# Knowledge management for construction organisations: a research agenda

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## Abstract

**Purpose** – This paper aims to review the knowledge management (KM) processes, knowledge conversion modes and critical success factors (CSFs) and contextualise them to the construction setting to guide effective KM implementation.

**Design/methodology/approach** – This paper is conceptual in nature. It begins with a review of issues faced by construction organisations, which led them to consider implementing KM. This is followed by a comprehensive review of KM processes, knowledge conversion modes, KM CSFs and their application to the construction industry.

**Findings** – Based on the socialisation, externalisation, combination and internalisation (SECI) model, the knowledge conversion modes are discussed, linking them to the KM processes of knowledge creation, sharing, storage and application. The KM CSFs identified from construction literature suggest that they can be categorised into two groups, namely, factors within organisational control (managerial influence, technological influence and resource influence) and factors beyond organisational control (social influence, political influence, environmental influence, economic influence, industry influence and construction technology influence). The resulting review is discussed in terms of how construction organisations can implement KM effectively to achieve the desired project performance outcomes in terms of time, cost and quality.

**Research limitations/implications** – Although this paper has made some theoretical contributions, a quantitative analysis will further reinforce its value both in theory and practice, particularly in terms of applying the KM processes and CSFs to different organisational, industry and country settings. A quantitative research is being carried out in the major construction sector in Sri Lanka to establish the relationships between the KM processes, knowledge conversion modes and KM CSFs with project performance outcomes, which will be reported in a subsequent publication.

**Practical implications** – As the construction industry uses a considerable number of knowledge workers, implementing KM for project planning and execution is the key to sustaining the growth of construction organisations and industry, particularly when KM implementation is linked to project performance outcomes. Practical implications are provided in terms of what successful KM implementation entails.

**Social implications** – Effective KM implementation can serve as a conduit for construction organisations to build capacity and develop the ability to react quickly to social challenges brought about by different stakeholders, even before the project commences, so that the project performance outcomes will not be affected. Another social implication is the role played by project team members, in which efforts have to be put in place to facilitate the use of KM processes, so that teams can align project activities to the general good of their organisations.

**Originality/value** – A comprehensive KM framework that guides the construction industry on KM implementation is long overdue. This research represents the first of such attempts to view KM from a wider

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perspective, both in terms of internal and external influences affecting construction organisations. Once the conceptual framework developed is validated, it is expected to bring enormous benefits to different stakeholders.

**Keywords** Critical success factors, Construction organisations, Knowledge management processes, Knowledge conversion modes

**Paper type** Conceptual paper



## 1. Introduction

Knowledge management (KM) has infiltrated the world of managing and organising organisational activities and resources (Heisig *et al.*, 2016), and the construction industry is no exception. Traditionally, construction organisations have been known to use project management techniques in project planning and execution to achieve project management performance outcomes in terms of time, cost and quality (Handzic and Durmic, 2015; Yeong and Lim, 2010; Zhai *et al.*, 2014). However, the inability of such techniques in achieving the desired outcomes for the past 70 years have led construction organisations to search for a more viable and sustainable approach (Flyberg *et al.*, 2003), with KM identified as a promising one. This explains why a considerable number of construction organisations have turned to KM implementation (Idris and Kolawole, 2016).

Construction organisations are known to use a large number of knowledge workers (k-workers) in project teams which comprise project managers, engineers and technical staff from different backgrounds who work together to achieve the desired project performance outcomes. In fact, the knowledge of project team members has been deemed the most critical asset leading to successful project performance outcomes (Idris and Kolawole, 2016).

However, recent studies have suggested that construction organisations have little understanding of knowledge and KM (Idris and Kolawole, 2016). This is evident from the study of Handzic and Durmic (2015) where projects are still not delivered on time, within budget and the required quality, with a failure rate of up to 70 per cent. Because of this, many construction organisations are slow to implement KM in projects.

Further, studies conducted on this sector are still scarce (Ajmal *et al.*, 2010; Zhao *et al.*, 2013), with limited attempts to apply the KM processes and knowledge conversion modes to the construction setting. Another major issue is that the KM critical success factors (CSFs) proposed by researchers within the construction domain remain fragmented, with a comprehensive framework and definition yet to emerge, let alone a perplexing definition by Al-Tmeemy *et al.* (2011) who view KM CSFs in terms of end results rather than the means to achieve them in projects. This has further confused the construction industry regarding what KM CSFs really mean. It is therefore not surprising when Yeong and Lim (2010) discovered that project failures were attributed to poor KM implementation in project planning and execution, where the knowledge acquired from previous projects was not leveraged.

These issues suggest the imperative need to use proper procedures and techniques to acquire, create, share and store knowledge amongst the project staff (Donate and de Pablo, 2015) to ensure project performance success. Taking the cue from Drucker (1993) that the ability to identify and harness new knowledge is vital, particularly for project-based organisations to compete in this knowledge economy, this study reviews the KM processes, knowledge conversion modes and KM CSFs from the conceptual standpoint to guide construction organisations towards successful KM implementation to achieve the desired project performance outcomes. The resulting findings will benefit not only construction organisations but also policymakers and industry, particularly when supported by future empirical data to enrich the body of knowledge in this area.

The rest of the paper is organised as follows. The paper reviews the KM processes, knowledge conversion modes and KM CSFs as documented in the literature, followed by their applications in the construction setting. As a result, theoretical, practical and social implications and recommendations are derived at. The paper is concluded with directions for future research.

## 2. Literature review

### *2.1 Tacit vs explicit knowledge*

Polanyi (1962) categorises knowledge as both tacit (subjective) and explicit (objective). Whilst explicit knowledge is recorded as information, tacit knowledge resides with the people. Specifically, in the construction sector, explicit knowledge comprises standards, specifications, guidelines, drawings and conditions of contracts, to name some. On the other hand, tacit knowledge resides in the minds of employees of project teams which has to be acquired, stored, used and shared. Understanding the interaction between tacit and explicit knowledge will enable project team members to leverage on them, resulting in the creation of new knowledge (Nonaka, 1994) to solve various issues from project planning to execution, and to be used in future projects which is beneficial for achieving the desired project performance outcomes.

### *2.2 Knowledge conversion modes*

According to Nonaka and Takeuchi (1995), there are four modes of knowledge conversion, namely, socialisation, externalisation, combination and internalisation. This resulted in the development of the socialisation, externalisation, combination and internalisation (SECI) model of knowledge dimensions which explains how tacit and explicit knowledge are converted into organisational knowledge.

Interaction between project team members occurs frequently in the project environment. Frequent meetings are held to review the project progress, assess quality and cost, as well as to resolve any other issues that emerge from time to time. Socialisation activities of this nature are vital for the discovery of new ideas and concepts by project team members (Yang *et al.*, 2010). Because of this, Nonaka and Takeuchi (1995) opine that the knowledge creation cycle commences with socialisation, in which tacit knowledge is converted into explicit knowledge. Tacit knowledge resides in the minds of people (Polanyi, 1983) which is gained through direct experience of each individual in the project team. As each project has different requirements, the tacit knowledge gained is highly personal and difficult to formalise or transfer to others. It is only through socialisation activities that project team members transfer their experience through concepts or ideas which create new insights to address project-related issues.

The concepts and ideas created as a result of the socialisation process can be shared, disseminated and transferred to others through verbal and non-verbal means (Bratianu and Orzea, 2012), which activate the second mode of knowledge conversion cycle, namely, externalisation. Externalisation is the key mode out of the four modes of knowledge conversion, as new explicit knowledge is created from tacit knowledge (Nonaka *et al.*, 2001). In projects, externalisation takes place via the motivation of project staff to share their knowledge through efficient use of metaphors, analogies and cognitive models.

The resulting new knowledge created through the externalisation mode can be combined with the existing explicit knowledge to manage and enhance project activities effectively and efficiently. The combination mode (Nonaka and Takeuchi, 1995) is hence a process of creating new explicit knowledge structure and combining them with existing knowledge in the form of standards, specifications, codes of practices and meeting minutes, amongst

others, in a project. Such a combination of explicit knowledge, when put into practice, leads to the last mode of the knowledge conversion cycle, which is internalisation. Accordingly, in the internalisation mode, explicit knowledge is converted into tacit knowledge which is closely related to the concept of learning by doing (Bratianu and Orzea, 2012). Such practical application of knowledge is critical, as it improves the existing knowledge of project teams and leads to the creation of tacit knowledge to solve existing as well as address future issues in project activities.

### *2.3 Knowledge processes*

Wiig (1997) defines KM as processes which improve the effectiveness of organisations because of the use and continual renewal of knowledge assets. Lai and Chu (2000) define KM processes as the initiation, creation, modelling, repository, distribution and transfer, as well as use of knowledge in retrospect. To Stollberg *et al.* (2004), KM processes involve the identification, acquisition, preparation, allocation, dissemination, use and retention of knowledge. Peachy and Hall (2005) describe KM processes as knowledge capture, selection, storage and service. More recently, Gonzalez and Martins (2016) define KM processes as knowledge acquisition, storage, distribution and use. Alryalat and Al-Hawari (2008) define KM processes differently from other studies, namely, process for knowledge and process from knowledge.

Notwithstanding the different definitions, generally, KM processes can be defined by four continuous activities of knowledge creation, sharing, storage and application. These processes, as embedded in the SECI model, are regarded as the primary activities of KM (Wiig, 1993), whereas KM CSFs are recognised as secondary activities or enablers to support KM implementation (Salleh and Goh, 2002; Sharimllah Devi *et al.*, 2013; Wiig, 2000).

### *2.4 Knowledge management critical success factors*

Yong and Mustaffa (2013) acknowledge Rockart for being the first person to coin the term "critical success factors" or CSFs in 1982. Accordingly, CSFs suggest the more significant matters of which any industry or organisation should concentrate on at any given time to utilise their limited resources to succeed (Rockart, 1982). Since then, many industries have given due attention to CSFs to achieve business success (Yong and Mustaffa, 2013).

CSFs differ from organisation to organisation, industry to industry and even country to country. Hence, the identification of the right KM CSFs for the construction industry requires different situational evaluations which can be very subjective (Bullen and Rockart, 1981). To identify the CSFs that support KM implementation, it is imperative to understand KM, as many of the success factors are derived from the definition of KM itself.

Beijerse (2000) defines KM as management of information within the organisation, which is characterised by culture, structure, strategy and systems, as well as capabilities of individuals. These characteristics have been regarded as amongst the CSFs to support KM implementation. To the construction organisations, these CSFs are imperative in enabling them to mobilise the right resources at the right time in view of the dynamic context of technology, budget and human resources during project planning and execution, taking into consideration the culture and structure of the organisations. These KM CSFs can influence the decision-making process of these organisations in terms of the KM processes to be implemented to achieve effectiveness and efficiency (Jennex and Olfman, 2006) of projects (Al-Zaharani, 2013; Rangasamy and Ghosch, 2002) in terms of time, cost and quality (Nilashi *et al.*, 2015).

As KM CSFs differ between organisation, industry and/or country, a comprehensive set of factors needs to be identified (Idris and Kolawole, 2016). To achieve this, a thorough search of

literature relating to KM CSFs in construction organisations was carried out using Google Scholar by pairing key words between "knowledge management critical success factors" and "construction projects", "construction", "infrastructure" or merely "projects". The use of these key words led to other publications related to "building", "housing" and "contractors". As a result, nine related studies were identified, published between 1997 and 2016, covering different countries with varying CSFs. The KM CSFs were analysed to identify a common theme for them to be clustered together. The different sets of KM CSFs were then clustered under a bigger group, i.e. influence, in which the influences were subsequently categorised to provide a bigger picture and for appropriate implications and conclusions to be drawn from the analysis. The use of this method was supported by the study of Scarso *et al.* (2008), which established a framework for analysing the CSFs of communities of practice within the sphere of KM.

Following this systematic revision methodology, the earliest study conducted by Davenport *et al.* (1997) on the construction industry has identified eight CSFs:

- industry value;
- organisational infrastructure;
- standard flexible knowledge structure;
- culture;
- motivational practices;
- different channels for knowledge sharing;
- support from senior management; and
- clarity of language and purpose.

Wang *et al.* (2014) and Zang (2005) found 11 CSFs for public–private infrastructure organisations. They consist of:

- leadership and support;
- information technology (IT);
- strategy and planning;
- culture;
- organisational infrastructure;
- KM resources;
- conferences, training and education;
- motivational aids;
- processes and activities;
- measurement; and
- human resource management.

Specifically, Wang *et al.* (2014) found that culture, strategy and IT are CSFs for successful project execution.

A study by Idris and Kolawole (2016) on the Nigerian construction industry identified the following CSFs: strategy; culture; leadership; organisational infrastructure; IT; KM technical activities; KM resources; and KM conferences, training and education. The study found significant relationships between strategy, culture, organisational infrastructure, IT, KM technical activities and KM implementation.

These studies share one common characteristic, whereby CSFs are viewed as internal issues managed by the organisation. These issues influence organisational decision taking, which is the case of many other studies as well (King *et al.*, 2008; Musa *et al.*, 2015). Specifically, these studies aim to integrate human, physical and financial resources to achieve the desired project performance outcomes. However, Yong and Mustaffa (2013) define CSFs to also include factors beyond the control of organisations. Specifically in the Malaysian construction projects, the following five major categories have been identified:

(1) factors related to project;
(2) factors related to procurement;
(3) factors related to project management and planning;
(4) factors related to project stakeholders; and
(5) factors related to external environment.

Factors related to projects include the complexity of the project and urgency in meeting project deadlines. Factors related to procurement consist of competitive procurement, transparency in procurement process and the tendering method. Factors related to project management and planning include mutual trust amongst project stakeholders, effective communication amongst them, strong commitment amongst project stakeholders, working relationship with them and goal setting. These are the factors identified to be within organisational control (Yong and Mustaffa, 2013).

The two factors beyond organisational control include factors related to stakeholders (project financing, confidence of clients in the construction team, technical and managerial skills, adaptability to amendments in project plans, leadership and authority, involvement in and monitoring of project progress, as well as effective project budget monitoring) and external environment (economic, social, political, weather conditions, industry-related issues, construction technology, regulatory changes, problems with surrounding neighbours and unforeseen site conditions) (Sambasivan and Soon, 2006). In addition, Kokou and Akogbe (2014) categorise external environmental factors to include sub-contractors and suppliers, market and customers. Li *et al.* (2005) and Yong and Mustaffa (2013) also place great emphasis on human-related soft factors, particularly during the project management, planning and implementation stages to achieve project performance outcomes.

Al-Tmeemy *et al.* (2011) found 13 CSFs for building projects from the perspective of contractors. The criteria include time, cost, quality, safety, functional requirements, competitive advantage, market share, scope, reputation, revenue and profits, as well as benefits to stakeholders. However, from the KM perspective, these CSFs are defined in terms of the ends to be achieved and not the means of achieving the ends.

It can be observed that the KM CSFs remain fragmented despite some similarities. Based on the review, two major categories of KM CSFs are proposed. Table I shows the summary of KM CSFs within organisational control, whilst Table II shows the CSFs beyond organisational control as identified from the literature.

The factors within organisational control have a direct impact on individuals of construction organisations as shaped by organisational processes and procedures. They are further categorised into three sub-categories: managerial influence, technological influence and resource influence. Factors related to managerial influence include:

- industry value;
- support from and authority of senior management and organisational leaders;
- motivational practices and aids;

| No. | Categorisation by authors | Source(s) |
|---|---|---|
| 1. | Managerial influence | Industry value (Davenport *et al.*, 1997), support from and authority of senior management and organisational leaders, motivational practices and aids (Davenport *et al.*, 1997; Idris and Kolawole, 2016; Sambasivan and Soon, 2006; Wang *et al.*, 2014; Zang, 2005); strategy and planning (Idris and Kolawole, 2016; Wang *et al.*, 2014; Zang, 2005); culture (Davenport *et al.*, 1997; Idris and Kolawole, 2016; Wang *et al.*, 2014; Zang, 2005); teamwork, process and activities, performance measurement (Wang *et al.*, 2014; Zang, 2005); benchmarking (Salleh *et al.*, 2013); involvement in and monitoring project progress and effective project budget monitoring (Sambasivan and Soon, 2006) |
| 2. | Technological influence | IT (Idris and Kolawole, 2016; Wang *et al.*, 2014; Zang, 2005); KM technical activities (Idris and Kolawole, 2016); different channels for knowledge sharing, flexible knowledge structure and clarity of language and purpose (Davenport *et al.*, 1997) |
| 3. | Resource influence | Financial support, KM resources, human resource management (Wang *et al.*, 2014; Zang, 2005); organisational infrastructure (Davenport *et al.*, 1997); KM conferences, training and education (Idris and Kolawole, 2016; Wang *et al.*, 2014; Zang, 2005) |

**Table I.** Summary of studies on KM CSFs in the construction setting (within organisational control)

| No. | Categorisation by authors | Source(s) |
|---|---|---|
| 1. | Social influence | People affected because of the project, surrounding neighbours affected because of project activities and people benefited from the project (Sambasivan and Soon, 2006) |
| 2. | Political influence | Sources of finance, confidence of politicians, regulations, adaptability to amend project plans (Sambasivan and Soon, 2006) |
| 3. | Environmental influence | Weather conditions and ground conditions of project (Sambasivan and Soon, 2006) |
| 4. | Economic influence | Economic stability and sound economic policy (Yong and Mustaffa, 2013) |
| 5. | Industry influence | Availability of resources (Yong and Mustaffa, 2013), subcontractors and suppliers, and market price of material and labour (Kokou and Akogbe, 2014; Sambasivan and Soon, 2006) |
| 6. | Construction technology influence | IT and online platform, and new construction methods (Yong and Mustaffa, 2013) |

**Table II.** Summary of studies on KM CSFs in the construction setting (beyond organisational control)

- strategy and planning;
- culture;
- teamwork;
- process and activities;
- performance measurement;
- benchmarking;
- involvement in and monitoring project progress; and
- effective project budget monitoring.

Factors related to technological influence include:

- IT;
- KM technical activities;
- different channels for knowledge sharing;
- flexible knowledge structure; and
- clarity of language and purpose.

Factors related to resource influence include:

- financial support;
- KM resources;
- human resource management;
- organisational infrastructure;
- KM conferences; and
- KM training and education.

Sambasivan and Soon (2006) point out that when these internal CSFs are clearly identified, the construction managers can take proactive action to avoid the negative impacts resulting in project delays, poor quality and cost overrun.

The KM CSFs beyond the control of the construction organisations can be divided into six sub-categories:

(1) social influence;
(2) political influence;
(3) environmental influence;
(4) economic influence;
(5) industry influence; and
(6) construction technology influence.

Factors related to social influence include:

- people affected because of the project activities;
- surrounding neighbours affected because of the project activities; and
- people benefiting from the project.

Factors related to political influence include:

- sources of finance;
- confidence of politicians;
- regulations; and
- adaptability to amendment of project plans.

Two KM CSFs have been identified under the environmental influence, namely, weather conditions and ground conditions of projects. Factors related to economic influence include economic stability and sound economic policy. The three factors related to industry influence are:

(1) availability of resources;
(2) subcontractors and suppliers; and
(3) market prices of materials and labour.

Whilst the two factors related to construction industry technology include:

- IT and online platform; and
- new construction methods.

These CSFs impose opportunities and threats to construction organisations (Sedighi and Zand, 2012), and hence, they influence the project performance outcomes although construction organisations have little control over them.

In addition, a review of the CSFs found that factors in one category can influence factors in other categories, for example, technological influence (internal) and construction technology influence (external). The external CSFs influence internal CSFs as well (Sedighi and Zand, 2012). Because of this, Yong and Mustaffa (2013) suggest that the ability of construction organisations to understand and obtain relevant information through proper KM implementation will enable them to react actively to changes in the environment, taking into consideration the strengths and weaknesses of their internal environment to achieve the desired project performance outcomes.

It is also apparent from the review that whilst the factors within organisational control have been investigated, it is apparent that external environmental factors have been given little attention in KM literature. Hence, this study proposes a set of comprehensive KM CSFs to support the KM processes in the construction industry which can be applied to different organisational, industry and country settings. The following section provides a conceptual review of the KM CSFs, where their relations to KM processes in the construction setting are discussed.

## 3. Conceptual review of the KM critical success factors

### *3.1 Managerial influence*

Support from senior management in implementing KM has been acknowledged as one of the most important CSFs (Davenport *et al.*, 1997). KM implementation will fail if the management of construction organisations does not see its value in terms of a promising alternative to the existing project management techniques in planning and managing project execution (Idris and Kolawole, 2016) to bring about the desired project performance outcomes. Accordingly, top management must demonstrate the leadership styles required to champion KM implementation (Singh, 2008).

Similarly, the importance of motivation and goal orientation of project teams in achieving project deliverables has been documented (Salleh, 2009). Motivating project teams in setting their goals in terms of project deliverables by engaging them in KM activities throughout the project will help to overcome various challenges and ensure that the desired deliverables are met. To do so, a knowledge-friendly culture needs to be created within construction organisations, as KM is largely people-based (Chong and Choi, 2005; Larson, 1999).

Many researchers have also reached a consensus that teamwork is a CSF to support KM implementation (Chong and Choi, 2005; Conley and Zheng, 2009; Cristina, 2009; Kanagasabapathy *et al.*, 2006). Accordingly, teams have been found to outperform in a collaborative environment to achieve common team goals through the sharing of knowledge and skills (Conley and Zheng, 2009; Enshassi *et al.*, 2016; Harris and Harris, 1996). This is

particularly applicable to construction organisations where project management involves many project teams during the various stages of project execution, i.e. technical, procurement, quality control, progress monitoring and construction supervision. The knowledge and skills possessed by each team member is vital to execute various project activities to achieve the goals and objectives of each project team with project performance outcomes in mind.

Performance measurement is recognised as a key performance indicator in any industry. Virtually, every market and customer are demanding for products and services that are of higher quality at lower cost. In the construction industry, clients often demand for projects to be completed on time with the agreed cost and quality (Idris and Kolawole, 2016). This implies that the construction organisations need to measure their performance frequently to achieve the desired project performance outcomes. Traditionally, financial measures have been used to measure and evaluate project progress as well to ensure effective project budget monitoring. However, the knowledge-based economy calls for non-financial and intangible measures to be considered as well in measuring the performance of organisations (Chong and Choi, 2005; Cristina, 2009; Kanagasabapathy *et al.*, 2006; Wong, 2005). Such measures are necessary since KM deals with the intangible assets of any organisation, i.e. knowledge and skills of project team members to capture the impact of KM (Carneiro, 2001).

Similarly, benchmarking – a structured process which enables the enhancement of current organisational standards by adopting superior practices (Moffett *et al.*, 2008) – has been identified as a CSF to support KM implementation in many studies (Kale and Karaman, 2011; Kanagasabapathy *et al.*, 2006; Luzia *et al.*, 2013) across many industries (Carpenter and Rudge, 2003). Benchmarking involves comparing local construction organisations with those of international standing which possess the capability to compete with the local organisations (Sedighi and Zand, 2012), as well as between projects internally (Chong *et al.*, 2006).

### *3.2 Technology influence*

Knowledge is often fragmented in construction projects, as different employees provide different inputs to the same project. Every project is expected to utilise knowledge systematically and actively to monitor any deviation so that corrective actions can be taken on a timely basis. On this score, information and communications technology (ICT) can support the KM processes where the knowledge acquired and held by the k-workers can be captured and transferred quickly to others through different channels such as e-mail, databases and through other means such as Intranet, workflow whiteboard, videoconferencing and data mining (Berraies *et al.*, 2014; Riggins and Rhee, 1999; Storck and Hill, 2000), hence enabling project team members to learn, solve problems and make decisions faster (Jeng and Dunk, 2013). When accessibility to knowledge improves, an environment of knowledge sharing is created.

In addition, ICT also enables new knowledge to be created (Gold *et al.*, 2001) through the identification and codification of tacit knowledge held by project team members not only to solve problems and arrive at decisions for project execution but also to be used for future projects. The flexibility of knowledge structure further ensures effective communication amongst project team members working in proximity as well as in distant locations. However, it is worth noting that IT is just an enabler.

### *3.3 Resource influence*

The construction industry needs to constantly acquire new technologies, materials, processes and systems to add value to construction projects. Because of this, availability of

financial support is crucial not just for the execution of project activities but also investment in KM (Sedighi and Zand, 2012).

Sedighi and Zand (2012) highlighted the importance of finance to support training and development of project team members. As a matter of fact, employee training has been identified as one of the CSFs to support KM implementation (Chong, 2006) not just to meet project requirements but also to achieve the desired project performance outcomes. In fact, Wong (2005) insisted that the budget for training should be viewed as a strategic investment rather than cost, and that the impact of training should be seen as a long-term measure. More importantly, learning increases interaction amongst employees, which creates new knowledge for the organisation (Lee and Choi, 2003).

In addition, construction organisations also need to invest in appropriate KM resources and human resources to drive KM implementation. For this, Nejatian *et al.* (2013) emphasise that people with T-shaped skills (managerial expertise in addition to technical expertise) are of paramount importance to the industry as they have a direct effect on knowledge sharing and development. Besides recruiting people with T-shaped skills, construction organisations can also develop such skills in their existing employees through training and application of the relevant skills to be used in projects (Shao *et al.*, 2013).

### *3.4 Social influence*

Project delays often occur because of the protests by the people affected by project locations (Sambasivan and Soon, 2006). Protests can be because of many reasons, including delays in compensations and relocation of the people affected. Protests may also be made by people affected by air, dust, sound pollution and/or traffic congestions. These stakeholders can exert powerful social influence by organising committees and pressure groups, which may lead to political influence. Besides protests, social influence may also come from other stakeholders who have vested interest in the projects. Although this factor cannot be controlled, this suggests the need for construction companies to take social acceptance and consequences of projects into consideration.

### *3.5 Political influence*

Although successful completion of projects has been defined in terms of achieving project cost, time and quality (Navarre and Schaan, 1990), project success is also characterised by the degree of safety, stakeholder satisfaction and long-term business impact. As such, politicians are increasingly playing the role of an important project stakeholder, particularly in large infrastructure projects. Governments are also major investors in these projects, either on their own or through public–private partnership initiatives. Hence, they have a major say on project activities and in defining the measure of project success, especially when the projects are defined and enforced by government regulations. Realising this, there is a need to build trust and confidence in politicians, whereby involving them early in projects through effective communication channels can create an environment of healthy and sustainable working relationships (Andersen *et al.*, 2006; Yong and Mustaffa, 2013). As a result, better quantity and quality of information sharing can be established.

### *3.6 Environmental influence*

The natural environment is changing rapidly because of many factors beyond the control of human beings. However, with proper systems, tools and mechanisms in place, weather and ground conditions can be predicted up to a certain degree of reliability. Having said so, although there exist web tools to predict weather conditions and identify ground conditions of projects (Jeng and Dunk, 2013), adverse weather conditions such as flood and cyclones are

largely unavoidable. Using KM processes to obtain and share information on environmental influence is hence critical for construction organisations. The information gathered and stored can be analysed to make predictions on the effect of environmental influence on the duration, cost and quality of construction projects.

### *3.7 Economic influence*

The construction industry contributes significantly to the gross domestic product (GDP) of any country. The US$1.7tn industry contributes 5 to 7 per cent to the GDP of most countries in the world (Kenny, 2007). Economic stability is hence necessary for the construction industry to expand their resources and participate in the growth of the sector. It is for this reason that Yong and Mustaffa (2013) opine that sound economic policy and economic stability are vital for construction organisations to sustain in the long run. Accordingly, a sound economic policy emphasises the priority areas to invest in to gain competitive advantage. For some developing countries, large construction activities such as power stations, irrigation systems and transportation systems such as highways, airports and seaports are required to compete with other economies (Biller and Nabi, 2013; Vidal and Marle, 2008). Economic policies, which change from time to time, will influence the performance of projects and sustainability of construction organisations.

The construction industry needs to take cognisance of both the economic stability and economic policy of its respective countries to expand the internal capabilities of its organisations. The patterns of global, regional and local economic policies and stability in relation to the construction sector could be studied by leveraging on the KM processes to obtain such information. Such studies would facilitate better and more accurate prediction of economic influences which have taken place and how they would affect construction organisations in the future, enabling project teams to anticipate changes and make informed decisions.

### *3.8 Industry influence*

When the construction industry in a country booms, human and physical resources are stretched and are often insufficient to support the construction activities. Construction organisations will need to look for resources from outside the industry or even country. These include subcontractors and suppliers, as well as human and other physical resources which influence the price and quality of materials, as well as labour (Kokou and Akogbe, 2014). Utilising the KM processes not only enables the resources to be identified but also helps construction organisations to develop a network to collect and share information on prices, quality and availability of resources. Such information could be shared with subcontractors and suppliers so that projects can be completed on time, with minimum cost and of acceptable quality.

### *3.9 Construction technology influence*

New construction technologies continue to be developed to minimise the use of resources and reduce the time taken to complete a construction project. These technologies, which include IT, online platforms and new construction methods, can emerge from different parts of the world. Organisations which leverage on these technologies will possess competitive advantage in terms of enjoying better project performance outcomes compared to those who do not. This calls for the construction organisations to make effective use of the KM processes to gain knowledge on innovative technologies that provide optimum benefits to them (Yong and Mustaffa, 2013).

## 4. Discussion and implications

### *4.1 Discussion*

The review suggests that for effective KM implementation, there is an imperative need for the construction organisations to put in place proper procedures and techniques for knowledge creation, sharing, storage and application by leveraging on the tacit and explicit knowledge of project team members to activate the knowledge conversion modes (socialisation, externalisation, combination and externalisation). Socialisation is the key to knowledge creation, whereas externalisation activities are important for knowledge sharing amongst project team members. The new knowledge created, which is combined with existing knowledge, needs to be stored. Internalisation involves knowledge that needs to be practised to manage future project-related activities (Laihonen *et al.*, 2015). These processes are carried out over time in an interactive and concerted manner so that new and existing knowledge is created, shared, stored and applied, taking into consideration both the processes for and from knowledge (Alryalat and Al-Hawari, 2008).

To encourage the use of KM processes, the construction organisations must leverage the support provided by KM CSFs. In so doing, an important distinction must be made between KM processes and KM CSFs. An understanding of the differences between the two is important for the construction organisations so that the KM processes can be properly executed for successful KM implementation to achieve the desired project performance outcomes.

Whilst a considerable number of studies have focussed on CSFs which are within organisational control, literature has also shed light on the CSFs beyond organisational control that impact on project planning and execution as well. Whatever the factors may be, literature suggests that a comprehensive understanding of the KM CSFs is vital to support KM implementation by construction organisations to achieve the desired project performance outcomes.

The next sub-section provides the research, practical and social implications arising from this review.

### *4.2 Research implications*

The attempt to review literature on KM processes and knowledge conversion modes and relate them to the construction industry perspective, as well as the identification of a comprehensive set of KM CSFs, using an established methodology in such setting enables an all-encompassing KM framework to be developed to guide effective implementation of KM. This research thus represents the first of such attempts to view KM from a broader perspective, addressing the fragmented nature of KM CSFs in this industry.

Having said so, as this research is conceptual in nature, an empirical survey is imperative to validate the proposed framework so that appropriate KM strategies can be formulated for construction organisations to achieve the desired project performance outcomes. This is especially prevalent in light of the differences in KM CSFs between one country, industry or organisation to another, which has implications on the varying degree of importance of the CSFs within and beyond organisational control. A proper identification of the more significant KM processes, knowledge conversion modes and KM CSFs will enable construction organisations to determine which areas that should be given more attention in view of the scarcity of resources possessed by them. Along with this is the consideration given to the different sizes and characteristics of construction organisations, as well as the diverse activities of project team members.

*4.3 Practical implications*

Through the development of a comprehensive KM framework encompassing the KM processes, knowledge conversion modes and KM CSFs, this paper has enhanced the understanding of construction organisations on what it takes to successfully implement KM to achieve the desired results.

The resulting review enables a number of recommendations to be derived at for the construction organisations in terms of factors to be considered when implementing KM. To begin with, an understanding of knowledge, KM processes, knowledge conversion modes and CSFs is imperative. This study sheds light on the interactions between knowledge conversion modes, KM processes and KM CSFs in the construction setting to enhance such an understanding. Specifically, it highlights the importance of institutionalising a formal process of identifying tacit knowledge, documenting and combining it with explicit knowledge to be shared amongst team members in existing and/or future project execution. It also emphasises the importance of having a clear understanding of the primary KM activities of knowledge creation, transfer, storage and application for construction organisations to start implementing KM. A thorough road map based on the project activities needs to be created to map the tacit and explicit knowledge possessed and those required to determine the procedures, techniques, tools and mechanisms to enable the knowledge conversion modes to take place.

In addition, the study also highlights the importance of considering the KM CSFs, both within and outside the control of construction organisations, as enablers to support KM implementation in the construction industry to achieve the desired project performance outcomes. By considering just the internal factors may only provide the organisations with a snapshot which may not contribute to meeting their desired deliverables. This will further demotivate the construction organisations intending to implement KM, given the significant time, resources and efforts required. The identification of opportunities and threats can inform construction organisations on the capacity needed to obtain information and act on them during project planning and execution.

Overall, the study suggests that top management of construction organisations plays an important role to recognise the value of KM and subsequently devise appropriate strategies to implement it. Strong leadership is required to provide strategic direction, plans and authority in terms of goals and objectives of each project (Bolisani and Scarso, 2015), and that appropriate KM strategies that incorporate the goals and objectives will enable a suitable environment to be forged for the creation, storing, sharing and use of knowledge which leads to the effective functioning of project planning and execution to achieve the desired project performance outcomes (Hansen *et al.*, 1999).

For this, Singh (2008) insists that the consulting and delegating type of leadership is significant to support KM implementation. This is applicable to construction projects which involve many consulting activities where expertise in numerous disciplines is required to execute them. The consulting type of leadership can influence the use of shared knowledge between the senior and junior project staff, which subsequently affects the degree of success of project execution (Zizek *et al.*, 2017). The same goes to delegation where there are different tiers in the organisational structure of projects, namely, the project manager, site manager, construction manager, technical manager, engineer, assistant engineer, foreman, supervisor and manual workers. Because projects encounter many challenges throughout the project life cycle which affect the morale of project team members, top management plays an important role in proper delegation of responsibilities and tasks at different levels for effective execution (Aleksic *et al.*, 2017). It is for this reason that Nonaka and Takeuchi (1995) insist that middle-top-down management style is important for knowledge creation.

Top management also plays an important role to empower and delegate responsibilities to its project managers to maintain the motivational level of project team members to set collective goals and to engage them in knowledge sharing (Geraint, 1998). The existence of synergy between team members will ensure their willingness to contribute and participate in knowledge activities to ensure successful team achievements (Gu *et al.*, 2016). For this to happen, management must constantly look for ways to motivate team members to share their knowledge in achieving common goals rather than concentrating on individualised, competitive goals (Enshassi *et al.*, 2016; Luca and Tarricone, 2001).

There is a need to establish a knowledge-friendly culture within construction organisations. This is particularly important when project team members have different beliefs, thinking patterns and work behaviours shaped by their diverse cultural backgrounds. A culture based on organisational trust, confidence, collaboration and learning amongst the project team members is vital to enable the project team members to think and behave in a consistent manner, as well as to encourage them to use their knowledge in project activities (Scarborough *et al.*, 1999) without underestimating their skills. Such a culture leads to trust, subsequently enabling knowledge creation, sharing and use in construction organisations (Jeng and Dunk, 2013), as well as amongst project teams (Davenport and Prusak, 1998; Hassen and Semercioz, 2010). In addition, a culture of collaboration also enables project team members to assist each other to address various technical and managerial issues (Lee and Choi, 2003). This allows for continuous exchange of knowledge, skills and expertise between the project team members, particularly from those with richer expertise in technical and project management skills to other team members, thus allowing learning to take place (Alavi *et al.*, 2006) to accept the changes that are often encountered in projects and propose necessary remedial actions to yield better project performance outcomes (Covey, 2013).

Investment in people with T-shaped skills is of paramount importance, as they have a direct effect on knowledge sharing and development. This is of the view that project team members with such skills are able to identify and pre-empt possible situations. The same goes to investment in training on KM. Budget allocation should not only be restricted to training programmes in project-related areas but also to KM itself (Bratianu and Leon, 2015; Ojambati *et al.*, 2012). Such training programmes would enable project team members to relate project activities to KM practices which lead to desired project performance outcomes. This can be accomplished by sending employees for appropriate KM training, conferences and education. In addition, construction organisations can leverage on IT for the provision of training. Since team members are often busy with project activities, training in the form of e-learning can also be offered as an alternative solution to facilitate learning.

There is also a need to consider performance measures that take into account the KM processes and KM CSFs. The management of construction organisations play an important role to recognise the value of intangible assets (Sedighi and Zand, 2012). On this score, the organisations could use the balanced scorecard approach to capture both the tangible and intangible outcomes (Chong *et al.*, 2006), as it provides a balanced measurement of financial, customer, process and learning and growth perspectives (Kaplan and Norton, 2001). This approach can be used at both business and project levels in terms of incorporating KM into the vision, mission, goals and strategies of construction organisations, as well as defining the overall goals and objectives of each project.

Specifically, at the project level, project costs and returns can be identified as financial measures, whilst intellectual property, quality, safety, functional requirements, competitive advantage and reputation, amongst others, can be identified as non-financial measures. Customer perspective is captured via satisfaction in terms of timely

completion of projects with the required quality, as well as meeting the requirements of other stakeholders who affect or are affected by the projects. These require project planning and execution activities and processes to be properly charted in sequential order, i.e. construction of foundation, structure and finishes, excavation, concreting, masonry, plastering and painting works, including the foreseeable challenges and how the KM processes can support these activities and address those challenges. Milestones in the form of key performance indicators introduced by Ahmad (2010) can be used to measure each stage of the project, where the outcomes of knowledge used and created can help to identify project performance gaps. The financial, customer and process perspectives require continuous learning and growth of project team members who apply their knowledge to meet project goals and objectives. This will help to monitor project progress on a frequent basis against the strategic goals and objectives of construction organisations (Robinson *et al.*, 2004).

The construction organisations can also carry out benchmarking exercise to identify superior practices within their organisations, as well as other organisations which have successfully implemented KM. Ideally, the organisations should commence benchmarking from within before looking at outside (Chong *et al.*, 2006). By looking at the superior practices from successful projects within organisations, they do not have to solve the same problems repeatedly and cost is saved. External benchmarking should be encouraged in areas where the construction organisations are lacking, such as in promoting the culture of KM and learning (Bratianu and Leon, 2015).

The KM CSFs beyond control of construction organisations also need to be considered, i.e. by capturing the knowledge required on the external environmental factors facing the industry in the balanced scorecard. As the factors in one category can influence factors in other categories, particularly the influence of external on internal KM CSFs (Sedighi and Zand, 2012), the identification of the external KM CSFs will enable construction organisations to identify threats and opportunities and map them to their strengths and weaknesses in project execution to keep track of environmental changes and/or uncertainties and react on them to achieve the desired project performance outcomes.

The review suggests that by having an IT system can support the KM processes internally, as well as in obtaining and using external information. By understanding and adhering to respective laws and regulations affecting the activities of construction projects through information stored in IT system can help build trust and confidence in governments to continue investing their resources in construction organisations which show potential to meet project deliverables. Wherever possible, the resulting information should allow construction companies to modify their project plans as and when required.

The same platform can be used to obtain information on weather and ground conditions to make predictions about the environment, as well as the economic conditions and policies affecting the construction industry so that any threat can be minimised, and perhaps converted into opportunities for construction organisations. In this case, clarity of language and purpose is vital to motivate project team members to leverage on the KM processes. This underscores the need to allocate sufficient budget to support investments in the IT infrastructure required in terms of hardware and software, as well as other organisational infrastructure and KM-related resources.

It is also possible for the construction organisations to form a network amongst themselves to learn about KM, share technologies and learn from each other. They can also form strategic collaborations and partnerships with other IT and/or research and development companies to maintain an optimal investment in KM, as well as in developing

newer construction technologies. Policymakers also have an important role to play by creating a platform for the industry to obtain information on KM, provide incentives and resources and to support its implementation in view of the significant contribution of the construction industry to the economy.

### *4.4 Social implications*

Many infrastructure projects suffer because of rejection by society at the inception of the project itself. Relocation of people in the neighbourhood creates much resistance despite the compensation provided, not forgetting interest groups which fight for a certain cause, e.g. a pollution-free environment. All these challenges need to be anticipated, with mitigation plans to minimise the negative social impact to be considered.

The capacity and ability to react to social changes is of paramount importance to the construction industry. Proper KM implementation can allow construction organisations to identify possible social pressures in advance and react quickly by taking appropriate action to avert any negative impact brought about by affected stakeholders such as people in the neighbourhood, protesters, lobbyists, societies and pressure groups. Keane and Caletka (2008) have also identified trade unions, local authorities, specialists and professionals which exert equally powerful social influence on projects. The use of KM platforms to acquire, store and share information on a variety of social pressures can enable construction organisations to develop mitigation plans, communicate and build relationships with affected stakeholders so that the project performance outcomes will not be affected (Odeyinka and Yusif, 1997; Takim and Adnan, 2008).

Another social implication that cannot be ignored is the role played by project team members. It is not uncommon for individuals to hoard knowledge for fear of the loss of ownership (Avey *et al.*, 2009). This is particularly prevalent in project teams that are transient in nature and are disbanded after the project is completed (Ajmal *et al.*, 2010) or individual members who compete for organisational recognition and rewards. Besides recruiting staff with T-shaped skills, construction organisations need to create an environment of mutual trust and meaningful relationships amongst project team members so that they are willing to share their knowledge for the general good of the organisation.

## 5. Conclusion and future research directions

This paper has achieved its objectives by comprehensively reviewing the knowledge processes, their interactions with knowledge conversion modes and KM CSFs, as well as applying them to the construction setting with the hope of guiding proper KM implementation to achieve the desired project performance outcomes.

Whilst a comprehensive list of KM CSFs was proposed, the paper did not purport to suggest a list of CSFs to be prioritised on. An empirical investigation integrating all the KM CSFs is necessary. Another important consideration is the inclusion of demographics such as organisational size and the characteristics of project teams, which may call for focus on different KM CSFs. An empirical research linking the KM processes, knowledge conversion modes, KM CSFs and project performance outcomes, moderated by the demographic factors, is currently being undertaken on construction organisations in Sri Lanka. The findings will further reinforce the value of this paper, both in theory and practice. The results will be reported in a subsequent publication.

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