EXPLORATION OF CRITICAL FACTORS IMPACTING THE INTEGRATION OF EXPERIENTIAL KNOWLEDGE WITH BIM IMPLEMENTATION

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ABSTRACT

This paper explores critical factors impacting the integration of experiential knowledge into BIM implementation for improved decision-making in building construction projects. The construction industry is a knowledge-intensive industry, and knowledge has been identified as a vital resource for improving decision-making. Therefore, integrating experiential knowledge and BIM implementation could help construction organisations make informed decisions while implementing BIM in building construction projects. Nevertheless, the effective integration of experiential knowledge into BIM implementation can be influenced by some factors. This study started with a comprehensive review of the extant literature on factors impacting BIM and experiential knowledge integration, followed by interviews with 30 subject experts within the UK construction industry. Twenty-six factors were extracted through the comprehensive review of extant literature and categorised into three groups: individual-related, team-related, and organisational-related factors. The interviewees also identified job security, litigation and sufficient budgetary allocation as additional factors impacting the integration process. These critical factors can enhance the ease with which construction firms integrate experiential knowledge into BIM implementation for improved decision-making and help them to realise the benefits accruable from the integration process.

***Keywords**: BIM implementation, construction projects, experiential knowledge, impacting factors, integration.*

INTRODUCTION

The construction industry is a knowledge-intensive industry, and knowledge has been identified as a vital resource for improving decision-making. Integrating experiential knowledge (EK) with BIM implementation (BI) could help construction organisations make informed decisions while implementing BIM in building construction projects. EK refers to things recalled from experience, things tacitly or implicitly learned or acquired (Storkerson 2009). Managing EK is particularly important to the construction industry where expertise is rare, expensive and highly mobile because of the temporary nature of construction projects. EK is considered a valuable asset that can improve decision-making if effectively integrated with BI during project delivery (Bhatija, 2017). However, the effective integration of EK into BI can be influenced by some factors. While factors influencing BIM adoption among construction organisations have been substantially investigated, previous studies are yet to explore critical factors impacting the effective integration of EK with BI.

Given the knowledge gap, this paper seeks to answer the question: what are the critical factors impacting the integration of EK with BI within the UK construction projects? To answer this question, the study aims to explore critical factors impacting the effective integration of EK with BI. The following two objectives are set out to fulfil the aim of the study:

i. To identify and extract relevant factors impacting the integration of EK with BI, and
ii. To explore and group the extracted factors into categories of factors impacting effective integration of EK with BI.

To achieve these objectives, the paper adopted an exploratory research method starting with a review of extant literature relating to EK and BI to extract relevant factors imparting integration of EK with BI. These factors are then categorised and validated through in-depth semi-structured interviews with thirty (30) subject experts from the UK construction industry. The rest of this paper is structured as follow: the next section reviews the extant literature on relevant factors impacting the integration of EK with BI. The research methodology adopted for the study is discussed in the subsequent section, which is followed by the findings and discussion. Finally, the key findings and a direction for future studies are highlighted in conclusions.

LITERATURE REVIEW

Experiential Knowledge (EK)

EK refers to things recalled from experience, things tacitly or implicitly learned or acquired (Storkerson 2009). EK is considered to be a part of decision-making, especially in complex and uncertain situations (Sauter 1999). It can also be seen as a resource or an action guide, with emphasis on its contextual, subjective, unconscious and emotional properties (Boardman 2014). In the context of this study, EK refers to knowledge and insights learned from direct participation in BI, which resides in peoples' heads. It is a form of tacit knowledge that has been acquired over some time by working on several BIM-enabled projects.

Only a few studies had ventured to study the importance of EK to construction. This negligence may not be unconnected with the fact that EK is sometimes considered inferior to formal knowledge (Storkerson 2009) and, therefore, undervalued (Baillergeau & Duyvendak 2016). In comparison with non-EK, Fazey (2006) highlighted some aspects of EK that may seem less valuable. These aspects include the changing nature and value of EK when made explicit as it loses its 'tacitness'; the difficulty in qualifying how and why people know what they know due to the way it is stored and processed in the brain; the difficulty in recalibrating it against other forms of knowledge; and the difficulty in determining the extent to which the EK is relevant to a specific situation. Despite this perception, the importance and value of EK have been explored in other industries, such as business studies, sports and health. Construction can also leverage EK from previous projects to improve decision-making and minimise uncertainties associated with each project through effective integration into BI.

Experts can foresee issues and make reasonable predictions based on their experiential knowledge, even if they can't explain how (Fazey et al. 2006). Though it is possible to articulate some of the experts' EK, the real value of their knowledge manifests while faced with real-life challenges in areas in which they are well-experienced. Hence, EK is domain- and context-specific as it is based on a unique set of experiences within a specific domain or context. This specificity of EK limits its application only to relevant domains and contexts like BI in construction projects. Professionals who have participated in the implementation of many BIM-enabled projects will have developed a deep understanding of the process to exhibit the hallmarks of experts. Thus, the need to effectively manage EK and integrate it with BI becomes more important considering that BIM experts tend to change organisations frequently and their experiential knowledge is totally lost when they leave the construction industry.

BIM Implementation (BI)

BI refers to the set of activities undertaken by an organisational unit to prepare for, deploy or improve its BIM deliverables (products) and their related workflows (bimdictionary.com). However, for this research, BI refers to a path-dependant process where one decision leads to another, and the decision made at the early stage of a project has implications on the rest of the project phases. The literature review has shown that there are several perspectives and approaches to the concept of BI. For example, Morlhon et al. (2014) suggested that BI could be seen from a technological perspective, new functionalities perspective, or its maturity perspective. Other studies emphasised the operational, social and technical dimensions of BI. However, one approach to BI implementation commonly found in the literature is the top-down, technology-push approach. According to the technology-push approach, business processes must be tailored along with the new BIM ways of working for them to be advantageous. This technology-push approach has been criticised for lacking considerations for the social and behavioural dimensions of BI (Hartmann et al. 2012). Çıdık et al. (2013) argued that the present polarised technology-centred and human-centred perspectives of BI are problematic and called for more emphasis on the human-centred understanding of BI. Buttressing the point, Miettinen and Paavola, (2014) also submitted that the technological vision of BI does not fully consider the social and behavioural dimensions of the implementation.

EK gained from participating in BIM projects can be considered as a key issue when BI is seen from a human-centred perspective. The inability to fully realise the potential value of BI has been linked to people-related issues (Brewer & Gajendran 2012). Although previous studies (e. g. Succar et al. 2013) have identified the need for stakeholders to improve their skills and competencies, however, no study has explored factors impacting the integration of EK with BI in building construction projects. Integrating EK into BI remains a complex undertaking, requiring the identification of critical factors that can facilitate the integration process.

Factors Impacting Integration of EK into BI

A thorough review of extant literature revealed that several factors could influence the ease and effectiveness of knowledge integrating processes. For example, Lin et al. (2012) documented factors impacting knowledge integration from previous studies to include: organisational structure, combinative capability, relational capital, and absorptive capabilities; formal intervention; principle, content, process, and fame; coordination and socialisation capabilities within teams; and frequent communication and team identification. The study concluded that social integration is an essential mediator between interpersonal attraction and knowledge integration in information systems development projects. Recently, Takhtravanchi and Pathirage (2018) classified the critical factors influencing knowledge integration within construction traditional procurement projects under three major themes: organisational culture, contractual boundaries, and KM system. Organisational culture encompasses open environment factors like mutual trust, willingness to share knowledge and enough time for KI activities. Contractual boundaries are influenced by the clear liability of the project team for knowledge sharing throughout the project life cycle. KM system factors include adopting proper tools for KI, improving importance awareness of KI, building trust, incentivising team members to participate in KI, clear definition of objectives, among others.

There are existing studies on factors influencing BI in different regions of the world. For instance, Amuda-Yusuf (2018) identified five factors influencing the adoption and implementation of BIM within the Nigerian construction industry, while Ozorhon and Karahan (2016) study focused on the critical success factors for BI within the Turkish construction industry. However, Antwi-Afari et al. (2018) reviewed publications on critical success factors for BI between 2005 and 2015 and grouped them into five categories: collaboration among AEC stakeholders, early and accurate 3D visualisation, coordination and planning of construction work, enhancing the exchange of information, improved site layout planning and site safety.

It can be deduced from the above discussion that different sets of factors have been put forward for KI and BI by different authors. Previous studies have considered these factors separately. There is yet to be a study that considers the factors impacting the integration of EK and BI together. However, there is still a paucity of studies on factors impacting the integration of EK with BI. This knowledge gap suggests the need to identify relevant factors that impact the effective integration of EK and BI. To address this gap, a comprehensive review of the extant literature on relevant factors impacting the integration of EK and BI was carried out. Table 1 shows a list of twenty-six relevant factors extracted from the literature along with references. Following their extractions, these factors were grouped as individual, project, and organizational-related factors to be validated through subject expert interviews.

Table 1: Factors considered relevant to impacting integration of EK with BI from the literature

S	Factors	References
1	Level of face-to-face interaction among individual colleagues	Amuda-Yusuf (2018); Antwi-Afari et al. (2018); Cascio and Shurygailo (2008); Nesan (2012)
2	Willingness and ability of individuals to freely share experiential knowledge	Fischer (2013); Wu & Lin (2013), Wong (2005)
3	Level of involvement and participation of individuals in decision making	Fong and Chu (2006); Takhtravanchi and Pathirage (2018); Nesan (2012)
4	Rewards and incentives for individuals involved in integrating experiential knowledge	Shin et al. (2008); Fong and Chu (2006); Nesan (2012)
5	Effective and honest communication among individual colleagues	Shang and Shen (2014); Yaakob et al. (2016); CEN (2004); Nesan (2012)
6	Level of training, education and apprenticeship available to individuals	Ozorhon and Karahan (2016); Shang and Shen (2014); Yaakob et al. (2016); Nesan (2012)
7	Level of trust among individuals involved in integrating experiential knowledge	Arif et al. (2015); Shang and Shen (2014); McManus et al. (2016); Nesan (2012); Saini et al. (2017)
8	Individual's level of creativity	Baskerville & Dulipovici (2006); Nesan (2012)
9	Open and collaborative discussions among project team members	Antwi-Afari et al. (2018); Gold et al. (2001)
10	Availability of adequate time for activities to integrate experiential knowledge among project team	Fong and Chu (2006); Takhtravanchi and Pathirage (2018); CEN (2004); Nesan (2012)
11	A knowledge-oriented culture among the project teams that encourages creative and innovative ideas	Davenport et al. (1998); Lee and Choi, (2003); Ayub et al. (2016)
12	Availability of appropriate KM tools for integrating experiential knowledge among project team	Liebowitz (1999); Takhtravanchi and Pathirage (2018);
13	Early composition of project team members and their continuity on the project	Takhtravanchi and Pathirage (2018); Nesan (2012)
14	Well-defined KMP for integrating experiential knowledge among the project team.	Arif et al. (2015); Wong (2005), Egan (1998)

15	Level of commitment to knowledge integration activities among the project team.	Wu and Lee (2016); McKenzie et al., (2001);
16	Level of mutual understanding and trust among project team	Arif et al. (2015); Takhtravanchi and Pathirage (2018); Shang and Shen (2014)
17	Project team motivation, and presence of motivational aids	Arif et al. (2015); Nesan (2012); Saini et al. (2017)
18	Level of complexity of the projects	Jin and Kotlasky (2012)
19	Organisation's leadership support for, and commitment to activities relating to the integration of experiential knowledge	Arif et al (2015); Ozorhon and Karahan (2016); CEN (2004); McManus et al. (2016); Saini et al. (2017)
20	Organisational culture that encourages activities relating to the integration of experiential knowledge	Shang and Shen (2014); Yaakob et al. (2016); Ozorhon and Karahan (2016); Takhtravanchi and Pathirage (2018);
21	Organisation's efficiency at leveraging experiential knowledge to improve decision making	Wong and Radcliffe (2000); Lu et al. (2018)
22	Flexible organisational structure that encourages activities for integrating experiential knowledge through lateral communication	Shin et al. (2001); Shang and Shen (2014)
23	Organisational reward systems that incentivise activities for integrating experiential knowledge	Fong and Chu (2006); Shin et al. (2001)
24	Organisational infrastructural systems that support the integration of experiential knowledge (e.g. open workspace)	Shin et al. (2001); Wong (2005); Zhang et al. (2008); McManus et al. (2016)
25	The size of the organisation (e.g. small, medium or large)	Ozorhon and Karahan (2016)
26	Organisational transparency and openness	Smith (2014)

RESEARCH METHODOLOGY

This paper adopted an exploratory research method involving a comprehensive review of the extant literature on factors relevant to the integration of EK with BI and interviews with subject experts for the validation and classification of the extracted factors. Using literature review has been accepted as a research methodology for advancing knowledge within the construction management discipline (Olubunmi et al. 2016; Ganiyu et al. 2018). Based on the reviewed literature, this paper extracted twenty-six (26) factors that were considered critical to the integration of EK into BI. In selecting these factors, only factors that are related to the integration of EK and BI within the context of the construction industry were selected. Subsequently, semi-structured interviews were conducted with thirty (30) professionals and subject experts within the UK construction industry to seek the extent to which they agreed that the identified factors are critical to the integration of EK with BI. In line with the factors derived from the literature, the interviewees were asked to tell what they think are the individual, team, and organizational factors that affect the integration of EK with BI. The sample size was considered adequate based on Saunders et al. (2012) recommendation, who suggested a minimum of 5 – 25 participants for semi-structured, in-depth interviews.

Table 2 provides the summary of the profile of participants in the semi-structured interviews. The experts were encouraged to provide as many factors as they wish that they considered important for EK integration into BI under each of the three categories of factors (i.e. individual, project and organizational). The interview phase adopted a non-probability sampling method, using both purposive/judgmental sampling and snowball techniques. These sampling techniques allow a researcher to deliberately choose experienced and information-rich participants for in-depth exploration of the phenomenon under investigation (Palinkas et al. 2016). The interview duration varies with the time available to the interviewee and the wealth of experience with the subject matters. However, the average time for the interviews was about 56 minutes.

Table 2: Profile of the Interviewees and Interview Summary

Participant's Title	No	Organisation Size	Year of Experience	Interview Mode
BIM Director	4	3 – Large	8 – 10 years	WebEx & Phone call
		1 – Small	5 years	Phone call
BIM Manager	12	7 – Large	4 – 12 years	WebEx, Face-to-face & Phone call
		3 – Medium	4 – 9 years	Face-to-face & Phone call
		2 – Small	5 – 10 years	Face-to-face & Phone call
BIM Coord.	5	1 – Medium	10 years	WebEx
		1 – Small	7 years	Phone call
		3 – Large	4 – 10 years	WebEx, Face-to-face & Phone call
Inform. Manager	5	2 – Small	5 – 6 years	Phone call
		1 – Medium	10 years	Face-to-face
		2 – Large	5 – 10 years	WebEx & Face-to-face
Client Rep.	2	1 – Small	7 years	Phone call
		1 – Large	10 years	Face-to-face
Cost Est.	2	1 – Small	7 years	WebEx
		1 – Medium	4 years	Phone call

Audio clips of the interviews were transcribed using an online transcription software tool (Otter Transcribe) which were subsequently edited for analysis using NVivo 11. Analysis of qualitative data follow structured methods, starting with reading and re-reading the transcripts to gain adequate familiarisation with the data (Braun and Clarke 2006). This stage was followed by coding and describing the data under the three pre-determined categories of individual, project, and organizational-related factors to seek to which extent the expert practitioners' views were covered by the factors identified in the literature. Findings of these interviews are presented and discussed in the subsequent section.

FINDINGS AND DISCUSSIONS

This section presents and discusses the findings from the interviews conducted with subject experts on the factors impacting the effective integration of EK with BI. The interviewees' responses are presented and discussed based on the three pre-determined categories, which are individual-related, project team-related, and organisational-related, as shown in Table 3.

Table 3: An example of the coding scheme for the impacting critical factors.

Category	Example of Factors	Quotations	Participant's Group Title
Individual-related Factors	Level of trust among individuals	*"So, trust is also another thing. So, I think with blockchain coming in, it is creating a different trust structure with people and trust in sharing knowledge" BM2*	BIM Director

Project Team-related Factors	A knowledge-oriented culture among the project teams	*"Culture is definitely has got a part to play actually. …and to be honest, the most successful in implementing the technology are the ones where the culture of the project is right." BM4*	BIM Manager
Organisational-related Factors	Organisation's leadership support	*"Organisational leadership support, I believe, is necessary to facilitate effective integration of EK with BI" BC4*	BIM Coordinator

i. Individual-related Factors:

Integration of EK with BI requires individual stakeholders who must be able and willing to participate in the knowledge integration during BI. Accordingly, individual-related factors were identified as critical to impacting on effective integration of EK with BI. Interviewees identified individuals' willingness and ability to freely share EK, individuals' level of involvement and participation in knowledge integration, adequate reward and incentive systems for individuals participating in knowledge integration. A senior BIM manager emphasised the importance of willingness to learn and share experience thus:

"…they have to be willing to learn, they must be eager to learn. Otherwise, you cannot train someone without this, let's say, mentality to learn new things. It's very important."

"Yeah, it's that one, unless you give someone incentive, you give them the time, or you give them some kind of financial reward is just keeps us so busy. They don't have time; they are not going to do it."

In addition, the following factors were also identified under the individual-related factors: effective and honest communication among individuals involved in knowledge integration and the level of trust among such individuals. The level of trust among individuals is highly proportional to their willingness to share and integrate knowledge (Rutten et al. 2016).

ii. Project Team-related Factors:

The construction industry is project-based, and projects are usually executed by teams of professionals working together temporarily. The project-based nature of the construction creates learning opportunities through knowledge sharing and experiences from best practices while implementing BIM (Ganiyu et al., 2018; Wang & Meng, 2018). Hence, project team-related factors are identified as critical for integrating EK into BI. The identified factors under this category include a knowledge-oriented culture that encourages knowledge sharing among project teams, the willingness of team members to engage in open and collaborative discussion, allocation of sufficient time to team members for knowledge integration activities, and the level of mutual trust and understanding among team members. A cost estimator argued that open collaboration among project team in the interest of all members:

"Actually, it's in our interest to collaborate and work together and actually share experiences because of our work, we all benefit because of that."

Some of the interviewees also identify factors such as the presence of knowledge integration motivational aids, the early composition of the team members and continuity on the project, availability of appropriate KM tools among team members.

iii. Organisational-related Factors:

Construction projects are usually handled by firms/organisations that specialise in building and engineering (civil or heavy) works. The structure and the culture of these organisations could impact the way knowledge integration processes (Takhtravanchi & Pathirage, 2018; Shang and Shen, 2014). Hence, many interviewees argued that organisational culture and flat organisation structure positively impact willingness to integrate EK with BI. According to a BIM Coordinator and two BIM managers:

> *"A flat management structure, with a number of individuals, all expected to learn and share knowledge, and actually develop at the same pace, should be encouraged." BC*

> *"Culture, definitely, has got a part to play actually. ...and to be honest, the most successful in implementing the technology are the ones where the culture of the project is right." BM*

Other factors that were unanimously agreed to fall under organisational-related factors are leadership support and commitment to activities relating to knowledge integration, an institutionalised reward system for knowledge integration, availability of infrastructural systems to support knowledge integration at an organisational level, and organisational transparency and openness. However, there was a divided opinion on whether organisation size significantly impacts the ability to integrate EK with BI. While the majority of interviewees believed that size has little or nothing to do with it, some argued that large organisations are more constrained in terms of leveraging EK. For example, one of the information managers submits that:

> *"When a company is very big, it means that they have a lot of divisions, like they have a lot of departments, a lot of experts, and people are more constraint in things that they do."*

In addition to the extracted factors, interviewees identified job security, litigation and stigmatisation, and sufficient budgetary allocation for knowledge integration as critical to the integration of EK with BI. The fear of losing one's job or relevance can prevent people from sharing their experiences for integration. A BIM manager claimed that many people have lost their job or rendered redundant after sharing their knowledge with colleagues:

> *"Some people feel scared that they might lose their job when they share their knowledge and experience with others, which is a big one actually."*

The construction industry is prone to litigation. The fear of litigation and stigmatisation can prevent people from sharing precious experiences from past mistakes. Knowledge integration could be capital-intensive, and insufficient budgetary allocation can limit the effective integration of EK with BI. Some BIM managers observed thus:

> *"There is a fear around the legalities of sharing information, sharing knowledge, is real in our industry."*

> *"Money is always a limiter. So, obviously, you know, it's having the budget to give the time and the budget to make sure you get the right people in place…"*

Previous studies have documented benefits accruable from the integration of EK with BI to the construction industry. Integrating EK with BI can facilitate effective projects management and team collaboration. It can also increase efficiency and productivity by saving time and efforts spent on locating and re-using domain knowledge (Bhatija 2017). Utilising experts' experiences can also help reduce redundancy and rework in BIM projects (Jallow et al., 2013). Besides, the integration enhances effective communication among project stakeholders, allows capturing and sharing of useful knowledge, compresses the learning curve, and is useful in responding to uncertainties (Bhatija 2017). Identifying the critical factors impacting the integration of EK with BI can ensure the realisation of these benefits.

CONCLUSIONS

This paper explores the critical factors impacting the integration of EK with BI. Twenty-six factors considered relevant to integrating EK with BI were extracted from the review of extant literature. These factors were subsequently grouped as individual-related, project team-related, and organisational-related and explored through interviews with experienced thirty subject experts from the UK construction industry. The findings from the interviews have been found to be widely aligned with the factors extracted from the literature. Besides the factors extracted from the literature, the interviews also identified job security, litigation and stigmatisation, and budgetary allocation as additional factors that can impact the effective integration of EK with BI. As a result, through an extensive literature review and quotes from expert practitioners, this research provides insights on what are the various factors that can impact the integration process and how. Construction firms should use the findings of this study to identify critical factors to consider while integrating EK with BI for improved decision-making. Nevertheless, as this is a purely exploratory study, future research should test the generalisability of the identified factors using a quantitative method.

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