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*Full Length Research Paper*

# Preliminary approach to improve knowledge management in engineering management

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**There is a steady change in engineering management from an information age to knowledge age where there is an increasing need for knowledge management. The construction industry has a poor record in the management of its knowledge, and results in huge wastage of resources and detrimental effect to quality. In addition, knowledge management in the context of the Malaysian construction industry has many available gaps for improvement. As such, a study amongst Malaysian construction professionals as a preliminary approach to improve the practice of knowledge management has been initiated. The objectives of this study are to identify the effectiveness of previous knowledge management practices and to determine critical factors that can promote and improve the standard of knowledge management. Both quantitative and qualitative approaches including questionnaire surveys, semi-structured interviews, and a participant observation case study have been employed. Crucial knowledge management enablers are thoroughly identified in this study. Critical factors for optimization have been recommended to improve the knowledge management efficiency in engineering.**

**Key words:** Engineering management, construction performance, knowledge, knowledge management, project quality.

## INTRODUCTION

The construction industry is an important and productive sector due to its direct contribution and its dominant role to stimulate growth in a nation. However, the construction industry has a poor record in the management of its knowledge and results in huge wastage of resources and detrimental effect to quality. Carrillo et al. (2000) claimed that the structure and working practices in the construction industry makes it more difficult to share knowledge. In addition, knowledge management in the context of the Malaysian construction industry has many available gaps for improvement. Knowledge contributes largely towards the performance of construction projects, but the awareness of the nature of knowledge in the construction industry which is very important has not been satisfactorily understood (Shehu and Akintoye, 2010).

Generally, the industry is an important propelling cog with strong forward and backward linkages with other industries and professional services (Ofori, 1990). In Malaysia, a vision for the construction industry to be a world class, innovative, and knowledgeable global solution provider has been formulated in accordance with the objectives and goals of Vision 2020 (CIDB, 2007). To further contribute towards the objectives of seeing Malaysia becoming a developed nation by the year 2020, it is envisaged that Malaysia will develop a construction industry that is internationally efficient and competitive (CIDB, 2007). The industry will enhance the quality of life among Malaysians through the tangible implementations of the Government's socio-economic policies into infrastructure and buildings (United Nations, 1997). Globally, the construction industry bears the hallmarks of professionalism, but its tarnished image of being "dirty, dangerous, and difficult" still lingers on (CIDB, 2007:17). To counteract, one of the initiatives taken would be in the raising of knowledge standards among the construction industry players. Effective implementation would certainly lead to a change in its current image to one that is more

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appealing and reputably respected (CIDB, 2007).

## BACKGROUND AND CURRENT PROBLEMS AFFECTING KNOWLEDGE MANAGEMENT IN CONSTRUCTION INDUSTRY

The view that knowledge is a valuable asset to construction companies has become widely acknowledged and has gained substantial attention in the recent years (Rezgui et al., 2010) There has been an emerging importance placed on knowledge management within the construction industry as proper management of knowledge is an essential part of survival in the industry (Dave and Koskela, 2009; Mohamed et al., 2006). Therefore, construction companies should acquire a wider outlook of the significance of knowledge as a valuable asset in obtaining the competitive advantage.

According to Pathirage et al. (2007), definitions of knowledge range from the practical to the conceptual to the philosophical and from narrow to broad in scope. It is worth noting that many authors have defined knowledge from their distinctive angles, perspectives (Zhang et al., 2009; Fei et al., 2002) and contexts through many generations (Renderee, 2006). Manjula and Mustapha (2006) stated knowledge as actionable information in the right context that facilitates intelligent decision making. Knowledge is "the ability of persons to evaluate information and act efficiently" (Greiner et al., 2007:5). Nonaka and Takeuchi (1995) viewed knowledge as a human process of justifying individual's beliefs. Despite the various definitions of knowledge, McIntyre (2007) feels that the definitions provided in the literature are still not sufficient as he highlighted that there are some faulty or incomplete definitions around the concept of knowledge.

Knowledge can be classified into personal, shared and public, practical and theoretical, foreground and background, internal and external, hard and soft (Pathirage et al., 2007), structured and unstructured (Herrgard, 2000), knowing how and knowing that, and procession perspective and structural perspective (Jashapara, 2004). However, the most common and realistic classification of knowledge is the classification into tacit and explicit (Teerajetgul et al., 2009; Anup and Anuj, 2006). It is worth nothing that knowledge can fall within a spectrum of tacit to explicit, where one extreme end of the spectrum forms completely tacit knowledge and explicit knowledge on the other extreme end (Sun and Mushi, 2010). As the name suggests, explicit knowledge is often referred as knowledge that is modifiable, systematic, and formal and can be expressed in words and numbers (Pathirage et al., 2007). In contrast to explicit knowledge, tacit knowledge is often found invisible, not easily expressible and highly personal (Abdul-Hamid, 2006). This is due the fact that, tacit knowledge is acquired by internal individual processes like experience, internalization, consideration, or individual talents (Herrgard, 2000). Therefore, tacit and explicit knowledge cannot and should not be managed and taught in the same manner (Davenport et al., 1998).

Despite the fact that knowledge forms the key asset to drive organizational survival and success (Jashapara, 2004), knowledge would be worth less than what it should without a proper management of it. According to Anup and Anuj (2006), an organization will be able to utilize its knowledge at the most optimal level if the organization possesses the right kind of knowledge at the right time. Thus, managing knowledge is an essential part in organizational survival (Mohamed et al., 2006) and knowledge management is seen as the survival weapon of construction companies (Kuan and Aspinwall, 2004). Offsey defined knowledge management as "the broad processes of locating, transferring and more efficiently using information and expertise within an enterprise" (Abdul-Hamid, 2006: 155). In addition, Mohamed and Anumba (2006) highlighted that knowledge management is not simply about extracting the knowledge stored in an individual's mind and converting it to an accessible format, it is about making knowledge available to facilitate communication between individuals, team members and the group of specialists. Knowledge management should also be able to make continuous improvements possible and should be firmly related to objectives and strategies of the companies (Greiner et al., 2007). In parallel, Damodaran (2006) feels that effective knowledge management can be achieved when knowledge is turned into timely aided for action. In relation to effective knowledge management, it is also important to highlight that oversimplification of problem setting and scope in knowledge management may only result in weakness (Fei et al., 2002). Therefore, a systematic and structural approach is essential in making knowledge management a success (Mohamed and Anumba, 2006).

The Malaysian construction industry has experienced various changes in the last decade such as the expansion of the construction market across other countries in the region (Giuffrida, 2006). The industry evolves alongside globalization where there are greater exposures to both challenges and risks. Tah (2001) concluded that the industry constantly suffers from poor performance due to lack of formalized risk management procedures and a knowledge-based approach to con-struction. In order to address the vague needs in the construction industry, knowledge management has been adopted across the globe among construction professionals in developing economies of the industry.

The implementation of successful and effective knowledge management in the construction industry is by no mean easy. Knowledge plays a crucial role in today's fast-changing environment, thus, knowledge management evidently complements the initiatives to improve value in the construction industry. In absolute agreement with Pathirage et al. (2007), knowledge has always been

vital in the performance of an organization. However, there is a steady change in the construction industry from an information age to knowledge age where there is an awareness of the need of knowledge focus or management in the implementation of its strategies. All construction-related parties: From clients to architects, engineers, surveyors, general contractors, subcontractors, suppliers and other construction parties, all have their respective roles to play in order to improve the value of construction projects. Knowledge management does not merely act as a stepping stone for the construction industry to strive towards knowledge-based economy, but it is an initiative to meet future challenges.

## AIM AND OBJECTIVES OF THE STUDY

The aim of this research is to establish effective approaches to improve knowledge management in the Malaysian construction industry. Within the aim, a few dominant objectives are expressed as follows:

1. To identify the effectiveness of previous knowledge management practices in the Malaysian construction industry;
2. To identify critical factors that can promote and improve the standard of knowledge management in the local construction industry; and
3. To summarize knowledge management mechanisms, IT tools and software, and output of project performance from a project that successfully applying knowledge management approaches through case study.

## RESEARCH METHODOLOGY AND PROCEDURES

Quantitative and qualitative research methods were employed in order to achieve the objectives, which include a questionnaire survey, a semi-structured interview survey, and a participant observation case study.

### Questionnaire survey

A questionnaire survey was developed in an easy-to-answer manner to seek the view of practitioners on knowledge management practices in the construction industry. Subsequently, statistical analysis approaches were carried out through Statistical Package for Social Sciences (SPSS) software to obtain the results of the survey. A total of 600 questionnaires were posted to architects, quantity surveyors, and engineers. A total of 97 respondents took part in the quantitative questionnaire survey which reflects a response rate of 16.2%. Table 1 contains the proportion of the respondents' demographic details for each category. The details for the respondents were classified into five categories, namely: Gender, age group, job position, education level, and number of years experienced in construction industry.

### Semi-structured interview survey

The forms of semi-structured interview sessions were conducted as a supplementary process to enhance the questionnaire findings through subjective perspectives from construction professionals, which are to make the findings more practicable and humanistic. Questions were set based on the questionnaire survey findings in order to obtain a practice opinionated data on the current issues and improvement measures in within the knowledge management practice of the Malaysian construction industry. Three principally semi-structured interviews were conducted with construction professionals who have been involved in knowledge management practices within the construction industry. To ensure comparability, the interviewees chosen have been engaged in the construction industry for at least five years. The interviews were ranging from twenty to forty minutes. The experiences of the interviewees A, B, and C working in the construction industry are 5, 8, and 30 years, respectively.

Within this context, the interviews were conducted within the Klang Valley, which is significantly known as the hub for development and growth of the entire Malaysia. The interviews with these participants were audio-recorded. Consequently, the following subsections discussed the data identified based on the emerged themes as proposed by the interviewees. The researcher aims to add on to previous researches as there have been a few significant perceptions revealed through the interviews conducted. It is generally assumed that the interviewees in one way or the other are been familiarized with the term "knowledge management".

### Participant observation case study

To assess the findings of the questionnaire survey and the interview survey, one participant observation case study was conducted on an internationally-scaled project, referred to as "Project A" hereof. Project A was organized in the Klang Valley by two main organizers, namely: Organization X and organization Y, held in the final quarter of 2008. Originated from distinct and different backgrounds, organization X and organization Y made collaborative efforts to develop a platform to achieve project management excellence within organizations of different backgrounds and disciplines.

The researcher participated in Project A from May 2008 until November 2008, an approximate observation period of six months. The researcher's involvement commenced from the initial planning stage until the completion of the project. Prior to the planning stage, the inception stage has been well-defined consisting of Project A's aims and objectives, missions and visions, as well as the project's team structure. The availability of resources, tools and infrastructures were demarcated along the progress of the project.

One of the major problems in designing a case study is in defining the appropriate units of analysis to be used. McClintock et al. (1979) and Mohamed and Anumba (2006) stressed that such units are present in literally almost all activities, processes, or components of organizations, in spite of the direct or indirect nature of the units. Within the conducted participant observation case study, there are several selected "units of analysis" for Project A, namely: Knowledge management mechanisms, IT tools and software used, and output of performance, which will gear towards achieving the objectives of the research.

## RESULTS AND DISCUSSION

### Results from questionnaire survey

### Perception of knowledge management at different levels of intellectual

As illustrated in Table 2, there are significant variations in

**Table 1.** Respondents' demographic details.

| Demographic categories | Category breakdown | Frequency | Percent | Cumulative (%) |
|---|---|---|---|---|
| Gender | Male | 76 | 78.4 | 78.4 |
| | Female | 21 | 21.6 | 100.0 |
| Age group | 20 - 29 | 19 | 19.6 | 19.6 |
| | 30 - 39 | 18 | 18.6 | 38.1 |
| | 40 - 49 | 27 | 27.8 | 66.0 |
| | > 50 | 33 | 34.0 | 100.0 |
| Education Level | Secondary education | 1 | 1.0 | 1.0 |
| | Diploma level | 9 | 9.3 | 10.3 |
| | Bachelor degree | 63 | 64.9 | 75.3 |
| | Postgraduate level | 24 | 24.7 | 100.0 |
| Job position | Director/CEO | 22 | 22.7 | 22.7 |
| | Architect | 10 | 10.3 | 33.0 |
| | C and S Engineer | 12 | 12.4 | 45.4 |
| | M and E Engineer | 2 | 2.1 | 47.4 |
| | Quantity surveyor | 45 | 46.4 | 93.8 |
| | Others | 6 | 6.2 | 100.0 |
| Years of experience in the construction industry | 1 - 5 | 20 | 20.6 | 20.6 |
| | 6 - 10 | 9 | 9.3 | 29.9 |
| | 11 - 15 | 14 | 14.4 | 44.3 |
| | 16 - 20 | 11 | 11.3 | 55.7 |
| | > 20 | 43 | 44.3 | 100.0 |

**Table 2.** Perception of knowledge management implementation as a criterion.

| | | Frequency | Percent | Cumulative (%) |
|---|---|---|---|---|
| Personal Level[a] | Yes | 93 | 95.9 | 95.9 |
| | No | 4 | 4.1 | 100.0 |
| Project level[b] | Yes | 92 | 94.8 | 94.8 |
| | No | 5 | 5.2 | 100.0 |
| Organizational level[c] | Yes | 87 | 89.7 | 89.7 |
| | No | 10 | 10.3 | 100.0 |

[a]Goodness-of-fit: Chi-square = 81.660; $p < 0.05$, [b]Goodness-of-fit: Chi-square = 78.031; $p < 0.05$, [c]Goodness-of-fit: Chi-square = 61.124; $p < 0.05$.

the responses received towards the perception of knowledge management at different intellectual within the construction industry, namely: Personal, project, and organizational level. The p-value is under the 5% level of significance. Results of the questionnaire shows that 93 (95.0%) and 92 (94.8%) respondents perceived that knowledge management is an important criterion at the personal and project level, respectively. In addition, 87 (89.7%) respondents supported the significance of knowledge management in an organizational context. According to Table 2, the Goodness-of-fit Chi-squares at the personal and project level are 81.660 and 78.031, respectively, which are much higher than that on the organizational level at 61.124. Hence, it observed that knowledge management is more significantly perceived in the individual and project levels than the organizational

**Table 3.** Output of one sample t-test for regularity for implementing knowledge management.

| | Test value = 3.00 | | | | | |
|---|---|---|---|---|---|---|
| | t | df | Sig. (2-tailed) | Mean difference | 95% confidence interval of the difference | |
| | | | | | Lower | Upper |
| Implementation of knowledge management in respondent's organization | 11.893 | 96 | 0.000 | 0.89 | 0.74 | 1.03 |

**Table 4.** Output for one sample t-test for application of knowledge management techniques.

| Knowledge management techniques | Test value = 3.00 | | | | | | Ranking |
|---|---|---|---|---|---|---|---|
| | t | df | Sig. (2-tailed) | Mean difference | 95% confidence interval of the difference | | |
| | | | | | Lower | Upper | |
| Communities of practice | 3.343 | 96 | 0.001 | 0.32 | 0.13 | 0.51 | 6 |
| Face-to-face meeting | 12.123 | 96 | 0.000 | 0.92 | 0.77 | 1.07 | 1 |
| Brainstorming | 4.773 | 96 | 0.000 | 0.41 | 0.24 | 0.58 | 4 |
| Training | 6.387 | 96 | 0.000 | 0.51 | 0.35 | 0.66 | 3 |
| Job Rotation and observation | 4.151 | 96 | 0.000 | 0.36 | 0.19 | 0.53 | 5 |
| Mentoring | 7.298 | 96 | 0.000 | 0.62 | 0.45 | 0.79 | 2 |
| Recruitment | 2.563 | 96 | 0.012 | 0.22 | 0.05 | 0.38 | 7 |

level. Hence, it clearly observed that knowledge management is more significantly perceived in the individual and project levels than the company level. On the other hand, from an organizational perspective, the significance of knowledge management as a criterion is slightly undermined.

## Extent of knowledge management implementation in various organizations

The respondents were asked to indicate the extent or regularity of implementing knowledge management in their organizations. Generally, all the respondents signified an occurrence of knowledge management within their organizations. Result shows that 56 (57.7%) often implemented knowledge management in their organizations and 17 (17.5%) respondents choose very often. There are 20 (20.6%) respondents who indicate that “sometimes”. they do implemented knowledge management. Nonetheless, only 4 (4.1%) respondents have “rarely” applied the concept of knowledge management. Generally, the mean value of 3.89 indicates that there is an extensive implementation of knowledge management in the construction industry in Malaysia.

Table 3 summarizes the result of one sample t-test to the extent of knowledge management implementation in the construction industry. It was found that the p-value at the 95% level of confidence possess a t-value ($t(96) = 11.893$, $p < 0.05$). Further, the t-test revealed a statistically reliability, where the t-value is greater than the one-tailed critical t-value. This implies that the alternative hypothesis of $\mu > 3.00$ is accepted, which means know-ledge management is quite often (mean = 3.89) adopted in the construction industry. Hence, this validates that the implementation of knowledge management is vastly accepted in most construction organizations. Needless to say, appropriate measures need to be carried out to further improve and intensify the concept of knowledge management.

In depicting the perception of professionals on implementing knowledge management in the construction industry, generally, civil and structural engineers scored the highest mean of 4.17, while quantity surveyors scored the lowest mean of 3.73. The remaining professionals such as architects and electrical engineers scored an approximate mean of 4.00. Consequently, this shows that construction professionals acquire a common practice in implementing knowledge management in their respective field of work.

## Application of knowledge management techniques

A set of proposed knowledge management techniques is narrowed down and identified. The proposed knowledge management techniques are obtained from the studies by Pow (2006) and Low (2008). Table 4 summarizes the results of one sample t-test on the common knowledge management techniques applied in the construction

**Table 5.** Output of one sample t-test on the perception of improved knowledge management .

| | Test value = 3.00 | | | | | |
|---|---|---|---|---|---|---|
| | t | df | Sig. (2-tailed) | Mean difference | 95% confidence interval of the difference | |
| | | | | | Lower | Upper |
| Perception of appropriate measures to improve knowledge management | 11.651 | 96 | 0.000 | 1.03 | 0.86 | 1.21 |

**Table 6.** Output of one sample t-test for challenges in knowledge management.

| Challenges in Knowledge management | Test value = 3.00 | | | | | | Ranking |
|---|---|---|---|---|---|---|---|
| | t | df | Sig. (2-tailed) | Mean difference | 95% confidence interval of the difference | | |
| | | | | | Lower | Upper | |
| High competitive market place | 8.759 | 96 | 0.000 | 0.93 | 0.72 | 1.14 | 1 |
| Focus on creating client's value | 7.743 | 96 | 0.000 | 0.79 | 0.59 | 1.00 | 2 |
| Time constraints | 6.219 | 96 | 0.000 | 0.70 | 0.48 | 0.92 | 3 |
| Trend of early retirement | 4.660 | 96 | 0.000 | -0.60 | -0.85 | -0.37 | 5 |
| High complexity of construction works | 6.077 | 96 | 0.000 | 0.66 | 0.44 | 0.88 | 4 |

industry. With the confidence level predetermined at 95%, most of the driving forces are identified to have a significant level less than 0.05 ($p < 0.05$). It was found that all techniques possess a t-value greater than the one-tailed critical t-value, meaning that each of the null hypotheses is rejected. This provides an overview of the wide proposed techniques application in and among the respondents' construction organizations. All the variables obtained a mean higher than 3.0. Nonetheless, recruitment and communities of practice have the two lowest means at 3.22 and 3.32, respectively. Other techniques such as job and observation, brainstorming, training, and mentoring have mean scores ranging from 3.36 - 3.62. Face-to-face meeting has the highest mean at 3.92, where approximately 75% of the respondents have applied the technique on a frequent basis within their organizations.

According to Clark (1996), Wenger et al. (2002) and Squier (2006), face-to-face meeting is widely applied not only in the construction industry but among strategic commercial organizations as well. Thus, it strongly indicates that face-to-face meeting is a universal implemented technique. The training and mentoring scheme is also prioritized and employed in construction organizations especially to achieve successful knowledge dissemination (Argyris and Schon, 1996; Boyce, 1996). In particular, Wenger et al. (2002) and Squier (2006) emphasized on the uprising technique on communities of practice. The respondents also expressed their views on the less frequent applied knowledge such as recruitment, which is associated closely with the current economic downturn as well as the competitive market in the construction industry.

## Views on improving knowledge management practices

Questions were expressed to recognize the need for knowledge management improvement based on the current situation experienced, encountered, or observed. Approximately 84% of the respondents perceived an immense necessity to take corrective measures to improve knowledge management in the construction industry. Hence, an average mean of 4.03 substantiates the generally acceptance in implementing actions to enhance the process of managing knowledge.

A one sample t-test was conducted to validate the perception of improving knowledge management in the Malaysian construction industry as shown in Table 5. With the p-value determined, at less than 5% level of significance, all the respondents are identified to that significant level. The one sample t-test conducted, possess a t-value ($t(96) = 11.651$, $p < 0.05$) greater than the one-tailed critical t-value. Thus, this reflects the acceptance of the alternative hypothesis. The t-test corroborates the wide-spread embrace towards improving the implementation of knowledge management in the construction field.

## Challenges in knowledge management

The selection of proposed challenges is derived from various literatures (Kamara et al., 2002; Anumba, 2003; Carrillo et al., 2004; Anumba et al., 2005). Challenges which significantly occur in the construction industry were identified. Table 6 summarizes the results of one sample

**Table 7.** Output of one sample t-test on human capital dependency.

| | Test value = 3.00 | | | | | |
|---|---|---|---|---|---|---|
| | t | df | Sig. (2-tailed) | Mean difference | 95% confidence interval of the difference | |
| | | | | | Lower | Upper |
| Dependency on human capacity than technological advancement | 13.647 | 96 | 0.000 | 0.98 | 0.84 | 1.12 |

t-test of the challenges entailed in the practice of knowledge management. With the confidence level predetermined at 95%, all variables are identified to have a significance level under 0.05 ($p < 0.05$). On the contrary, the one-tailed critical value for trend of early retirement is more than the observed t-value ($t(96) = -4.660$, $p < 0.05$). Hence, the null hypothesis of $\mu \leq 3.00$ is accepted. Thus, this implicitly defines that the majority of the proposed challenges have a significant impact in knowledge management except the trend of early retirement. Generally, majority of the proposed variables except the trend of early retirement obtained a higher mean value than 3.00. While most of the variables are generally significant to the challenges to knowledge management, the ranking is essential to determine its relative importance perceived by the sampled respondents. The perception of high competitive marketplace as the highest challenge has a mean of 3.93. This is followed by focus on creating client's value at 3.79, time constraints at 3.70, and high complexity of construction works at 3.66. With reference to the t-test and the mean value of 2.85, the trend of early retirement does not radically contribute to the challenges in implementing knowledge management.

## Dependency on human capacity and technological advancement

Subsequent to identifying the challenges in the implementation of knowledge management, a general question was posed to better comprehend the perception of the respondents' dependency on human capacity in comparison to technological advancement. In depicting the respondents', it is general acceptance with the perception that knowledge management practices are more dependent on human capital. 59.8% respondents agreed that knowledge management has high dependency on human capital and 20.6% strongly agreed with this statement. A mean of 3.98 obtained clearly shows that the respondents in general, place greater emphasis on human capacity than technological advancement in successful knowledge management implementation.

With the confidence level predetermined at 95%, the t-value ($t(96) = 13.647$, $p < 0.05$) as shown in Table 7 is much greater than the one-tailed critical t-value. Thus, the alternative hypothesis ($\mu > 3.00$) is accepted. The t-test result validates the greater emphasis on human capital compared to technological resources among construction professionals. In addition, the construction industry possesses a service-oriented nature which is highly dependent on people. Various researches (Carrillo et al., 2000; Massey et al., 2002; Pathirage et al., 2007; Low, 2008) have greatly accentuated the importance of people in the practice of managing knowledge. The output of this particular portion of the questionnaire is in line with the initiatives needed to improve knowledge management. Without disregarding the technical or technological based aspects, generally, the involvement and participation of people provide flexibility in enhancing the repositories and resources in construction organizations.

The propensity of reliance on human capital in managing knowledge with respect to the number of years experienced in construction industry is portrayed. As an overall trend, it is clear that the mean increased gradually as the years experience increases. Professionals with experiences of more than 20 years recognize a greater importance of human input in knowledge management (mean = 4.12), while individuals with 1 - 5 years of experience have a perception that emphasizes lesser on human resources (mean = 3.65). Such phenomenon is quite common as professionals who are well-seasoned in the industry perceive people factor as greater assets and contributions to the organization.

## Critical factors to improve knowledge management

It is necessary to identify factors that will further improve and enhance its' usage and dependability in the construction industry. Descriptive statistics to demonstrate the enablers related to top management responsibility, and resource and infrastructure towards improving knowledge management in the local construction industry are shown respectively. From the analysis on top management enablers as shown in Table 8, the result denotes that all variables have a mean above 4.0 except for reward and recognition. The top management's leadership, with a mean value of 4.30, is the most effective enabler to enhance the knowledge management practices in the Malaysian construction industry. It is followed by commitment and support at 4.25, motivation at 4.14, strategy at 4.00, and rewards and recognition at 3.90. On the other hand, from the resources and infrastructure perspective as illustrated in Table 9, human

**Table 8.** Ranking of top management's responsibility.

| Top management's responsibility | Ratings | | | | | | | | | | Mean | Ranking |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Strongly disagree | | Disagree | | Neutral | | Agree | | Strongly agree | | | |
| | No. | (%) | No. | (%) | No. | (%) | No. | (%) | No. | (%) | | |
| Commitment and support | 0 | 0.00 | 1 | 1.03 | 9 | 9.28 | 52 | 53.61 | 35 | 36.08 | 4.25 | 2 |
| Leadership | 0 | 0.00 | 0 | 0.00 | 3 | 3.09 | 62 | 63.92 | 32 | 32.99 | 4.30 | 1 |
| Motivation | 0 | 0.00 | 1 | 1.03 | 11 | 11.34 | 58 | 59.79 | 27 | 27.84 | 4.14 | 3 |
| Strategy | 0 | 0.00 | 1 | 1.03 | 20 | 20.62 | 54 | 55.67 | 22 | 22.68 | 4.00 | 4 |
| Rewards and recognition | 1 | 1.03 | 3 | 3.09 | 20 | 20.62 | 54 | 55.67 | 19 | 19.59 | 3.90 | 5 |

**Table 9.** Ranking of resources and infrastructure.

| Resources and Infrastructure | Ratings | | | | | | | | | | Mean | Ranking |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Strongly disagree | | Disagree | | Neutral | | Agree | | Strongly agree | | | |
| | No. | (%) | No. | (%) | No. | (%) | No. | (%) | No. | (%) | | |
| Organizational culture | 0 | 0.00 | 1 | 1.03 | 9 | 9.28 | 71 | 73.20 | 16 | 16.49 | 4.05 | 2 |
| Information technology | 0 | 0.00 | 0 | 0.00 | 19 | 19.59 | 61 | 62.89 | 17 | 17.53 | 3.98 | 3 |
| Human resource | 0 | 0.00 | 0 | 0.00 | 11 | 11.34 | 64 | 65.98 | 22 | 22.68 | 4.11 | 1 |
| Organizational structure | 0 | 0.00 | 1 | 1.03 | 19 | 19.59 | 64 | 65.98 | 13 | 13.40 | 3.92 | 4 |

**Table 10.** Output of Friedman's test on knowledge management enablers.

| Factors | Chi-square | df | Asymp. sig. |
|---|---|---|---|
| Top management responsibility | 32.867 | 4 | 0.000 |
| Resources and infrastructure | 8.126 | 3 | 0.043 |

resource is regarded as the most effective factor to improve the standards of managing knowledge, where a mean of 4.11 was obtained. Sub-sequently, organizational culture and information technology scored mean values of 4.05 and 3.98, respectively. Organizational structure was regarded the least effective factor, scoring a mean below 4.00.

To distinguish the two main stream enablers, Friedman test was conducted as shown in Table 10. A p-value under 1% level significance with Chi-square value of 32.867 proves that top management and responsibility is a significant factor in successful implementation of knowledge management. On the other hand, resources and infrastructure produced a p-value more than 1%, thus implying that there is a generally lesser significance in comparison to top management and responsibility.

Table 11 displays the correlation matrix between the factors related to top management responsibility and resources and infrastructure as rated by the respondents. The strongest positive correlation, which considered a strong relationship, was between commitment and support, and motivation (r = 0.647) with the p-value estimated at less than 1% level of significance. Commitment and support was also positively correlated with leadership (r = 0.536), while motivation correlated with organizational structure (r = 0.536) and leadership (r = 0.487), both with a moderate relationship.

Table 12 indicates that leadership is ranked as the most influential factor to improve the conduct of knowledge management in the Malaysian construction industry, with the mean value of 4.30. Nonetheless, one such factor is unable to stand on its own. Hence, it is followed by commitment and support at 4.25, motivation at 4.14, and human resource at 4.11. Out of the top four dominant factors, three are from the category of top management's responsibility. Hence, exceptional attention should be inculcated within top management organizations and structures. Trompenaars and Hampden-Turner (2004) pointed out knowledge management as a process which requires investment and relationship to exist on a deeper level of motivation, one that necessitates the involvement of people.

**Table 11.** Pearson correlation matrix between critical factors to improve knowledge management.

| Critical factors to improve knowledge management | | Organizational culture | Information technology | Human resource | Organizational structure | Commitment and support | Leadership | Motivation | Strategy | Rewards and recognition |
|---|---|---|---|---|---|---|---|---|---|---|
| Organizational culture | Pearson correlation<br>Sig. (2-tailed) | 1.000<br>- | Low | Low | Moderate | Moderate | Moderate | Moderate | Moderate | No relationship |
| Information technology | Pearson correlation<br>Sig. (2-tailed) | *0.221<br>0.030 | 1.000<br>- | Moderate | Low | Moderate | Low | Moderate | Low | No relationship |
| Human resource | Pearson correlation<br>Sig. (2-tailed) | *0.246<br>0.015 | **0.451<br>0.000 | 1.000<br>- | No relationship | Low | No relationship | Low | Moderate | Moderate |
| Organizational structure | Pearson correlation<br>Sig. (2-tailed) | **0.452<br>0.000 | **0.276<br>0.006 | 0.146<br>0.152 | 1.000<br>- | Moderate | Moderate | Moderate | Moderate | Low |
| Commitment and support | Pearson correlation<br>Sig. (2-tailed) | **0.453<br>0.000 | **0.398<br>0.000 | *0.254<br>0.012 | **0.311<br>0.002 | 1.000<br>- | Moderate | Strong | Low | Low |
| Leadership | Pearson correlation<br>Sig. (2-tailed) | **0.382<br>0.000 | *0.214<br>0.000 | 0.198<br>0.052 | **0.373<br>0.000 | **0.536<br>0.000 | 1.000<br>- | Moderate | Moderate | Low |
| Motivation | Pearson correlation<br>Sig. (2-tailed) | **0.421<br>0.000 | **0.324<br>0.000 | *0.236<br>0.020 | **0.536<br>0.000 | **0.647<br>0.000 | **0.487<br>0.000 | 1.000<br>- | Moderate | Low |
| Strategy | Pearson correlation<br>Sig. (2-tailed) | **0.303<br>0.003 | **0.270<br>0.000 | **0.419<br>0.000 | **0.397<br>0.000 | *0.250<br>0.013 | **0.374<br>0.000 | **0.326<br>0.001 | 1.000<br>- | Moderate |
| Rewards and recognition | Pearson correlation<br>Sig. (2-tailed) | 0.085<br>0.406 | 0.126<br>0.219 | **0.350<br>0.000 | **0.267<br>0.008 | **0.291<br>0.004 | **0.279<br>0.006 | **0.297<br>0.003 | **0.442<br>0.000 | 1.000<br>- |

*Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

**Table 12.** Summary of the ranking of knowledge management critical factors.

| Factors to improve knowledge management in the construction industry | Mean | Standard deviation | Ranking |
|---|---|---|---|
| Leadership | 4.30 | 0.524 | 1 |
| Commitment and support | 4.25 | 0.662 | 2 |
| Motivation | 4.14 | 0.645 | 3 |
| Human resource | 4.11 | 0.575 | 4 |
| Organizational culture | 4.05 | 0.547 | 5 |
| Strategy | 4.00 | 0.692 | 6 |
| Information technology | 3.98 | 0.612 | 7 |
| Organizational structure | 3.92 | 0.607 | 8 |
| Rewards and recognition | 3.90 | 0.784 | 9 |

**Table 13.** Ranking of potential benefits in improved knowledge management.

| Potential benefits in improved knowledge management | Ratings | | | | | | | | | | Mean | Ranking |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Strongly disagree | | Disagree | | Neutral | | Agree | | Strongly agree | | | |
| | No. | (%) | No. | (%) | No. | (%) | No. | (%) | No. | (%) | | |
| Increased customer value | 1 | 1.03 | 2 | 2.06 | 23 | 23.71 | 56 | 57.73 | 15 | 15.46 | 3.85 | 6 |
| Higher quality and productivity | 0 | 0.00 | 1 | 1.03 | 13 | 13.40 | 56 | 57.73 | 26 | 26.80 | 4.11 | 2 |
| Contribution to intellectual capital | 0 | 0.00 | 0 | 0.00 | 26 | 26.80 | 52 | 53.61 | 19 | 19.59 | 3.93 | 5 |
| Easier identification of occurrence of problems | 0 | 0.00 | 1 | 1.03 | 20 | 20.62 | 58 | 59.79 | 18 | 18.56 | 3.96 | 3 |
| Effective communications | 0 | 0.00 | 1 | 1.03 | 22 | 22.68 | 56 | 57.73 | 18 | 18.56 | 3.94 | 4 |
| Speedy innovation | 0 | 0.00 | 2 | 2.06 | 32 | 32.99 | 52 | 53.61 | 0 | 10.31 | 3.73 | 7 |

## Potential benefits of improved knowledge management

The main objective of this research is to establish effective approaches to improve knowledge management in the Malaysian construction industry. Questions in the survey proposed a set of potential benefits in improved knowledge management implementation. Generally, there is a highlighted importance in the proposed advantages. Improved decision-making, higher quality and productivity, and easier identification of occurrence of problems were ranked by the respondents as the top three potential benefits with mean values of 4.12, 4.11 and 3.96, respectively. The impending importance of such benefits is followed by effective communications at 3.94, contribution to the organization's intellectual capital at 3.93, increased customer value at 3.85, and speedy innovation at 3.73, as shown in Table 13. In addition, Table 14 displays the correlation matrix between the advantageous effects of improved knowledge management. Straightforwardly, the potential advantage to greater contribution to the intellectual capital of the organization is positively related to effective communications ($r = 0.535$) and speedy innovation ($r = 0.592$), where the p-value is estimated to be under 0.001. The analysis shows that improved decision-making is also moderately related to the benefit of easier identification of problems ($r = 0.486$). Such proposed benefits are key drivers for improvement efforts to enable successful and improved knowledge management. Naaranoja (2007) claimed that better management of knowledge within organizations will lead to improved performances.

## Results from interviews

In summary, all interviewees acknowledged the importance of implementing knowledge management in

**Table 14.** Pearson correlation matrix between potential benefits in improved knowledge management.

| Benefits in improved knowledge management | | Increased customer value | Higher quality and productivity | Contribution to intellectual capital | Easier identification of problems | Effective communications | Speedy innovation | Improved decision-making |
|---|---|---|---|---|---|---|---|---|
| Increased customer value | Pearson correlation<br>Sig. (2-tailed) | 1.000<br>- | Moderate | Moderate | Moderate | Moderate | Moderate | Moderate |
| Higher quality and productivity | Pearson correlation<br>Sig. (2-tailed) | **0.411<br>0.000 | 1.000<br>- | Moderate | Moderate | Moderate | Low | Low |
| Contribution to intellectual capital | Pearson correlation<br>Sig. (2-tailed) | **0.349<br>0.000 | **0.337<br>0.001 | 1.000<br>- | Moderate | Moderate | Moderate | Moderate |
| Easier identification of problems | Pearson correlation<br>Sig. (2-tailed) | **0.392<br>0.000 | **0.434<br>0.000 | **0.387<br>0.000 | 1.000<br>- | Moderate | Moderate | Moderate |
| Effective communications | Pearson correlation<br>Sig. (2-tailed) | **0.377<br>0.000 | **0.384<br>0.000 | **0.535<br>0.000 | **0.416<br>0.000 | 1.000<br>- | Moderate | Moderate |
| Speedy innovation | Pearson correlation<br>Sig. (2-tailed) | **0.352<br>0.000 | **0.273<br>0.007 | **0.592<br>0.000 | **0.326<br>0.001 | **0.467<br>0.000 | 1.000<br>- | Moderate |
| Improved decision-making | Pearson correlation<br>Sig. (2-tailed) | **0.330<br>0.001 | **0.289<br>0.004 | **0.335<br>0.001 | **0.486<br>0.000 | **0.335<br>0.001 | **0.473<br>0.000 | 1.000<br>- |

**Correlation is significant at the 0.01 level (2-tailed).

construction organizations. According to the participants, knowledge management has an adverse effect towards the entire organization if not implemented appropriately. Nonetheless, it is generally perceived that the practices of knowledge management have brought more benefits to the construction business. The researcher emphasized on the three levels of knowledge in organizations, namely: The individual (personal) level, the project level, and the organizational level. All three interviewees shared the same opinion that knowledge on different management levels are perceived and treated differently. As interviewee C highlighted, organizational knowledge management would generally be more geared towards the entire management of the organization such as human resources management, knowledge management, safety and health

**Table 15.** Summary of knowledge management approaches in varying stages.

| Knowledge management techniques | Stages within project A | | | |
|---|---|---|---|---|
| | Inception and planning | | Project commencement | Post project |
| | Intra org. | Inter org. | | |
| Brainstorming | ☑ | ☑ | ☑ | ☑ |
| Cross-functional teamwork | ☑ | ☑ | ☑ | |
| Face-to-face meeting | ☑ | ☑ | | ☑ |
| Job rotation and observation | | | ☑ | |
| Mentoring | ☑ | | | |
| Post project review | | | | ☑ |
| Project briefing and review | ☑ | ☑ | ☑ | |
| Recruitment | ☑ | ☑ | ☑ | |
| Storytelling | ☑ | | | |
| Technical gathering | ☑ | ☑ | ☑ | |
| Threaded discussion | ☑ | ☑ | | |
| Written reports and manuals | ☑ | ☑ | | ☑ |

management, time management and communication management. Whereas, for individuals, such driven knowledge is usually for the benefits and well-being of the individuals'. In addition, interviewee B stated that in many construction organizations, especially one that derives from a contractor's background, such knowledge management practices are barely formalized into structure programs or laid down in documentations. Interviewee B also emphasized that despite the lack of such formalization, varying levels of knowledge managing custom is still evident in such construction organizations despite the vagueness.

During first half of the interview, the researcher highlighted appropriate knowledge management concepts including tools, techniques, and methods commonly used in the local construction scene. Interview A, who is currently involved in an uprising construction property development in Mont Kiara, the northern suburb of Kuala Lumpur, stated "I personally think that meetings, regardless of either being impromptu, informal or structured – are the most effective in the entire lot. I personally think that it is probably the expectation of the globalization era, where everyone jumps into the bandwagon of technology savvy methods. Clearly, I can not deny the fact that such innovations are brilliant, but, they are still less powerful than the old-school methods." To add on, both interviewees B and C highlighted the infinite impossibilities to solely be dependent on technological advancement. From the viewpoints of these construction professionals, it is very certain that human aspects in knowledge management, in the construction industry are of utmost importance. The responses received from all three interviewees related to the question "what is the extent or regularity of knowledge management practices in the Malaysian construction industry?" were very subjective in nature. Interviewee C stated "the extent or how much knowledge management is being implemented goes back to my original point about the levels in which knowledge is more emphasized. If individual knowledge is the main priority, by all means, much extent cannot be seen as individual knowledge tends to be implied than real actions and structures. However, if organizational knowledge is the core value of the company, the results would be the opposite of what have been mentioned earlier."

In similar viewpoint, interviewees regard know-ledge sharing as the focal point or essence in the implementation of knowledge management in the local construction scene. Interviewee B then mentioned that the employment of knowledge management practices is highly dependable on the nature of the construction project. Interviewee A added that "you need to understand who you are working for. You certainly even need to know precisely what you are working at the end product. Simply, you need to know what advantages it brings. So if you are working in a different environment, more improved measures of managing knowledge needs to be done."

## Participant observation case study

### Knowledge management mechanisms

As Mohamed and Anumba (2004) highlighted, there is a need to look into the strategies and methods to fully utilize and maximize their potentials. Therefore, this participant observation case study first serves to identify and investigate the knowledge management approaches used in carrying out Project A. Table 15 depicts the overview of the knowledge management methods implemented during the stages of Project A. Each stage is further discussed alongside illustrations and examples

**Table 16.** Summary of IT tools and software used for knowledge management in project A.

| Information technology (IT) tools and software | Stages within project A | | |
|---|---|---|---|
| | Inception and planning | Project commencement | Post project |
| Email | ☑ | ☑ | ☑ |
| Telephone | ☑ | ☑ | ☑ |
| Facsimile | ☑ | | ☑ |
| Knowledge sharing board | | ☑ | |
| Help desks | | ☑ | |
| Computer aided equipment (that is, projector, desktops and laptops, etc.) | ☑ | ☑ | ☑ |
| Cameras/ video cameras | | ☑ | |
| Bulletin board | | ☑ | |

to support such occurrences in the following sub-section.

### Information technology (IT) tools and software used

Borghoff and Pareschi (1997) highlighted the debate on the functions that IT can play in knowledge management. Nonetheless, the danger in entirely viewing IT as the sole driven factor for successful knowledge management is apparent. As much as the benefits that IT can offer, the tacit perspectives in managing knowledge are inspired to be well-maintained. Table 16 shows the types of IT infrastructure and tools implemented in Project A. Such tools and equipments whether technological aided or vice versa, include telephone and facsimile, computers and the Internet, and so on. On the other hand, conventional pinned up bulletin boards and enquiry help desks, were also established to aid knowledge management practices. Each of the tools is then further discussed in the following sub-section.

### Output of performance

While knowledge management practices have the potential to improve the performance within construction organizations, such similar effects have taken place in Project A. After tedious months of planning, the commencement of the 3-day project finally took place. The response and performance of Project A was considered a success. Successful performance of construction projects are usually measured by the value of the output – such as, monetary values, client's satisfaction, etc. Similarly, Project A's lucrative performance was valued and judged mainly by the response as well as the feedbacks from project participants, as well as project team members. It is necessary for a feedback loop in any project cycle. Hence, during the post-project review meeting held two weeks later, the overall project budget was gone through thoroughly, and the number of people who registered and participated in Project A was also scrutinized. Such measures are taken to measure the performance of the project. Despite the profit gained in terms of monetary value, the successful performance of Project A was more geared towards the satisfaction of the client' (project participants).

## DISCUSSION ON THE RESULTS

With the vision and mission of the Malaysian government to create more construction opportunities to sustain and maintain the edge of the Malaysian construction industry amongst the international construction market, it has become a known fact that knowledge management is considered to be one of the prime enablers. It is clear and thus cannot be denied that knowledge is an important asset in organizations, more so now in this fast paced knowledge economy era. Generally, as it has been revealed that there is a productively symbiotic interrelation between the various forms of knowledge. For example, tacit knowledge is subjected to the obviously known explicit knowledge; and vice versa. As Marwick (2001) stated, through conceptualization, elicitation, and ultimately articulation, typically in collaboration with others, some proportion of a person's tacit knowledge may be captured in explicit form.

Findings reveal that the construction industry possesses a service-oriented nature which is highly dependent on people. Almost 60% of the respondents agreed that knowledge management has high dependency on human capital and almost 21% of them strongly agreed with this statement. Without showing disregard to the technical or technological based aspects of knowledge management, it was generally found that the involvement and participation of people, provide flexibility in enhancing the repositories and resources in construction organizations. Fortunately, there is a growing interest on the recognition of managing knowledge in the construction industry. In this respect, knowledge management is at the very quintessence of an organization. Hence, it should not be ignored, but reflective phases

need to be undertaken to bring the best out of it. The findings of the study have shown that top management responsibility is the key factors to successful knowledge management implementation. Further, in an in-depth manner, it was found that the "people factor" is the stimulus to seamless practices. Despite the fact that managing people is a holistic challenge, the findings of the study have demarcated a greater emphasis on human capital or asset as the industry grows in terms of size and innovation. As it is generally impossible to predict what the future holds; there is also possible falter in predicting the direction of knowledge management in the construction industry. Human resource management is an indispensable part of construction project management and requires a well-planned program for its development and implementation. Knowledge management can play a significant role through its implementation.

Though Malaysia is one of the British Commonwealth nations, in contrast with the study conducted in UK by Abdul-Hamid (2006), professionals in the Malaysian construction industry perceived stronger dependency on human capital, while technological advancement is said to be a minor supporting aspect for improved knowledge management. In comparison with the studies conducted by Pow (2006) and Low (2008) that only focused in summarizing knowledge management techniques, this study did not only identify, but also ranked knowledge management techniques used amongst Malaysian construction organizations, of which the top three are: Face-to-face meeting, mentoring, and training. In addition, this study identified critical factors in improving the standard of knowledge management in the Malaysian construction industry at the first time.

## Conclusion and Recommendations

This entire study, which was based on a survey conducted on construction professionals, involved several directors of construction organizations, architects, engineers, and quantity surveyors who concluded that the extent of the viability of knowledge management is still at its infancy stage. There is generally, a lack of insights and understandings or the practicability of knowledge management among construction players. The study found that the top three knowledge management techniques used amongst Malaysian construction organizations are face-to-face meeting, mentoring, and training. The issues of human capital and technological advancements as crucial knowledge management enablers are thoroughly investigated in this study. Professionals with more experiences in the industry, perceived stronger dependency on human capital, while technological advancement is said to be a minor supporting aspect for improved knowledge management. Thus, to overcome such barriers, results showed that critical factors such as leadership, commitment and support, motivation, and human resources have been recommended to optimize performances of construction projects and to improve knowledge management efficiency.

The research does provide avenues for future researches to analyze the integral part of knowledge management within organizations. Furthermore, this study has indicated and confirmed the most commonly adopted knowledge management approaches in the Malaysian construction industry as well as its success enablers. As such, future studies can be carried out to investigate in particular such types of technique improprieties in detail. Besides that, the factors and possible directions of knowledge management can be further enhanced to achieve the objective of the Malaysian construction industry to be a world-class provider, as well as an inter-nationally competent nation.

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