

Overview of Building Information Modelling (BIM) adoption factors for construction organisations

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Abstract. Improvement and innovation in building visualization, project coordination and communication are the major benefits generated by Building Information Modelling (BIM) for construction organisations. Thus, as many firms across the world would adopt BIM, however they do not know the clear direction in which path they are moving as there is no specific reference available for them to refer to. Hence, the paper seeks to identify the factors of BIM adoption from previous research. The methodology used in this paper is based on literature review from various sources such as conference articles and journals. Then, the findings were analysed using content analysis. The findings show that there are 24 factors found from literature that influence the adoption of BIM and four (4) factors such as vendor, organisational vision, knowledge, and implementation plan are among the least factors mentioned by previous researchers.

1. Introduction

Building Information Modelling (BIM) is an innovation approach in architectural, engineering and construction industry as a modelling technology which encompasses AEC digital data throughout the construction life cycle. Succar [1] added that this digital data is integrated with policies, processes and technologies. In addition, all the digital data involve human activity of BIM software or other related software, hardware and technologies in order to build the digital model [2]. Hence, from various definitions, BIM can be concluded as a digital data in the form of 3-dimensional model as it is able to create a better understanding for construction team.

In worldwide, the adoption rate of BIM has been increasing over the past years especially by commercial contractors [3]. The level of adoption rate in North America has increased from 28% (2007) to 71% (2012) where contractors gave the highest adoption rate (74%) as compared to the architects (70%) and the engineers (64%) [4]. In 2016, in the United Kingdom, the government mandated the application of BIM. Therefore, the adoption rate is has increased from 60% to 95% for last three years [5]. In Malaysia, even though the adoption rate of BIM among construction organisations or known as contractors, is only 5.2% from 2007 to 2013 [6], the number will increase as Construction Industry Development Board (CIDB) has enhanced a lot of seminar, talks and conferences regarding BIM adoption. According to Wong et al. [7] many firms across the world adopt BIM, however they do not



have a clear direction of path they are moving to. Moreover, during the adoption, some firms failed to adopt BIM and the rest succeeded [7].

Thus, the identification of BIM adoption factor is essential to assist the companies to continue adopting BIM in real practices. Nevertheless, it is found that BIM adoption model are insufficient especially on organisational adoption perspective. Hence, the objective of this research is to explicate the BIM adoption factors from various literature, as a basis to develop a research framework that will then fill the existing gap.

1.1. BIM in worldwide scenario

Globally, BIM has already existed more than twenty years [8](Hadzaman, Roshana, & Nawawi, 2015)(Hadzaman, Roshana, & Nawawi, 2015)(Hadzaman, Roshana, & Nawawi, 2015)(Hadzaman, Roshana, & Nawawi, 2015)(Hadzaman, Roshana, & Nawawi, 2015)(Hadzaman, Roshana, & Nawawi, 2015)(Hadzaman, Roshana, & Nawawi, 2015)(Hadzaman, Roshana, & Nawawi, 2015)(Hadzaman, Roshana, & Nawawi, 2015)(Hadzaman, Roshana, & Nawawi, 2015). The idea of BIM was led by the United States where the US General Services Administration or GSA was responsible to promote and provide strategic implementation to US public projects [9]. In United Kingdom, the common strategic framework which consists of four strategies such as leadership, vision, collaborative framework and client and industry capability and capacity is developed in order to assist public sectors to implement BIM successfully [5].

Other leaders in BIM adoption and implementation are Norway, Finland, and Denmark [9]. There are various activities organised by these three government bodies in order to increase the BIM adoption. Singapore is active in BIM agenda as its Construction and Real Estate Network (CORENET) provides various strategies in BIM implementation [10]. In Japan, the engagement and the implementation of BIM showed a positive return in investment or ROI especially for the contractors [9]. Meanwhile, the Australian government rigorously implement various strategies in BIM implementation through proposed work programs [11]. However, currently there are mandates of BIM noted from the Australian government [9]. In Hong Kong, the Hong Kong Housing Authority has its standards and requirements in BIM adoption and implementation such as collaboration, incentive and proven benefit, standard and common practice, legal and insurance, information sharing and handover, promotion and education, compliant BIM tool, audit and risk management and global competitiveness.

Hence, the experience by prior BIM industries is necessary to identify and avoid the shortcoming problems especially for new BIM comers such as Malaysia. The Malaysian Public Work and Department (PWD) introduces BIM into the construction industry early 2007. However, the adoption and implementation of BIM in Malaysia took a long time. Only in 2010 it first took place, where the National Cancer Institute construction project was to be built [12]. As it is the national agenda to embrace new technology, recently many private sectors also have taken actions by adopting and implementing BIM in their organisations. Moreover, to promote this new technology, CIDB organises various programmes in order to improve the adoption rate in the construction organisations.

In 2014, CIDB developed BIM roadmap which focused into seven pillars (see table 1) such as Standard and Accreditation (P1), Collaboration and Incentives (P2), Education and Awareness (P3), National BIM Library (P4), BIM Guidelines and Legal Issues (P5), Special Interest Group (P6) and Research and Development (P7). The Seven pillars were constructed by CIDB in order to facilitate many organisations in adopting and implementing BIM.

1.2. Definition of adoption

According to Rogers [14] and Arpaci [15], adoption is the decision to use an innovation with available action. For new innovation, there are five decision making processes which are knowledge, persuasion, decision, implementation and confirmation [14]. Thus, Rogers [14] affirmed that adoption is under decision process. Furthermore, Winch [16] and Hosseini et al. [17] found that adoption for the construction context is the decision made to use the innovation by professionals in that organisation.

Hence, this paper aims to identify the gap between decision and implementation process where the adoption occurs in two situations which is continued adoption and discontinued adoption.

Table 1. Summary of seven pillars for Malaysian BIM Roadmap [13].

Item No.	Pillars	Activities
1	Standard and Accreditation (P1)	BIM standard and common practices, guidelines, reference documents, accreditation for certification of BIM projects.
2	Collaboration and Incentives (P2)	Collaboration with other bodies and vendors, BIM funds and supports including cost software, hardware and training).
3	Education and Awareness (P3)	BIM conference, competition, promotion, award, training modules and syllabus.
4	National BIM Library (P4)	BIM library standard, cloud computing, national BIM library
5	BIM Guidelines and Legal Issues (P5)	National BIM guide, legal issues
6	Special Interest Group (P6)	BIM committee to share the information
7	Research and Development (P7)	Research fund and sponsor

1.3. BIM adoption factors

From previous studies, BIM factors have been identified and presented in table 1. It is discovered that there are 24 factors of BIM adoption available. Table 2 will be an initial basis for an ongoing PhD research to construct preliminary conceptual framework. In prior study by Gu and London [18], BIM adoption is grouped into two main areas which are the technical tool, - functional requirements and need, and the non-technical strategic issues. The finding shows the development of the collaborative BIM decision framework with three associated aspects; product, process, and people produced.

According to Eadie et al. [19] relative advantages, government pressure and competitive pressure are the factors influencing BIM adoption especially for UK construction contractors. A recent study by Zakaria et al. [20] have identified four categories in BIM adoption such as organisational culture, people (training, education), technology (interoperability, infrastructure, equipment) and government recognition (external support). Furthermore, Zakaria et al. [21] support the findings with the preliminary survey where nine factors such as policy, process, people, organisational strategy, management, training, education, external pressure and external supports are discussed.

These factors were also agreed by Enegbuma [22] where people, technology (relative advantages, data management, infrastructure) and process are the main adoption elements in their article. Besides, Succar [23] also discussed policy, process and technology (infrastructure, vendor, relative advantages, data management, equipment) as the factors of BIM adoption. On the contrary, Osman et al [24] found that Technology (compatibility, interoperability, complexity, relative advantages) organisational (management, training, financial resources, BIM risks) and environment (external pressure, external supports and subcontractor relationship) are the factors in BIM adoption. In addition, Yaakob et al. [25] affirmed that BIM adoption especially for organisational level are focusing on four categories such as technology, organisation, process and legal.

Meanwhile, Ahn et al. [26] classified BIM adoption to be sorted under 15 main categories: Benefits of BIM adoption, organisational structure, BIM experts education background, BIM education and training, BIM implementation cost, project type of BIM implementation, BIM software, BIM risks, BIM contract method, BIM fee structure, BIM implementation plan, BIM at the construction phase, subcontractor relationship, future direction of BIM and new employees. Nevertheless, Son [27] et al. and Jusoh [6] reviewed the literature on BIM adoption and suggested that perceived usefulness and perceived ease of use are the main elements in influencing behavioral intention of BIM adoption. Hence, all the variables mentioned above will be gathered and discussed in section 3.

Subsequently, all the variables found in table 1 are tabulated in table 3 to identify which variables are insufficient according to Seven Pillars of BIM Roadmap.

2. Research Method

An existing BIM factors are identified from various previous literatures. Then, all the adoption variables are analysed through content analysis as a basis of to develop a preliminary framework.

3. Findings and Discussions

From table 2, the highest adoption factor cited by previous literature is people. Nine (9) researchers or 12% agree that people is the most factors in adopting BIM. This shows that, mentality, attitude and resistance of people are the key elements in adopting and implementing of BIM. The second highest in this table is relative advantages. According to Rogers [14], relative advantages is the real advantages of BIM as compared to other products. Thus, six researchers agreed that the advantages of BIM will influence the adoption of BIM.

Next, compatibility of software is also recorded as the most frequent cited factors from previous research. The researchers believe that the ability of BIM software to work together with other components would also contribute to BIM adoption. In addition, management, training and education are also listed among top ten most important factors. From the literature, there are 5 researchers mentioned about this factor. In terms of management factor, encouragement and support from top management or company leaders are necessary as they will influence the development of organisations. Meanwhile, training and education from professional bodies also enable the organisations to be conversant with BIM.

Having the similar score which is 4 researchers cited are policy, external pressure and support. In organisation, a good policy will deliver good result. Moreover, the policy will show a clear guideline of how the implementation of BIM in that organization should be. Nevertheless, these situations would not happen if there are no external pressure and support from various respective bodies. In this case, government plays vital roles in order to enhance the implementation of BIM.

In the context of Malaysian researchers, none of the researchers discussed the variables such as vendor, organisation vision, implementation plan and knowledge. However, most of Malaysian researchers discussed the top ten factors.

The next section discusses the comparison of available variables in table 2 with Seven Pillars of BIM Roadmap for Malaysia's Construction Industry. The comparison was tabulated in table 3 below. From the table 3, P4, and P5 show the least factors cited by previous researchers. Moreover, there is only one researcher from Malaysia who discussed both pillars. On the contrary, most researchers discussed P2, in their study, followed with P3 and P1. There is only one factor discussed P6 and P7. From table 2, none of the researchers discussed knowledge in their study, however, according to BIM Roadmap for Malaysia's Construction Industry, knowledge is categorised under P6. In Special interest group (SIG) (P6) encourages people to have more discussion and sharing of ideas and knowledge through training. Thus, knowledge is one of variables in P6.

Hence, it could be deduced that these variables found from the literature are necessary to be included and evaluated develop adoption framework.

Table 2. Summary of studies related to BIM adoption factors.

Item No.	BIM adoption factors	Malaysia			Korea		Australia	Nigeria	United Kingdom	Total numbers of literature
1	People	Zakaria et al. [20]			Osman et al. [24]		Enegbuma et al. [22]		Jusoh. [6]	
2	Relative advantage	x	x	x	x	x	x	x	x	9
3	Compatibility		x	x	x	x	x	x	x	6
4	Management		x	x	x	x	x	x	x	5
5	Training	x	x	x	x	x	x	x	x	5
6	Education	x		x	x	x	x	x	x	5
7	Policy			x	x	x	x	x	x	4
8	External pressure		x	x	x	x	x	x	x	4
9	External supports	x	x	x	x	x	x	x	x	4
10	Infrastructure	x		x						3
11	Interoperability	x	x			x				3
12	Data management			x			x	x	x	3
13	Equipment and Peripherals	x					x	x	x	3
14	Vendor				x		x			2
15	Process		x	x						2
16	Organisational strategy			x		x				2
17	Financial resources		x			x				2
18	BIM risk		x			x				2
19	Security			x			x			2
20	Complexity		x							1
21	Organisational vision					x				1
22	Implementation plan						x			1
23	Subcontractor relationship		x							1
24	Knowledge									0
										75

Table 3. Summary of studies related to BIM adoption and Seven Pillars of BIM Roadmap for Malaysia’s Construction Industry.

Item No.	Seven Pillars of BIM Roadmap		BIM adoption factors
1	Standard and Accreditation (P1)	Process [21]; [22] Policy [21]; [23]; [28]; [25] Implementation plan [26]	
2	Collaboration and Incentives (P2)	Infrastructure [20]; [23]; [22] Compatibility [23]; [28]; [24]; [25]; [6] Interoperability [20]; [24]; [25] Vendor [27]; [23] Complexity [24] Equipment and Peripherals [20]; [23]; [26] People [20]; [19]; [21]; [28]; [27] [22]; [25]; [26]; [6] Organisational strategy [21]; [26] Organisational vision [26] Financial resources [24]; [26] BIM risk[24]; [26] External pressure [24]; [28]; [21]; [9] External supports [24]; [28]; [21]; [20] Subcontractor relationship [24]	
3	Education and awareness (P3)	Training [20]; [21]; [24]; [25]; [6] Education [20]; [21]; [27]; [26]; [6]	
4	National BIM Library (P4)	Data management [18]; [22]; [23]	
5	BIM Guidelines and Legal Issues (P5)	Security [18]; [25]	
6	Special Interest Group (P6)	Management [27];[21]; [24]; [25]; [6]	
7	Research and Development (P7)	Relative advantage [19];[28]; [23]; [24]; [22]; [26]	

4. Conclusion

In a nutshell, this research reveals the factors of BIM adoption across various literature. This research found 24 variables which are the most frequent variables cited by previous researchers. Various factors identified from literatures can be references to many organisations in adopting BIM. Hence, the next research will explain the detail of these variables as a basis to develop BIM adoption framework.

Nevertheless, regardless of many factors identified, the most important factor in encouragement of BIM in Malaysia is government's roles and supports. Without supports from, the development of BIM in Malaysia will be ineffective and remain as uncompetitive country compared to others.

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