“Knowledge integration challenges and critical success factors within construction traditional procurement system”

AUTHORS	Mohammad Takhtravanchi https://orcid.org/0000-0002-0827-7229 Chaminda Pathirage https://orcid.org/0000-0002-9372-677X

ARTICLE INFO	Mohammad Takhtravanchi and Chaminda Pathirage (2018). Knowledge integration challenges and critical success factors within construction traditional procurement system. *Knowledge and Performance Management*, *2*(1), 24-37. doi:10.21511/kpm.02(1).2018.03
DOI	http://dx.doi.org/10.21511/kpm.02(1).2018.03
RELEASED ON	Thursday, 11 October 2018
RECEIVED ON	Tuesday, 13 February 2018
ACCEPTED ON	Thursday, 20 September 2018

JOURNAL	"Knowledge and Performance Management"
ISSN PRINT	2543-5507
ISSN ONLINE	2616-3829
PUBLISHER	LLC “Consulting Publishing Company “Business Perspectives”
FOUNDER	Sp. z o.o. Kozmenko Science Publishing

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
21	3	7

BUSINESS PERSPECTIVES

LLC "CPC "Business Perspectives"
Hryhorii Skovoroda lane, 10, Sumy,
40022, Ukraine

www.businessperspectives.org

Mohammad Takhtravanchi (UK), **Chaminda Pathirage** (UK)

KNOWLEDGE INTEGRATION CHALLENGES AND CRITICAL SUCCESS FACTORS WITHIN CONSTRUCTION TRADITIONAL PROCUREMENT SYSTEM

Abstract

The purpose of this study is to explore and identify the challenges and Critical Success Factors (CSFs) of Knowledge Integration (KI) in terms of capturing, sharing and transferring knowledge within construction projects based on the Traditional Procurement System (TPS). On the basis of available studies on KI and TPS within the industry investigated, multiple case studies were developed to reach the aforementioned objective, involving two case studies to reflect the building sector within construction industry. Furthermore, an Interpretive Structural Modelling (ISM) approach was used to summarize and identify the relationships between the identified challenges. 'Culture of Organization, 'Contractual Boundaries' and 'Knowledge Management System' (policies and strategies of organization) are identified as the main challenges. Having an 'open environment' and 'clear liability of project members for sharing knowledge at different phases of project' are two of identified CSFs, which will assist project managers to enhance the KI process within construction projects undertaken through the TPS.

Received on: 13th of February, 2018
Accepted on: 20th of September, 2018

Keywords Knowledge Integration, Knowledge Management, Traditional Procurement System, construction project, project management

JEL Classification L20

Mohammad Takhtravanchi, Ph.D., School of the Built Environment, University of Salford, Salford, UK.

Chaminda Pathirage, Ph.D., School of the Built Environment, University of Salford, Salford, UK.

INTRODUCTION

Knowledge is meaningful, reflection and abstraction of information that resides in people's minds and is influenced by cognitive frameworks, experiences, skills, perception and intuition. It is a meaning made by the mind that can create rules, comprises lessons learned, predicts outcomes, organizes principles, creates problem-solving methods and explains relationships. As knowledge is a critical resource, Knowledge Management (KM) is a fundamental and mandatory issue that brings success to organization. It is essential for organizations, specifically in knowledge-based industries like construction. They recognize that an effective use of their knowledge may enable them to be innovative and improve the project performance in terms of reliability, cost, and quality while reducing project costs. In other words, knowledge and KM can bring sustainable competitive advantage, which is critical for construction organizations.

KM is a wide concept that includes various processes among which the three main ones are: capturing, sharing and transferring. Using these three processes together can integrate knowledge within project-based organizations, which tend to embark on rework thereby often repeating the same mistakes again. Researchers use different terminology for Knowledge Integration (KI). Carlilo (2004) indicates that

http://dx.doi.org/10.21511/kpm.02(1).2018.03

KI is the process of transferring, translating and transforming knowledge between individuals involved within the same organization. KI is defined as "the process of transferring knowledge, both tacit and explicit, across organizational boundaries, sharing it with individuals and teams at the recipient site, and applying the resultant knowledge to solve problems" (Haddad & Bozdogan, 2009). Farzin et al. (2014) state KI as the process of combining and holding individuals' information and knowledge in order to create new knowledge. The operational definition of KI in this research is the process of capturing, sharing, and transferring knowledge, both tacit and explicit, within and across projects. This will result in reusing knowledge, enhancing problem-solving process and project performance. In the construction industry, project knowledge mostly resides in minds of project members and is frequently not captured and transferred across projects in order to be used in future (Shokri & Chileshe, 2014). This means that knowledge is not integrated structurally between project members and across projects. In other words, construction industry suffers from lack of KI. As the nature of construction projects and its teams is temporary, the continuity of using the same project team members in the future projects will decrease, which leads to project knowledge loss. Within this context, the failure to integration knowledge will result in increasing the possibility of 'reinventing the wheel', which means spending more time, cost and losing competitive advantage within the industry. Therefore, one of the key factors in improving construction project performance is how to structurally integrate knowledge and its utilization in projects (Winch, 2010; Forman et al., 2011; Shokri-Ghasabeh & Chileshe, 2014). In this regard, project managers face challenges to integrate knowledge that are required to be tackled.

1. LITERATURE REVIEW

1.1. Knowledge integration in construction project

One of the main factors that cause the unnecessary construction rework cost is the design mistakes that are mostly caused by lack of training, experience and knowledge (Love et al., 2011). Researchers (Heylighen et al., 2007) indicate that the design team, specifically designers, are highly secretive, not keen to share their knowledge and use KI techniques (Panuwatwanich et al., 2012). In other words, the social network between project members at design phase needs to be developed and improved in order to capture and share innovative knowledge, which is created through designing process in construction projects (Bashouri & Duncan, 2014).

The effective KI will enhance project members and organizations to respond rapidly to problems and facilitate processes, specifically in the designing phase. Each construction project is unique and has its own problems and, therefore, it is the responsibility of the members of the project team to use their previous experience and knowledge to resolve them. Moreover, each project will add new experience and knowledge to the project team. Salter and Gann (2003) suggest that the project knowledge held by project team plays a key role in solving problems. The competitive advantage of organization and successful completion of a project lie in the ability of effectively integrating knowledge (Hari et al., 2005). Therefore, KI plays a significant role in improving performance of organizations in terms of quality, time, reliability and reducing costs, specifically in project-based industries like construction.

1.2. Knowledge integration in Traditional Procurement System

The KI procedure is critical to project performance (Nonaka & Takeuchi, 1995), especially in a project-based industry like construction. Due to the temporary nature of construction projects, people who worked on these projects, both in the design and construction team, tend to disperse after the project ends. This means their experiences and the knowledge they have achieved through the project will be wasted and not be used in future projects, if it is not captured structurally (Kasvi et al., 2003). The importance of KI has attracted discussions in both academia and industry. As knowledge is the most value-added input and output of projects, then the study of KI between teamwork within project and across projects will provide a meaningful insight for stakeholders and academics that enable them to further improve the performance and competitiveness of the industry. This issue is more apparent in projects undertaken through the Traditional Procurement

System (TPS) as its nature is based on the separation of design and construction process. In other words, the TPS does not guarantee an integrated line of communication and reporting between consultants and contractors.

The main factor that distinguishes the TPS from other types of procurement methods like 'Design and Build', 'Develop and Construct', 'Package deal', and 'Turnkey' is the separation of organizations that are responsible for the implementation process of the main elements of the project like designing and construction. In this method, the design team works are based on pre-defined conditions, which are different from site conditions encountered by contractors at construction phase. The contractors involve long after the designing is finished, thus their knowledge of constructability, value engineering and so forth is slightly incorporated at the construction phase. This separation directly impacts the process of KI during project lifecycle.

According to CIOB report (2010), people involved in the designing team have less experience on construction practices. Furthermore, the report indicates that lack of communication, design team problems, and design faults are the most significant problems that arise within the TPS. As the period of the design and construction phases is lengthy, good communication needs to exist between all members of a project. Secondly, the TPS suffers from a lack of buildability during the design and construction phases. Designers are not motivated and well experienced enough to manage the construction work and the cost and time of a project effectively. There is no ethos of sharing knowledge between the design and construction phases in a TPS due to the liability concerns, misinterpretation of the information, risks, and unauthorized reuse of intellectual properties (Aziz et al., 2012; Love et al., 2013). Additionally, the people involved in the construction phase are unable to contribute to the design of a project until it is too late. However, not only identifying the challenges of KI that exist within the TPS, but also the Critical Success Factors (CSFs) for tackling them will enhance the KI process and enable the project managers to improve the project performance, which benefits all parties involved in a project. Therefore, the aim of this research is to identify the challenges and CSFs of KI within a construction project undertaken through the TPS.

2. RESEARCH METHODOLOGY

The research aims to explore and identify the challenges and CSFs of KI in terms of capturing, sharing and transferring knowledge within construction projects based on the TPS. The first stage of this research included a thorough study of the relevant literature, which aimed to understand the concept of KI and its challenges in the TPS. The main part of the research, the second stage, involved conducting multiple case studies that included two case studies from the building sector within construction industry. According to CIOB (2010), the TPS is the most efficient and suitable method only for projects up to £5m, but it is primarily used in projects that overran in terms of costs and time. Therefore, the selected projects were complex, large and costed over £5m. The selected case studies differ in that one of them is a completed project and the other is an ongoing project at construction phase. As most of the problems and errors occurred in project lifecycle are related to designing phase, the cases were selected from same organization involved at designing phase in order to analyze and compare the process of KI. Overall, three organizations, including one designing and two construction, were involved in the case studies. The outcomes obtained from the case studies allow to draw some conclusions on the challenges and CSFs of KI adopted by designing organizations.

The main research tool was semi-structured interviews, where a number of open-ended questions were used in order to identify the key challenges and CSFs of KI. The questions allowed respondents to give their views based on their own experiences concerning the challenges within traditional construction projects and the factors that affect KI within this type of procurement. Respondents were selected based on their understanding and knowledge of these concepts: KM, KI, Knowledge Capturing, Knowledge Sharing, Knowledge Transferring, and Construction Projects undertaken through the TPS. The interviewees' profile is illustrated in Table 1.

The interviews lasted one hour and some were extended as the interviewees were very open and eager to talk and discuss their experiences.

http://dx.doi.org/10.21511/kpm.02(1).2018.03

Furthermore, all interviews were audio-recorded – with interviewees' permission – then transcribed and entered into NVivo software. Thematic analysis was undertaken of the transcripts with a particular focus on the challenges of KI in terms of capturing, sharing and transferring knowledge. The results of both case studies analysis were synthesized and compared with findings from the literature review in order to identify challenges and CSFs. Furthermore, an Interpretive Structural Modelling (ISM) approach was used to summarize and identify the relationships between the identified challenges. ISM is a quantitative technique to analyze qualitative data. This approach has been used by researchers to identify and represent interrelationships among various variables related to the issue (Raj & Attri, 2011). In this research, for confidentiality reasons, the companies' names mentioned in transcripts are pseudonyms.

Table 1. Interviewee's profile

Interviewee	Case study (CS)	Experience with organization	Total experience
Project manager	CS1, CS2	15 years	25 years
Architect	CS1	8 years	13 years
Site manager	CS1	10 years	18 years
Engineer	CS1	4 year 3 months	11 years
Architect	CS2	3 years 7 months	6 years
Site manager	CS2	15 years	35 years
Engineer	CS2	6 years 5 months	16 years

3. FINDINGS

The unique characteristic of the TPS, also known as the separated method, is the separation of responsibility within the design phase and the construction phase in the procurement process of the project. Previous research (Masterman, 2002; Takhtravanchi & Pathirage, 2016) has only identified challenges of KM, in general, within a construction project undertaken through TPS (Table 2). In this research, KI mainly focuses on three main processes of KM. Therefore, these challenges were further used in both structuring the interviews questions and analysis of findings from case studies with the aim of identifying KI challenges and their differences with KM challenges.

Table 2. KM challenges within the TPS

Source: Authors.

No	Challenges
1	Lack of awareness of the importance of tacit knowledge and its management
2	Lack of participation in knowledge management
3	Lack of time for participation in knowledge management (time pressure)
4	Lack of information and knowledge management
5	Lack of knowledge management system (policies and strategies)
6	Reinventing the wheel (high potential for the same mistakes and problems occurring)
7	Lack of incentives
8	Lack of proper use of knowledge management techniques
9	Lack of trust
10	Culture of organizations
11	Resistance to change (fear of change)

3.1. Knowledge integration challenges

A cross-sectional analysis was conducted of the case studies to identify the current challenges of KI in TPS. The responses from the interviews were analyzed with the help of computer software. The process started using a qualitative content analysis of the interviews' transcripts with the aid of NVivo software, which generates codes according to the identified concepts within the transcripts. The findings establish that knowledge in the design phase is more problematic and harder to manage due to the complexity of the design phase. This knowledge refers mostly to personal, and the company's, experience. The analysis revealed 10 challenges, which are shown in Table 3 and further analyzed through using ISM approach in order to identify the relationship between them.

Table 3. KI challenges within the TPS

Source: Authors.

No	Variables
1	Lack of awareness of the importance of tacit knowledge integration
2	Lack of participation in knowledge integration
3	Lack of time
4	Lack of information and knowledge integration
5	KM system (policies and strategies)
6	Lack of incentives
7	Lack of proper use of knowledge integration techniques
8	Lack of trust
9	Culture of organizations
10	Contractual boundaries

3.1.1. Interpretive Structural Modelling approach

The ISM-based approach can use practical experience and knowledge of experts based on various management techniques like brain storming, nominal group technique, etc. to decompose a complicated system into several elements and construct a multilevel structural model (Warfield, 1976). In other words, it can be used to identify and summarize relationships among specific variables, which define an issue or a problem. The various steps involved in the ISM approach, which are as follows (Charan et al., 2008):

Step 1: Identify and select the relevant variables. In this research, the challenges of KI in TPS have been identified.

Step 2: Structural Self-Interaction Matrix (SSIM) is developed. This matrix is used to indicate pair wise relationship among variables of the system under consideration

Step 3: Determine the reachability matrix. The SSIM matrix is used to develop the reachability matrix. However, the transitivity of the contextual relationships is a basic assumption made in ISM. This means if variable A is related to variable B and variable B is related to variable C, then variable A is necessarily is related to variable C.

Step 4: Decompose the reachability matrix into different levels. The developed reachability matrix from step 3 is partitioned into different levels in order to create structural model, a directed graph (diagraph), and the transitive links are removed.

A. Structural Self-Interaction Matrix (SSIM)

The SSIM is a contextual relationship among the variables and is developed based on opinions of interviewees. For this purpose, the interviewees from case studies were consulted in identifying the nature of contextual relationship among the variables. In order to analyze the variables, a contextual relationship of 'leads to' and 'facilitates' type must be chosen. This means that one variable leads to another or one variable facilitates another variable. Therefore, contextual relationship between the identified variables is developed.

Bearing in mind the contextual relationship for each variable and the existence of a relationship between any two variables (*i* and *j*), the associated direction of the relationship is questioned in a pair wise manner. Four symbols are used to denote the direction of relationship among variables:

1. *V* is used when variable *i* will facilitates or in fluences variable *j* (the relation from variable *i* to variable *j*).
2. *A* is used when variable *i* will be facilitated or influenced by variable *j* (the relation from variable *j* to variable *i*).
3. *X* is used when variable *i* and *j* will facilitate and influence each other (both direction relations).
4. *O* is used when variables *i* and *j* are unrelated (no relation between the variables).

The developed SSIM (see Table 4) represents the contextual relationships between identified KI challenges.

Table 4. Self-Structured Interaction Matrix

Source: Authors.

Variable	*V1*	*V2*	*V3*	*V4*	*V5*	*V6*	*V7*	*V8*	*V9*	*V10*
V1	–	*V*	*V*	*V*	*A*	*O*	*V*	*O*	*A*	*O*
V2	–	–	*A*	*V*	*A*	*A*	*A*	*X*	*A*	*A*
V3	–	–	–	*V*	*A*	*A*	*A*	*X*	*A*	*A*
V4	–	–	–	–	*A*	*A*	*A*	*A*	*A*	*A*
V5	–	–	–	–	–	*V*	*V*	*V*	*A*	*A*
V6	–	–	–	–	–	–	*V*	*X*	*O*	*O*
V7	–	–	–	–	–	–	–	*X*	*A*	*A*
V8	–	–	–	–	–	–	–	–	*A*	*O*
V9	–	–	–	–	–	–	–	–	–	*O*
V10	–	–	–	–	–	–	–	–	–	–

B. Reachability matrix

The next step in ISM approach is to transform the SSIM into a binary matrix, called the initial reachability matrix by substituting four symbols *V*, *A*, *X* and *O* to 1 or 0. The rules for this substitution are as follows:

1. If the (*i*, *j*) entry in the SSIM is *V*, then the (*i*, *j*) entry in the reachability matrix becomes 1 and the (*j*, *i*) entry becomes 0.

http://dx.doi.org/10.21511/kpm.02(1).2018.03

2. If the (i, j) entry in the SSIM is *A*, then the (i, j) entry in the reachability matrix becomes 0 and the (j, i) entry becomes 1.

3. If the (i, j) entry in the SSIM is *X*, then the (i, j) entry in the reachability matrix becomes 1 and the (j, i) entry becomes 1.

4. If the (i, j) entry in the SSIM is *O*, then the (i, j) entry in the reachability matrix becomes 0 and the (j, i) entry becomes 0.

Following these rules, the initial reachability matrix is illustrated in Table 5.

Table 5. Initial reachability matrix

Source: Authors.

Variable	*V1*	*V2*	*V3*	*V4*	*V5*	*V6*	*V7*	*V8*	*V9*	*V10*
V1	1	1	1	1	0	0	1	0	0	0
V2	0	1	0	1	0	0	0	1	0	0
V3	0	1	1	1	0	0	0	1	0	0
V4	0	0	0	1	0	0	0	0	0	0
V5	1	1	1	1	1	1	1	1	0	0
V6	0	1	1	1	0	1	1	1	0	0
V7	0	1	1	1	0	0	1	1	0	0
V8	0	1	1	1	0	1	1	1	0	0
V9	1	1	1	1	1	0	1	1	1	0
V10	0	1	1	1	1	0	1	0	0	1

The final reachability matrix is developed by considering the concept of transitivity, which was described in step 3 of SSIM approach. The 1* entries indicate the incorporate transitivity. The final reachability matrix along with the dependence and driving power is shown in Table 6.

Table 6. Final reachability matrix

Source: Authors.

Variable	*V1*	*V2*	*V3*	*V4*	*V5*	*V6*	*V7*	*V8*	*V9*	*V10*
V1	1	1	1	1	0	0	1	1*	0	0
V2	0	1	1*	1	0	1*	1*	1	0	0
V3	0	1	1	1	0	1*	1*	1	0	0
V4	0	0	0	1	0	0	0	0	0	0
V5	1	1	1	1	1	1	1	1	0	0
V6	0	1	1	1	0	1	1	1	0	0
V7	0	1	1	1	0	1*	1	1	0	0
V8	0	1	1	1	0	1	1	1	0	0
V9	1	1	1	1	1	1*	1	1	1	0
V10	1*	1	1	1	1	1*	1	1*	0	1

C. Level partitions

According to Warfield (1976), the reachability and antecedent set are derived from final reachability matrix. The reachability set for each variable consists of the variable itself and the other variables that it may impact, whereas the antecedent set for each variable consists of the variable itself and the other variables that may impact it. Following that, the intersection of these sets is obtained for all variables. Subsequently, the variables for which the reachability and intersection sets are the same occupy the top level in the ISM hierarchy. The top-level variables are those that will not lead the other variables above their own level. After identifying the top-level variable, it is removed from the other remaining variables. Then the same process is continued until levels of all variables are identified. These levels help in building the diagram and the final model of ISM.

Table 7. Partitioning of variables

Source: Authors.

Variable	Reachability set	Antecedent set	Intersection	Level
V1	1, 2, 3, 4, 7, 8	1, 5, 9, 10	1	III
V2	2, 3, 4, 6, 7, 8	1, 2, 3, 5, 6, 7, 8, 9, 10	2, 3, 6, 7, 8	II
V3	2, 3, 4, 6, 7, 8	1, 2, 3, 5, 6, 7, 8, 9, 10	2, 3, 6, 7, 8	II
V4	4	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	4	I
V5	1, 2, 3, 4, 5, 6, 7, 8	5, 9, 10	5	IV
V6	2, 3, 4, 6, 7, 8	2, 3, 5, 6, 7, 8, 9, 10	2, 3, 6, 7, 8	II
V7	2, 3, 4, 6, 7, 8	1, 2, 3, 5, 6, 7, 8, 9, 10	2, 3, 6, 7, 8	II
V8	2, 3, 4, 6, 7, 8	1, 2, 3, 5, 6, 7, 8, 9, 10	2, 3, 6, 7, 8	II
V9	1, 2, 3, 4, 5, 6, 7, 8, 9	9	9	V
V10	1, 2, 3, 4, 5, 6, 7, 8, 10	10	10	V

http://dx.doi.org/10.21511/kpm.02(1).2018.03

Source: Authors.

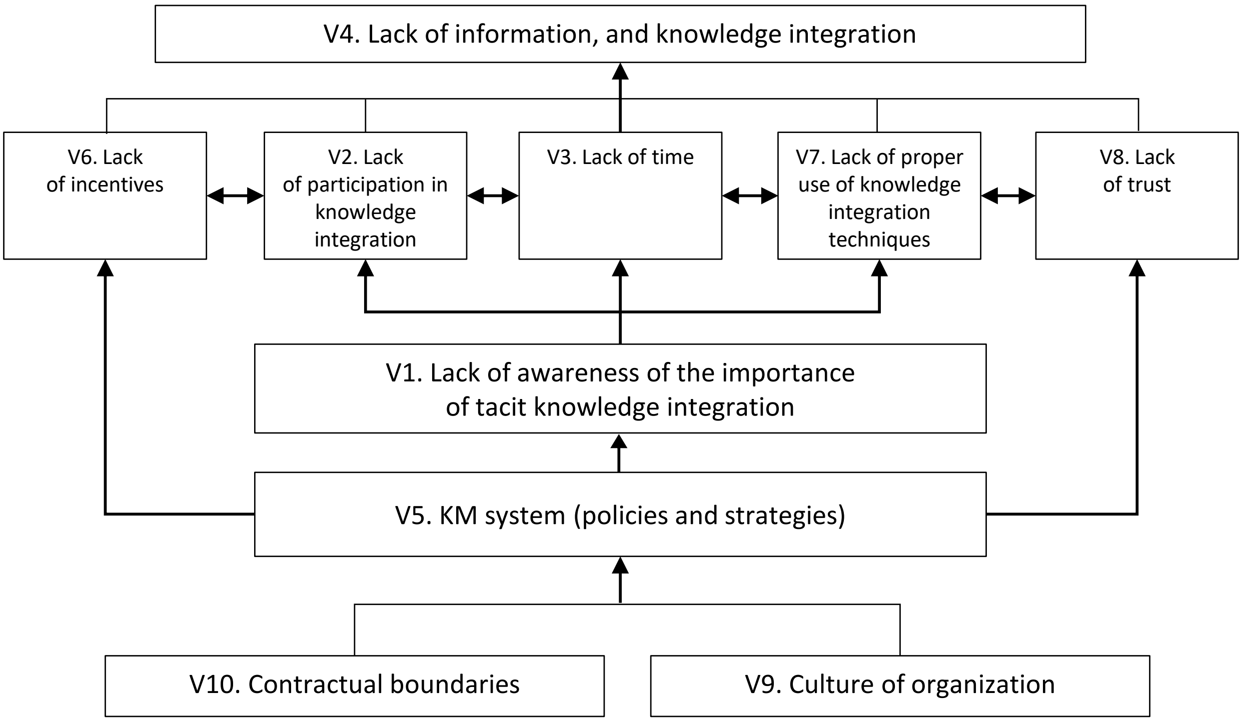

Figure 1. ISM-based model of KI challenges in the TPS

The reachability set, antecedent set, intersection and the participation level of variables are shown in Table 7, where all variables are distributed in five levels. Variable 4 (lack of information and knowledge integration) is found to be at level I. Therefore, variable 4 should be positioned at the top of the ISM model. Variable 9 and 10 (contractual boundaries and culture of organization) are found to be in the last level, V, which should be positioned at the bottom of the ISM model. Positioning at the bottom level of ISM model means that these variables are the main root of all variables positioned above them.

D. Formation of ISM-based model

It can be seen in Figure 1 that the 'Culture of organization' along with 'Contractual boundaries' are significant challenge when integrating knowledge in the TPS, as they come at the bottom of ISM hierarchy. The ISM model highlights the major challenges of KI and provides a mean for analyzing the interaction between these challenges. These challenges need to be tackled in order to ensure the success of KI in the TPS.

3.2. Critical success factors for knowledge integration

This section presents the data analysis in relation to the CSFs of KI in the traditional construction projects that were highlighted by interviewees in case studies. Figure 2 shows the themes that emerged from the analysis of the semi-structured interviews on the CSFs. The main themes are 'Culture of organization', 'Contractual boundaries', and 'KM system (policies and strategies), which are further discussed.

3.2.1. Culture of organization

The organizational culture is one of the important factors that affect the process of integrating tacit knowledge within TPS where different organizations with different culture involved in the project. Effective organizational culture depends on having an open environment to communicate and share individual ideas and experiences. An open environment means providing a trusted working environment, where project members dedicate enough time to share their knowledge with each other. Project manager CS1 and site manager CS2 stated:

http://dx.doi.org/10.21511/kpm.02(1).2018.03

Source: Authors.

Critical Success Factors

Name	Sources	References
Critical Success Factors	0	0
Contractual Boundaries	0	0
Clear liability of project members for sharing knowledge at different phases	7	15
Culture of Organisation	0	0
Open Environment	7	13
KM System (policies and strategies)	0	0
Adopting proper tools for KI	7	15
Adopting two-stage process traditional procurement	7	13
Building Trust	7	12
Designing sub-contractors use software that can be synchronised	7	12
Having Clear definition of objectives	7	11
Improving awareness on the importance of KI	7	15
Incentivise project members for participation in KI	7	15

Figure 2. Screenshot showing nodes on CSFs of Knowledge Integration

We have friendly environment. Internally, within the department our team members easily approach each other. We are working together as a one team. I think this is because we trust each other. The project managers creates this environment and gave us this feeling … within each team, I know exactly who I'm going to share my knowledge with and they are willing to share their knowledge with me.

Participants believed that project members should dedicate enough time to do lessons learned and that it should be done as soon as each task is completed. The lessons learned could be achieved through the meetings with contractors and consultants and between contractors. Engineer CS1 and architect CS2 stated:

I think it is very important to always ensure as soon as you finish the project to actually identify what works well and what doesn't. We always had problem in arranging meetings with contractors and consultants to document the problems and how they were solved after each phase of project, because contractors and consultants are recruited to another project whilst one is finished … I think the first is the reflection; we need to dedicate enough time to reflect and identify what went wrong.

3.2.2. Contractual boundaries

Project managers (CS1 and CS2) and site manager CS1 argued that in the TPS, contractual boundaries play a significant role in sharing knowledge between project phases, because it is the provisions of the contract that dictates the amount of knowledge and the liability of project member for sharing knowledge with other contractors.

It was clearly mentioned in our contract how to communicate and respond to '3Styles Group'. In the traditional, because we are liability for the design, we are responsible for the type of information and knowledge to share with 'Balbo Ltd' … In the traditional, the ethos of sharing knowledge is not there, and it depends on the contracts how much knowledge you shared.

Participants believed that the liability of project members on sharing information and knowledge at different project phases should be clarified in the contract. Furthermore, this clarification will enable both the project and knowledge manager to adopt appropriate policies and strategies for managing knowledge. Project and site manager CS1 stated:

As I explained earlier, we communicate with '3Styles Group' according to our contract. It is mentioned in the contract that I, as a project manager, should respond to enquiries that comes from them in a short time … Although their communication is according to their contract, but it takes time, as they have to send their request through email with full details of issue and asking for meeting, then we will arrange a date to discuss about the issue and resolve it.

3.2.3. KM system (policies and strategies)

The importance of KM lies in the fact that knowledge if managed properly is a valuable, competitive asset for organizations. It is more significant in construction projects undertaken through the TPS due to the fragmentation nature of this system, where the design team is separated from construction team. Therefore, it is important for organizations to adopt appropriate policies and strategies for managing knowledge in this type of project. The KM system includes how to integrate knowledge in terms of capturing, sharing, and transferring.

Participants (architect CS1 and project manager CS2) believed that effective the KM system in organization should initially improve the awareness of project members of the importance of KI in all its categories: capturing, sharing, and transferring.

I think everybody knows the value of knowledge and their experience, but the idea of integrating knowledge needs a bit more exploration, specifically in this type of procurement. The issue is in sharing and transferring part, in our organization I am willing to share my experiences with colleagues, but in this type of procurement, we have to share and collaborate with other organizations, that's where people have doubts. In terms of transferring, I think it is a good idea and needs a good strategy and plan from the beginning of project to prevent similar problem occurrence.

"Not in this particular project, in another project when it was over budget the client suggested having a meeting with contractors and consultants to identify what went wrong and where the problems was. Things like that are very helpful to make sure in the next time doing a project with a same and similar nature you won't do the mistakes twice.

This improvement requires adopting the proper tools in techniques and technologies for KI and having a clear definition of objectives. Most of interviewees highlighted that an effective KM system should build trust between project members and incentivize them to participate in KI. Project managers and site managers CS1 and CS2 stated:

I think the first is the reflection; we need to dedicate enough time to reflect and identify what went wrong. Two, now when we identify what went wrong, when we are working on second project, how clear are objectives, and how maybe some kind of methods statement or some kind of procedures which uses what we have learnt and how that is going to achieve our next objective. However, we also need to use the best tools for both achieving objectives and recording the lessons learned. When there is clear objective, it is easy to identify what you are trying to achieve and by then it is easy to actually see what works and what being used then in project.

We have friendly environment. Internally, within the department our team members easily approach each other. We are working together as a one team. I think this is because we trust each other, the project managers creates this environment and gave us this feeling.

I think KM and specifically KI will achieve greater success if there is good support from management and team leaders. People should be incentivized to participate in recording their experiences, sharing them with their colleagues and reusing their lessons learned. This motivation from leadership has a positive influence on team performance.

However, in terms of sharing knowledge between different phases of the project, participants believed that construction team can be involved a bit earlier (ahead of completion of the design) in the TPS in order to improve the teamwork, advice on best practice and decrease the possibility of 'reinventing the wheel' by sharing their knowledge and experiences. This requires improvement in the awareness of the client on the importance of appointing the contractors earlier (two-stage tendering traditional project). Furthermore, interviewees stated that the use of the BIM technology can facilitate the project's performance. They reported that sub-contractors at the design phase use the different designing software that leads to designing clashes: therefore, it is required to use software that can be synchronized to improve the communication of information. In this regard, participants noted that implementing BIM technology would minimize the occurrence of designing clashes and could improve the project performance. Architects CS1 and CS2 stated:

I think one problem that leads to designing clashes is using different software by sub-contractors that

http://dx.doi.org/10.21511/kpm.02(1).2018.03

cannot synchronized. It depends on the policy of organization to use what type of software. We didn't use BIM in this specific type of project, but we used it before. Although this technology is more used in other types of procurement, but I think it is applicable in the traditional procurement.

I think team-working and collaboration are important in this type of procurement, the early you can appoint and import contractors, more knowledge will be shared, and the less likely the common mistakes occur. As I mentioned before, this project is based on two-stage traditional project and we really benefit from having construction team earlier in terms of saving time and preventing designing clashes.

The mentioned CSFs are further discussed based on the classification of challenges after implementing the ISM approach.

4. DISCUSSION

Carrillo et al. (2000) stated that one of the main challenges that confront KM in construction industry is 'tacit dimension of project knowledge'. Regarding this, Aziz et al. (2014) said that this issue is more common in integrating tacit knowledge in construction projects undertaken through the TPS due to the nature of this system which is based on fragmentation rather than integration. In other words, knowledge is not properly integrated in this system in terms of capturing, sharing, and transferring, because the design and construction team are separated and project members are recruited in another project ahead of the completion of the current project.

The aim of conducting a case study as part of the research strategy was to explore KI within the traditional construction project in order to identify existing challenges and CSFs that organizations have for integrating tacit knowledge. In this regard, two cases were selected with having the same designing organization, one completed and one ongoing. The purpose was to analyze, compare and evaluate the process of KI within projects that have been designed by the same organization. The findings revealed that the KI was not structurally and completely implemented by the designing organization. The synthesis of case studies identifies a set of challenges that exist in the TPS (Table 3).

Comparing these findings with findings from literature (Table 2) reveals that most of them are similar and one of them is new. The 'Contractual boundaries' is identified as a new variable that affects the KI in the TPS. Figure 1 reveals that 'Culture of organizations' is positioned at the bottom level of ISM hierarchy along with the new variable 'Contractual boundaries'. The impact of these variables on the other variables is through 'KM system (policies and strategies)'. This means that these variables are the root of other variables that finally lead to lack of information and KI, which is positioned at the top level of ISM hierarchy. Project managers should consider these challenges and investigate them in order to effectively integrate knowledge. The rest of variables are mainly affected by these challenges.

Kamara et al. (2002) stated that transferring knowledge between different organizations involved in a project highly depends on the type of contract and contractual clauses. The 'Contractual boundaries' plays a significant role in bidirectional flow of knowledge between the design and the construction phase of a project, because it is the contract that dictates the way of communication of project members at different phases. Additionally, positioning this challenge below of 'KM systems' means the KM policies and strategies that are adopted by organizations for sharing knowledge between project phases in the TPS depends on the provisions of the contract.

In order to tackle this challenge, it is suggested to thoroughly consider and improve the communication and collaboration of the design and construction team in the provisions of their contract. This requires clarification of the liability of project members on sharing knowledge at different phases of project. Additionally, the awareness of the client and his consultants should be improved on the importance of KI and the benefits of importing contractors before completing the designing phase in the project (two-stage tendering traditional procurement). According to Masterman (2002), the involvement of contractors ahead of completion of the designing phase means more collaboration and sharing of knowledge with the designing team on best practices and lessons learned, which will lead to saving time, cost, and minimizing the designing and buildability issues. In other words, this would improve the project performance and decrease the possibility of reinventing the wheel.

Hari et al. (2005), Bessick and Naicker (2013) highlighted 'organizational culture' as the most important challenge in integrating knowledge in construction projects. The case studies findings highlighted the 'Culture of organizations' as another main challenge of KI within the traditional construction project. Existence of the supporting culture in organizations is required for having an efficient collaboration between project members in capturing, sharing and transferring tacit knowledge within the traditional construction project. This supporting culture means having an open environment in which project members are incentivized to work and communicate with each other. Additionally, it depends on the culture of the organization to adopt an appropriate KM strategy that prioritizes and incentivizes project members to participate in integrating tacit knowledge.

The key to this challenge is having an open environment (supporting culture), which improves the awareness of the project manager in the importance of KI. In this regard, Kwawu et al. (2010) stated that the organizational culture should be supportive in terms of improving awareness and willingness to participate in the KI process. This will lead to adopting an effective KM system that uses the appropriate tools and techniques to build trust, increase awareness of project members on the importance of KI and encourage them to participate in KI process, specifically in capturing and using lessons learned.

The 'KM system (policies and strategies)' along with variables 9 and 10 are at the bottom levels of the ISM model and are considered to be the main challenges in the TPS. Participants stated that motivation and collaboration between different project phases was not efficient enough and only based on their contract's clauses. This means that 'Contractual boundaries' play a significant role in adopting an effective KM system for collaboration and sharing knowledge between the design and construction phase in the TPS. Additionally, participants explained that even though their organization identified the lessons learned after each project, but they still had difficulty in finding the relevant knowledge. Fong and Chu (2006) stated that this difficulty is caused by lack of proactive management strategies in organization. This means the KM strategy and policies that are adopted by organizations were not effective for capturing and retrieving tacit knowledge in the traditional construction project. This requires proper guidelines and techniques for capturing knowledge that should be considered by project manager when determining the KM policies and strategies of projects.

It is clearly stated by participants that they only captured and shared their experiences and were not aware of the importance of transferring their experiences to another project in this type of procurement system. This means there were no guidelines provided by their organization to integrate tacit knowledge, and the adopted KM system by organizations did not improve the awareness of the importance of transferring knowledge between projects. Furthermore, recruiting experts is an effective strategy for keeping the knowledge inside organizations. Some participants stated that their organizations had this strategy and recruited experts who left the organization before and then returned for the current project. Other participants stated that their organization did not adopt effective a KM system and easily let experts leave their organization. This means that their organization was not aware of the importance of keeping their experts' knowledge, which is a competitive asset for an organization. Therefore, the CSFs for tackling this challenge is for the project managers to adopt an effective KM system (policies and strategies) that covers:

1. considering contractual boundaries (what type of knowledge and who is liable to share that knowledge) in implementing appropriate tools (techniques and technologies) for collaboration and sharing knowledge between the design and construction team;

http://dx.doi.org/10.21511/kpm.02(1).2018.03

Source: Authors.

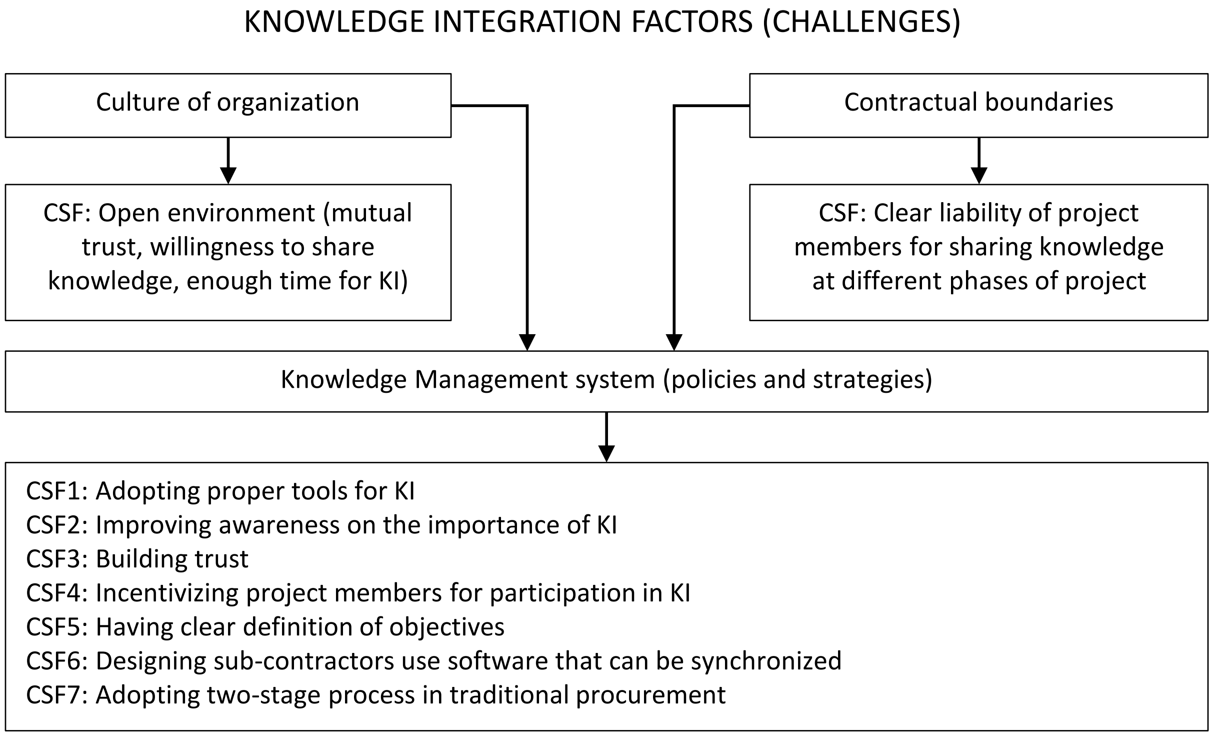

Figure 3. KI challenges and its CSFs within the TPS

2. clarifying objectives of a project;

3. improve the awareness of project members on the importance of KI;

4. freeing up time, building trust, and incentivizing project members in order to create an open environment and to participate in KI process;

5. implementing appropriate tools and techniques for identifying lessons learned and for capturing, sharing, and transferring knowledge;

6. using synchronized software by designing sub-contractors at designing phase in order to reduce designing clashes and save time and cost;

7. adopting two-stage tendering TPS.

The relationships of three main challenges of KI and the CSFs for each of them are illustrated in Figure 3.

The effective KM system will increase the awareness of project members on the importance of knowledge capturing and their willingness in sharing their knowledge during the project life cycle (Pan & Flynn, 2003; Carillo et al., 2004; Lin, 2007). The ‘Lack of awareness of the importance of tacit knowledge integration’ is positioned at the third level in ISM hierarchy. The ISM model (Figure 1) depicts this variable having no direct influence on the two specific challenges at the second level of the ISM hierarchy, which are ‘Lack of incentives’ and ‘Lack of trust’, because they are directly influenced by ‘KM system (policies and strategies)’. Additionally, this challenge is changed from ‘Lack of awareness of the importance of tacit knowledge and its integration’ (Table 2, *V1*) to ‘Lack of awareness of the importance of tacit knowledge integration’ (Table 3, *V1*) because findings revealed that most of the people and organizations involved in the construction projects are aware of the importance to their experiences and skills, but they are not aware of its importance of the process of KI in terms of transferring knowledge to the next project.

CONCLUSION

The aim of this study was to explore and identify the challenges and CSFs of KI in terms of capturing, sharing and transferring knowledge within construction projects based on the TPS. The study investigated this issue by analyzing relevant literature on the concept of KI and its challenges in the TPS, following by comparing this analysis with the findings from case studies in order to have a better understanding of this research phenomenon. Comparing the findings indicated that there were three main challenges that hinder KI process within the TPS in terms of capturing and sharing knowledge within a project and transfer it to the next project. These challenges were 'Organizational culture', 'Contractual boundaries', and 'KM system (policies and strategies)'. In order to tackle the first challenge, 'having an open environment' was identified as a CSF, which means providing a trusted working environment where project members dedicate enough time to share their knowledge with each other. As knowledge is an asset of organizations, the amount and liability of sharing knowledge is important for organizations. It is more significant in projects undertaken through the TPS due to the separation of the designing and construction team. This means the communication and collaboration of these team are based on the provisions of their organizations' contract. Therefore, clarifying the liability of project members on sharing knowledge at different phase of project was identified as a CSF for tackling the 'Contractual boundaries'. Poor management of knowledge within the project life cycle leads to considerable amount of knowledge loss. This is more common in the traditional construction projects due to the fragmentation nature of TPS which means different organizations that involved during the project life cycle run and maintain their own KM systems and disperse after completion of the project. Therefore, their knowledge would not be available and accessible when it is needed in other projects or at other phases. CSFs were identified to tackle the challenge of 'KM system (policies and strategies)' which are adopting proper tools for KI, improving awareness on the importance of KI, building trust, incentivize project members for participation in KI, having clear definition of objectives, designing sub-contractors use software that can be synchronized, adopting two-stage process in traditional procurement. This research extends the previous research on KM and would enable project managers and stakeholders to be aware of the key challenges and CSFs of KI within the TPS, enhance the project performance, and decrease the possibility of reinventing the wheel.

REFERENCES

1. Aziz, N., Gleeson, D., & Kashif, M. (2012). *Barriers and enablers of knowledge sharing: a qualitative study of ABB, Bombardier* (Bachelor Thesis in Business Administration). Ericsson and Siemens. School of Sustainable Development of Society and Technology.
2. Bashouri, J., & Duncan, G. W. (2014). A model for sharing knowledge in architectural firms. *Construction Innovation, 14*(2), 168-185. https://doi.org/10.1108/CI-10-2012-0057
3. Carlilo, P. (2004). Managing knowledge: lessons from the oil and gas sector. *Construction Management and Economics, 22*(6), 631-642. https://doi.org/10.1080/0144619042000226289
4. Charan, P., Shankar, R., & Baisya, R. K. (2008). Analysis of interactions among the variables of supply chain performance measurement system implementation. *Business Process Management Journal, 14*(4), 512-529. https://doi.org/10.1108/14637150810888055
5. CIOB (2010). *CIOB's Professionalism: An Inclusive Definition of Construction Management*. Ascot: The Chartered Institute of Building.
6. Farzin, M. R., Kahreh, M. S., Hesan, M., & Khalouei, A. (2014). A survey of critical success factors for strategic knowledge management implementation: applications for service sector. *Procedia – Social and Behavioral Sciences, 109,* 595-599. https://doi.org/10.1016/j.sbspro.2013.12.512
7. Forman, M., & Haugbolle, K. (2011). *The role of clients/end-users in the innovation of detached houses*. ARCOM.
8. Haddad, M., & Bozdogan, K. (2009). *Knowledge integration in large-scale organizations and networks-conceptual overview and operational definition*. Massachusetts Institute of Technology (MIT).
9. Hari, S., Egbu, C., & Kumar, B. (2005). A knowledge capture awareness tool: an empirical study on small and medium enterprises in the construction industry. *Construction and Architectural Management, 12*(6), 533-567. https://doi.org/10.1108/09699980510634128

http://dx.doi.org/10.21511/kpm.02(1).2018.03

10. Heylighen, A., Marin, W. M., & Cavallin, H. (2007). Building Stories revisited: Unlocking the knowledge capital of architectural practice. *Architectural engineering and Design Management, 3*(1), 65-74. https://doi.org/10.1080/17452007.2007.9684630
11. Kasvi, J. J. J., Vartiainen, M., & Hailikari, M. (2003). Managing knowledge and knowledge competences in projects and project organizations. *International Journal of Project Management, 21*(8), 571-582. https://doi.org/10.1016/S0263-7863(02)00057-1
12. Love, P. E. D., Lopez, R., & Edwards, D. J. (2013). Reviewing the past to learn in the future: Making sense of design errors and failures in construction. *Structure and Infrastructure Engineering,* 9(7), 675-688. https://doi.org/10.1080/15732479.2011.605369
13. Masterman, J. W. E. (2002). *An introduction to Building Procurement Systems* (2nd ed.). London: E & FN Spon.
14. Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company: how Japanese companies create the dynamics of innovation.* New York, Oxford University Press.
15. Panuwatwanich, K., & Stewart, R. A. (2012). Evaluating innovation diffusion readiness among architectural and engineering design firms: empirical evidence from Australia. *Automation in Construction, 27,* 50-59. https://doi.org/10.1016/j.autcon.2012.05.009
16. Raj, T., & Attri, R. (2011). Identification and modelling of barriers in the implementation of TQM. *International Journal of Product Quality Management, 28*(2), 153-179.
17. Salter, A., & Gann, D. (2003). Sources of ideas for innovation in engineering design. *Research Policy, 32,* 1309-1324. https://doi.org/10.1016/S0048-7333(02)00119-1
18. Shokri-Ghasabeh, M., & Chileshe, N. (2014). Knowledge management: Barriers to capturing lessons learned from Australian construction contractors perspective. *Construction Innovation, 14*(1), 108-134.
19. Takhtravanchi, M., & Pathirage, C. (2016). Knowledge management challenges within traditional procurement system. *International Journal of Computer, Electrical, Automation, Control and Information Engineering, 10*(12), 2452-2460.
20. Warfield, J. (1976). *Societal Systems: Planning, Policy and Complexity.* New York: John Wiley & Sons, Inc.
21. Winch, G. M. (2010). *Managing Construction Projects*. Wiley, Hoboken, NJ.