definition and classification of KM shows a wide spectrum of viewpoints. These ranges from the more mechanistic to more socially oriented. The mechanistic type assume an intellectual capital approach (knowledge is viewed as an asset) while the social type assumes a social constructionist approach where knowledge is constructed in the social relationship within organisations (McAdam and McCreedy, 1999).

Knowledge levels can be an asset only if they are enhanced and efficiently used (Carneiro, 2000). When associated with individuals, organizations and societies, knowledge serves different functions and has different forms. Knowledge of different kinds cannot be treated the same and that influences its use and management (Wiig, 2007). When discussing topics on knowledge, an important aspect that has to be considered is on the type of knowledge itself. The better understanding of the knowledge characteristic helps on future manipulation of technology towards this aspect. Knowledge can be characterised into two (2) types, which are, (i) explicit knowledge and (ii) tacit or implicit knowledge (Polanyi and Sen, 2009; Nonaka, 1994). Some researchers refer to these two (2) types of knowledge as knowledge

dimension (Markus, 2001; Siemieniuch and Sinclair, 2004). Explicit knowledge refers to knowledge that can be codified easily and can be in readable form. According to Kucza (2001), tacit knowledge refers to knowledge that is gained through experience and cannot be codified in anyway. For the purpose of undertaking the complex task of researching on knowledge management it is found necessary to use a simple and practical definition of knowledge. Hence, the meaning of knowledge with regards to this research context is information in the context of expertise or skills acquired through formal and informal learning (explicit) or experience (tacit) to accomplish a specific task or job.

## 2.2 Knowledge Management (KM) Processes

According to Asoh *et al.* (2002), “The concept of KM is nothing new. It has been practiced for a long time and mostly in an informal manner”. Corporations have always had some process to synthesize their experience and integrate it with knowledge acquired from outside sources.

Mohamed and Anumba (2006) emphasise that KM is not simply about extracting the knowledge held in an individual’s mind and converting it to an accessible electronic format, or disseminating and making available as an organization’s knowledge. It is about *providing knowledge to facilitate communication between individuals, teams and communities of specialists and thereby providing access to knowledge assets; individual experiences, lessons learnt, best practices etc.* Stelth and Le Roy (2009) state that the main purpose of any KM strategy is to reduce errors, create less work, provides more independence in time and space for knowledge workers, generates fewer questions, produce better decisions, reinvent fewer wheels, advance customer relations, improve services and develops profitability. **Table 2.1** shows the analysis of literature of KM Processes definition.

Table 2.1: KM Processes (Ying *et al.*, 2011)

Model	Definition of KM Process
Wiig (1993)	Creating and sourcing, codification and transformation, dissemination, application and value realization.
Arthur Anderson (1995)	Create, identify, collect, adapt, organize, apply and share knowledge.
Marquadt (1996)	Knowledge Acquisition, creation, transfer and utilization, storage.
O'Deli (1996)	Identify, collect, adapt, organize, apply, share, create knowledge.
Beckman (1997)	Identify, capture, select, store, share, apply, create, sell knowledge.
Nissen (1999)	capture, organize, formalize, distribute, apply knowledge.
Despres and Chauval (1999)	Create, map, store, share/transfer, reuse knowledge.
Gartner group (1998)	Create, organize, capture, access, use knowledge.
Davenport (2001)	Generate, codification, transfer, realization knowledge.
Alavi and Leidner (2001)	Creating, storing/retrieving, transfer, applying knowledge.

As such, KM involves series of systematic processes; and the review of the KM concept indicates that KM is an ongoing process in an organization which starts with acquiring relevant knowledge resources and continues through its proper utilization (Roknuzzaman *et al.*, 2009).

### 2.3 KM Process Elements

Every process sequence serves the systematic behaviour of managing knowledge of the organization, however there are no fix sequences due to the dynamic

characteristic that knowledge possess. It had been identified that the processes of knowledge creation, knowledge storing, knowledge sharing and knowledge update (Kucza, 2001; Yin *et al.*, 2008; Scarborough, 1999; Nicholas, 2004) are the elements of KM processes identified from previous research on KM.

### 2.3.1 Knowledge Creation

Dave and Koskela (2009) state that the basis of knowledge creation in organization is continuous interaction among individuals and a continuous conversion from tacit into explicit knowledge (and vice-versa) by individuals, supported by the group. In representing the creation of knowledge, Nonaka's and Takeuchi's (1995) model of knowledge conversion named SECI has become a main reference in the area of KM. **Figure 2.1** shows how the conversions of knowledge from tacit and explicit (and vice-versa) occur in each process.

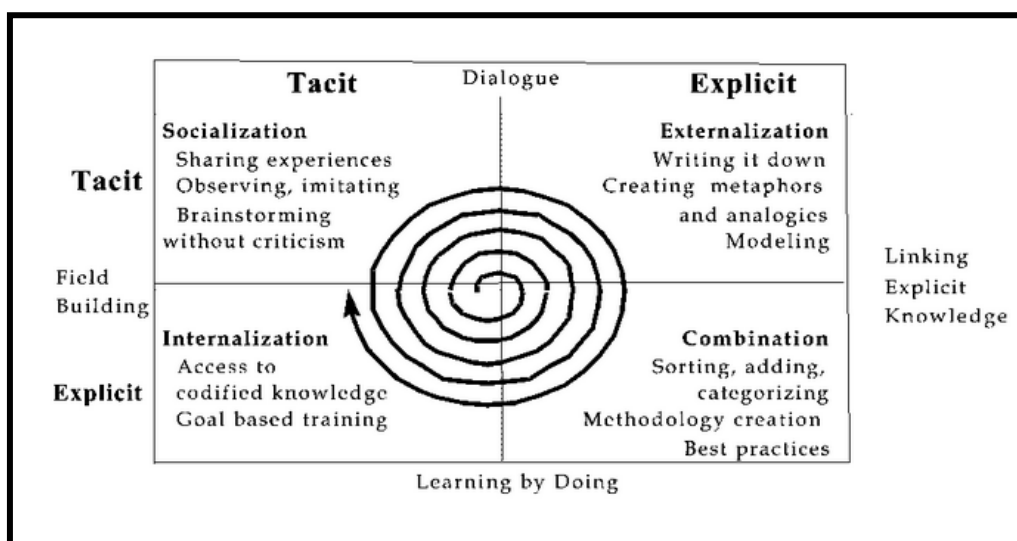


Figure 2.1: Spiral View of SECI Model (Nonaka, 1995)

The process of transforming or converting the tacit knowledge to other person tacit knowledge is called *Socialization* and can be achieved through sharing experiences, observing, imitating and brainstorming without criticism. The process of converting tacit knowledge to explicit knowledge can be achieved through writing, creating metaphors and modelling, and this activity is categorised as *Externalization*. Sorting,

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