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Citation: AIP Conference Proceedings **2016**, 020105 (2018); doi: 10.1063/1.5055507
View online: https://doi.org/10.1063/1.5055507
View Table of Contents: http://aip.scitation.org/toc/apc/2016/1
Published by the American Institute of Physics

Building Information Modeling (BIM) in Malaysian Construction Industry: Benefits and Future Challenges

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Abstract. Building Information Modeling is an innovative technology coupled with process and human interactions. BIM has been used by the Architecture, Engineering, and Construction (AEC) industry in developed and developing countries including Malaysia. The reason for having BIM in practice triggered by the Director of Public Works Department (PWD) in 2009; who urged construction companies to adopt ICT to enhance productivity and efficiency. This paper aims to explore the BIM implementation in Malaysian Construction Industry. A literature review was carried out to explore on existing BIM implementation that includes definitions, BIM applications, BIM benefits and BIM future challenges. The data collected from various sources such as books, journal articles, conference papers and material available on the Internet, which related to BIM. The review highlights on several BIM benefits regarding financial, better information, communication and coordination, respond to complexity, improved visual, improved sustainability, improved safety and also create service's or business's opportunities. Nevertheless, implementing BIM is not without challenges although it gains attention from many countries. Some issues regarding culture, technology, process and policy for the construction stakeholders, organizations and policymaker have been raised to take up the challenges for effective BIM implementation.

KEYWORDS: **Building Information Modeling (BIM), Construction Industry, Malaysia**

INTRODUCTION

BIM is a modeling technology and associated set of processes to produce, communicate and analyze digital information for construction life-cycle (1). It is a revolutionary technology and process that transformed the way building are designed, analyzed, constructed, and managed (2). BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life cycle; defined as existing from earliest conception to demolition. A basic premise of BIM is the collaboration by different stakeholders at different phases of the life cycle of a facility to insert, extract, update or modify information in the BIM to support and reflect the

Proceedings of the 3rd International Conference on Applied Science and Technology (ICAST'18)
AIP Conf. Proc. 2016, 020105-1–020105-9; https://doi.org/10.1063/1.5055507
Published by AIP Publishing. 978-0-7354-1734-2/$30.00

roles of that stakeholder (3). BIM is a technology (software) and process that brings together multidisciplinary stakeholders in a facility's lifecycle by using three-dimensional intelligent models (2). BIM brings a new paradigm within AEC, one that promotes integration among all multidisciplinary stakeholders in a construction lifecycle. The different BIM tools available in the market includes Revit, Bentley, ArchiCAD, Tekla and many others.

There are many signs that the use of BIM tools and processes is growing in some markets among the construction players (4,5). For instance, in every country, more than 90% of industry stakeholders expect to be using BIM within three years (6). A survey conducted in early 2007 found that 28 percent of the U.S. AEC industry was using BIM tools; that number had grown to 49 percent by 2009 (7). Furthermore, the UK Government has recently published a construction strategy article that requires the submission of a fully collaborative 3D BIM (with all project and asset information, documentation and data being electronic) as a minimum by 2016 (8). As BIM is well accepted globally and the demand is growing, the Malaysian government also calls for the construction industry players to increased ICT adoption that includes BIM adoption and mechanization in the industry, and innovations in building research Construction Industry Transformation Plan 2016-2020 (9).

In Malaysia, the idea to bring BIM into practice was highlighted by the Director of Public Works Department (PWD) in 2009; who urged construction companies to adopt ICT to enhance productivity and efficiency. The Malaysian government then announced BIM adoption in 2010 with the first infrastructure construction project, that is the National Cancer Institute in Sepang (10). Currently, the private and public sector are in the positive adoption of BIM. According to CIDB, more than 20 projects are utilizing the BIM concept at a different level of maturity (mybuildingsmart.org.my). Meanwhile, PWD is using BIM for its pilot project, which is Healthcare Centre Type 5 at Sri Jaya Maran, Pahang and Administration Complex Project of Suruhanjaya Pencegah Rasuah Malaysia (SPRM) at Shah Alam, Selangor, Primary School of Meru Raya Ipoh, Perak and Primary School of Tanjung Minyak 2, Melaka Tengah, Melaka (11). These pilot projects are part of Malaysian government's initiative in exposing government officers to BIM (12).

MALAYSIAN'S CONSTRUCTION INDUSTRY ISSUES

In the Malaysian context, Construction Industry Master Plan addressed the issue of inefficiency in the construction industry (13). Conflict of efficiency contributes to many linking factors that worsened project outcomes. The industry faced conflict for the inefficiencies of project outcomes including time and cost overrun, low productivity, poor quality that leads to customer's dissatisfaction. Contractors financial aspects (14), contractor's improper planning, contractor's poor site management, inadequate contractor experience, inadequate client's finance and payments for completed work, problems with subcontractors, shortage in material, labor supply, equipment availability and failure, lack of communication between parties, and mistakes during the construction stage (15) are the main caused of project delays beyond contract time.

From many problems stated, the nature of construction industry that is fragmented became a major source of problems above. Many acknowledged construction industry as a fragmented industry (16–19). A linear sequence conducted by project players for the design and construction process caused fragmentation throughout the project life cycle in the traditional procurement method. (20) pointed out that this method caused by the 'over the wall' syndrome that leads to the separation of the various parties and information in the construction project, increased cost due to design changes and unnecessary liability claims, poor of actual project life-cycle analysis and poor communication of design rationale and intent. Therefore, the task of AEC industry is encouraged to adopt and apply technologies to improve the quality and productivity of the industry (21,22).

Building Information Modeling (BIM) is one of the innovative technology in the planning, design, construction, and facility management that needs to be deployed. The important features of BIM are that it provides an object-oriented database that is made up of intelligent objects, the 3D representation of integrated information, and a relational database that is interconnected. The adoption of BIM as technology innovation can be seen as one of the potential solutions to the problems occurred and made the industry more efficient, effective, flexible, and innovative while improving the national productivity towards contributing to the economic growth.

Although implementing BIM could overcome constructions' problems. Its implementation remains at the low level (11,23). Construction players need to be aware of the benefits of BIM and its future challenges in helping them to improve implementation of construction processes. The next section of this paper will discuss BIM application in construction lifecycle and BIM benefits.

THE BIM APPLICATION IN CONSTRUCTION LIFECYCLE

BIM can be applied at various stage of the project, from inception through project delivery. BIM covers assessment of IT use in the development, management and legal compliance within the facility lifecycle for the entire construction community (7). BIM is used for model analysis, clash detection, product selection, and whole project conceptualization (24) to improve performance and quality of construction projects. Importantly, BIM also supports the concept of Integrated Project Delivery (IPD) which is a novel project delivery approach to integrate people, systems, business structures and practices into a collaborative process to reduce waste and optimize efficiency through all phases of the project lifecycle (25,26).

METHODOLOGY

Data for this paper was gain through a literature review focusing on BIM concepts, advantages and disadvantages of BIM in the Malaysian Construction Industry. The researchers' gathered information from books, journal articles, international conference papers and materials available on the internet.

BIM BENEFITS

BIM advantages vary either for short-term or long-term investment, for a project or business improvement. It offers various benefits that acknowledged by the researchers (Refer Table 1). Several benefits of BIM has been discussed on improvement in sustainability for integrated data environment (27), design management and knowledge (18,28), facilitates design analysis, improve safety, productivity and monitoring the equipment in real time in different project phases (28).

According to Li et al. (2014), BIM is a process involving the creation and management of objective data with property, unique identity and relationship. BIM is now increasingly used as an emerging technology (18) to assist in conceiving, designing, construction and operating the building in many countries (29). Besides, (30) posited BIM as a solution for communications and information barriers in AEC industry. The BIM technology helps to improve construction stakeholders' visualization before real construction by putting the building in a virtual environment before physical construction (31,32). Despite traditional practice, BIM technology and associated processes allow to the building design and construction process respond to the increasing pressures of greater complexity, faster development, improved sustainability while reducing the cost of the building and its subsequent use (4,28).

TABLE 1: Benefits of BIM

Author	Financial	Better information &communication	Better coordination	Improved sustainability	Respond to complexity	Improved visual	Create/ improved services/ business	Improved safety
(33)	x							
(5)		x	x					
(30)		x						
(31,32)		x				x		
(4,28)	x		x	x	x			
(4)	x	x	x		x		x	
(27)				x				
(28)		x	x		x			x

BIM FUTURE CHALLENGES

BIM implementation is growing in many countries. However, organizations and policymakers urged to take up the challenges regarding culture, technology, process and policy (Refer Table 2) for effective BIM implementation. Refer to the analysis done by (34); there is an urgent need to tackle the managerial aspects rather than the technical aspect of effective implementing BIM. They found the factors such as willingness to share and exchange information, knowledge, and education as critical to motivating managers and project participants in implementing BIM. As suggested by (35), the organization should first align BIM technology with their work process to realized benefits and dissemination of the technological innovation. The following sub-sections will discuss further BIM challenges.

Organizational Culture

As an emerging technology that integrates different background, experiences and multiple stakeholders, the team should realize their degree of inputs throughout the project lifecycle when implementing BIM. Recently, (36) explored the potential of quantity surveyor professionals to become major players with vast advantages to improve the value of the services in the BIM environment. Meanwhile, new roles such as BIM manager, and organization structure of project teams arise in BIM-enable projects (37). By this means, BIM shortly will involve other carrier prospects. Therefore, defining the rights and responsibilities are critical between team members and model users (2). Moreover, BIM is a cross-boundary system, within the organization, roles can be redefined based on individual's backgrounds. However, among organizations, project teams need to re-establish new communication channel and redefine the working pattern based on the new organization structure and role of their partners, which has a direct impact on the BIM collaboration (38).

To learn new technological innovation, the ability of receivers to absorb, adapt and modify new technology through education and training give a huge impact on to the receiver to become a sender of technology (39). Similarly, it is not possible for BIM adopters to disseminate their knowledge on BIM to other industry players or within the project team after knowledge acquired through education or training. Formal or informal education and training are crucial for staff to acquire BIM operational knowledge that involves the application of technology and also the management of process and information. In the implementation of BIM, education and training should be a continuous effort as the adopters might start with the small-scale project before becoming champion. Interestingly, the result revealed that decision to adopt new technology influenced by education investment when respondents concerned upon the types of skills graduate acquire rather than commercial value (30).

For BIM optimum performance, (3,36,40) urged organizations either companies or vendors, or both, to find strategies to lessen the learning curve of BIM trainees while (41) pointed out the need for better training materials and technical support. Also, the staff ability and the effectiveness of the training should be examined (2,37,42) to align an appropriate training strategy that will lead to an enhanced productivity payback (2,42). On the other hand, providing the staff with inappropriate training can also result in negative consequences. Importantly, it should encourage active participation of BIM learning and development within the organization and provide learning mechanism for new staffs in the organization (42).

The leadership of top management, the empowerment of the executive management team and dedication of employees are also important to ensure the full benefits of BIM adoption are to be realized. A significant impact to accelerate the pace of BIM implementation also requires leadership of senior management who has strong internal knowledge (7) to motivate individuals in the organization that is still lacking in knowledge to use new technology and to reduces the people's resistance to change (43). Also, (43) claimed that initiatives of superior management personnel in the industry are needed to influence the staff and support the readiness of process change that related to the culture within the organization. (36) and (44) argued that BIM projects still facing organizational challenges that limit the collaboration. Without the motivation of an individual leadership to hold team members for effective communication, the collaboration only exists for information exchanges rather than integrated problem solving and optimization. In term of training, (45) also stated that visible support and leadership by the senior management is paramount to encourage BIM implementation and improve the staff skill.

Furthermore, BIM should enable visualization and can allow knowledge flows in the complicated working environment throughout the project lifecycle. (36) and (33) pointed out the necessity of integration among various stakeholders. The need of integration reflects the importance of willingness to share information among project stakeholders (34). BIM broaden the work scope of stakeholders who require active information sharing and exchange, however, in reality, BIM only retrieve information and resources (38). Thus, effective communication still depends on human aspect and organizational culture that need to be managed.

Meanwhile, (37) believed that BIM integration would enhance success with trust between different project participants. Nevertheless, mutual trust on completeness and accuracy of 3D models is remained major attention for industry player, resulting in information exchange on 2D drawings only (41). The trust is the main factor for strong collaborative relationships at the inter-organizational level.

Technology

Technology has been described as an appropriate medium or tool for improving team integration to support and synchronize all the project's information and activities as a whole (26). Current BIM technologies available, varies and may provide different organizational capabilities. Hence the stakeholders are required to assess currently available technologies on the market with necessary concerns (45). The selection of the most appropriate software solutions for individual firms is extremely important. Software should be chosen to improve the potential of the organization after the investment has been made. In all cases, software should enhance the ability of individual firms to communicate with other firms and exchange information reliably (46). (47) and (48) highlighted the importance of BIM software selection based on right analysis of company demand instead of choosing on marketing promotion as it can influence the project execution throughout the building process. Furthermore, the demand or appropriate technological capability in project players was highlighted (23,36), as well as software compatibility to exchange data for effective use of BIM (49). Information cannot be transferred effectively with poor interoperability. The software application also requires the powerful processor to run smoothly (48). Due to that, organizations need to plan for an upgrade or change workstation carefully. At the same time, the organization must be careful regarding security to allow smooth communication. Low security always reduces the efficiency of remote communication, information sharing and harms trust between stakeholders (38). Furthermore, having technical support for early adopters may ease the process of using BIM. Inadequate of experience and skills in BIM implementation (40,49,50) reflects the importance of having technical support, particularly for new adopters.

Process

Regarding BIM process, many claimed that there is a lack of standard documents and guideline that can provide clear direction and instructions on BIM implementation (23,40,41,48). Stakeholders tend to use BIM according to their understanding and own definition that may result in less collaboration. The standardize BIM process and define guidelines will be necessary (3), and also will clarify on how BIM can be integrated into the current business practices. Based on (41), stakeholders should also understand the flexibility scope of BIM that can be accessed for only parts of the project's lifecycle.

Policy

Ownership of BIM needs to be protected by copyright laws and other legal channels to ensure data's security and owner's benefit. American Institute of Architects (AIA) has formalized and documented legal regulation for digital design system and argued that ownership of the final output should belong to the client. While the passive impact of this regulation is that designers no longer want to bear the risk of design errors, rather use this as an excuse to transfer commitment to the ultimate owners. Thus, model ownership combines with security system may, in turn, restrict users' access and hinder communication (38). Regarding procurement method, BIM-based work processes require significant contractual changes. According to (7), some project delivery methods are suitable for BIM implementation, but the use of Design and Build is seen as important to exploit BIM benefits to the fullest. Some research by (51,52) supported the implementation of BIM coupled with integrated project delivery for successful collaboration in the construction industry. Besides, government strategy will help to boost the implementation for early adopters of BIM. Research suggested that government incentives; enforcement regulations and policies are crucial to utilize BIM in projects particularly to reduce the people's reluctant to change attitude (50).

TABLE 2: BIM challenges

No.	BIM Challenges	Reference
	Organization Culture	
1	Learning curve of BIM trainees	(2,3,30,33,36,37,40–42)
2	Inadequate commitment from top management, leadership issue and need for executive support	(7,43,45,49,53)
3	Difficulty in process change management	(43,49)
4	Lack of collaboration, need for information sharing and communication	(33,36,38,44)
5	Trust	(37,41,53)
	Technology	
6	Cost of software and hardware	(48,49,53)
7	Selection of suitable software	(47–49)
8	Lack of interoperability, need for well-developed practical strategies for the purposeful exchange and integration of meaningful information	(33,49,53)
9	Security	(54)
10	Inadequate skills and competency, need for technical support	(40,49,50,53)
	Process	
11	No clear guidelines to implement, need for standardization	(23,33,40,41,48,53)
	Policy	
12	Legal and data ownership	(33,38,53)
13	Resistance to change, need for government strategy	(50)

CONCLUSION

The application of BIM varies throughout the construction lifecycle depending on the project needs. It could benefit construction stakeholders and has potential to enhance construction effectiveness and business improvement either in short-term's or long-term's aim. Malaysian Construction Industry (MCI) is progressing in implementing BIM. Nevertheless, the implementation level is still low. Thus, based on many future challenges for BIM, which includes organization's culture, technology, process and policy, the Malaysian government and construction industry players need to collaborate and play their roles in supporting BIM development in Malaysia.

ACKNOWLEDGMENT

The authors wish to thank the Ministry of Education Malaysia, Universiti Utara Malaysia (UUM) and University of Salford, the United Kingdom for supporting this construction research.

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