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Applications of building information model (BIM) in Malaysian construction industry

M M Tahir[1], N A Haron[1], A H Alias[1], A T Al-Jumaa[1], I B Muhammad[2] and A N Harun[3].

[1]Department of Civil Engineering, Faculty of Engineering, Universiti Putra Malaysia, Malaysia

[2]Department of Architecture, School of Environmental Technology, Federal University of Technology, Minna, Nigeria

[3]Department of Management of Technology, Malaysia-Japan International Institute of Technology, Universiti Teknologi Malaysia, Jalan Sultan Yahya Petra, 54100 Kuala Lumpur, Malaysia

(mtahir1129@gmail.com, nuzul@upm.edu.my, aidihizami@upm.edu.my, azher_taha1978@ymail.com, mibdoko@gmail.com)

ABSTRACT: Since the introduction of BIM in Malaysia in 2009, the technology adoption rate is slow when compared to other countries of the world. Most of the construction companies in Malaysia have an insight on the BIM concept but are yet to implement it in the management of their construction projects. By the year 2020, the Malaysian government will make BIM mandatory, this makes it important to carry out research on the possible applications of the technology. A qualitative method of enquiry was used for this study in Klang Valley using semi-structured interview. The responses received were analysed using Principal component analysis (PCA). The result of the analysis showed that "quantity take-off and estimation", "clash detection and coordination", "integration and collaboration of stakeholders", and "design and visualisation" as the main applications of BIM in Malaysia presently. The implication of this findings is that the Malaysian construction industry productivity is likely to increase to meet the demand of the population through the implementations of BIM. More also, BIM technology is regarded as the future of construction industry, which makes it very important for the industry.

Keywords: Applications of BIM, BIM, Malaysian construction industry.

1. INTRODUCTION

Building Information Model (BIM) in construction design is regarded as an alternative approach for design which makes it easy to present digital designs which contains all the necessary information about the proposed project before it is constructed [1]. BIM is an innovative design tool which has changed a lot in the construction industry such as project procurement, execution, and facility management [2]. This shows that BIM can be said to be the future of construction industry.According to Bryde, Broquetas [3], BIM is a suitable tool for management of construction projects, as such, project managers should take advantage of it in managing their projects. More also, Enegbuma, Ologbo [4] stated that BIM reduces uncertainties which result in successful completion of projects. This has so far proven to be the most important benefit of BIM application. It is important to note that BIM is applicable at all stages of a project (Initiation to operation and maintenance) [5].

A widely cited definition of BIM is provided by the US National Institute of Building Sciences (2007) which defined it as "a digital representation of physical and functional characteristics of a facility, and 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". For the purpose of this research, the definition credited to the National BIM Standard (NBIMS) Project Committee of the Building SMART alliance (2010) will be adopted, which defines it as, "a digital representation of physical and functional characteristics of a facility. As such it serves as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle from inception onward. The BIM is a shared digital representation founded on open standards for interoperability" [6].

BIM is basically a 3D digital representation of a facility. The model could be used in expressing the entire facility life-cycle. The quantity of material and its properties can be easily obtained, and the scope of work required can easily be defined and isolated from the model. Contract documents, drawings, procurement details, specifications, and other construction documents can easily be interrelated using the model [7, 8]. The model which is data rich, object-oriented, intelligent, and a digital representation of the facility in which drawings and appropriate information for various stakeholders can be extracted for project delivery and decision-making [9]. It integrates architectural, structural, Mechanical, Electrical and Plumbing (MEP) models [10].

In practice, the information contained in the model do not always show the real life situation which limits its application in construction projects. The model is disconnected from the physical project which reduces its usefulness throughout the facility life-cycle in supporting decisions [11]. This is as a result of lack of framework to guide practitioners and researchers to come up with solutions to link BIM and physical facilities. The implementation of this model by most AEC companies is as a result of it benefit for long-term and productivity gain when compared to conventional practices [12]. The potentials of the application of Building Information Model (BIM) in the management of construction projects is similar to the PMBOK knowledge areas, this makes BIM an important tool for project managers [13]. BIM as a promising technology facilitates project management, the possibility of integrating building models and products makes BIM have a high potential for management of projects life-cycle [14]. BIM can be used at all the stages of a project in it life-cycle, it is used in understanding the project needs by the owner, it is also used for analysis, design and development of the project by the design team.

However, since the introduction of BIM in Malaysia in 2009, the technology adoption rate is slow when compared to other countries of the world. Most of the construction companies in Malaysia have an insight of the BIM concept, but due to the absence of guidance, government support, and well-trained personnel have been the major cause for the slow rate of adoption of the technology [9]. This is considered as a major setback for the Malaysian construction in adopting BIM when compared to US which crossed the gap within 5 years of the introduction of BIM to their industry [15]. In November 2016, the chief executive officer of CIDB, Datuk Ahmad Asri Abdul Hamid, made a press statement saying "property developers will be mandated to use BIM by 2020 for their construction works" [16]. This is a good development for the industry, but however, BIM as an alternative technology in Malaysia needs to be studied to know it applications and possible areas of improvement in the industry. More also, the BIM maturity level appreciation in Malaysia with regard to increasing demand for efficiency and competitive advantages is been hindered by several factors [17] which include low research on applications of BIM in the management of construction projects.

2. METHODOLOGY

A qualitative method of research was used for this study. Qualitative research makes use of subjective data which are produced from the respondent's minds (Creswell, 2013). The purpose of the qualitative approach was to reaffirm findings of the applications of BIM from the literature and to uncover other applications in Malaysia. The study was conducted using semi-structured interview. The targeted respondents for the interview were architects, engineers, project managers, and BIM coordinators who are experts and have knowledge and understanding of the applications and benefits of BIM. Expert sampling method was used in selecting respondents from the population in Malaysia (Klang Valley). The data obtained from the interview were reported and analysed using Descriptive analysis, Cronbach's alpha test, Exploratory Factor analysis, and Content analysis by carefully constructing data categories.

3. RESULTS

Data were obtained through the use of semi-structured interview with 18 respondents who were experts and have extensive knowledge about BIM. The respondents were architects, engineers, BIM coordinators, and project managers. Prior to the interview, a pilot study was conducted with 3 respondents, in order to ensure that respondents understand the questions asked. Data from the pilot study was used to restructure the interview questions for better understanding of the respondents.

3.1 Demographic Characteristics of the Respondents

The respondents for the semi-structured interview were from different backgrounds in terms of their job positions, industry working experience, BIM working experience, and their level of education. Descriptive statistics was used in examining the different distributions of variables from their backgrounds as shown in Table 1 below.

Table 1: Frequency distribution of Respondent's demographic characteristics

Variable	Item	Frequency	Percentage
Job description	Architect	6	33.3
	BIM coordinator	3	16.7
	Engineer	4	22.2
	Project manager	5	27.8
Industry working experience	Less than 5years	4	22.2
	5-10 years	8	44.4
	More than 10 years	6	33.3
Working experience with BIM	Between 1& 2 years	4	22.2
	3-5 years	10	55.6
	More than 5 years	4	22.2
Highest level of qualification	BSc	3	16.7
	MSc	13	72.2
	PhD	2	11.1

Table 1 above shows the summary of the background of the respondents. The result shows the highest number of respondents to be architects with 33.3% followed by project managers with 27.8%. The other respondents were Engineers and BIM coordinators having 22.2% and 16.7% respectively.

However, the result of the respondent's industry working experience shows that 44.4% of the respondents have been working in the industry between 5-10 years. While 33.3% of the respondents have spent more than 10 years in the industry, and only 22.2% of the respondent have spent less than 5 years in the industry. More also, 55.6% of the respondents had 3 to 5 years working experience with BIM in their various projects, while the respondents with more than 5 years working experience with BIM and those that had between 1 and 2 years working experience with BIM had 22.2% each. The level of education of the respondents showed that they are qualified to participate as respondents in the survey as 72.2% of them had Master's degree, 16.7% had Bachelor degree, and 11.1% of the respondents had PhD degree in their various professions. All of these characteristics of the respondents shows that they are all qualified to respond to the semi-structured interview questions as experts.

3.2 Reliability Analysis

The reliability test was conducted on the questions using Cronbach's alpha test to measure the questions reliability. The reliability analysis results are shown in Table 2.

Table 2 Reliability analysis on applications of BIM

Application of BIM	Scale Mean if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	Cronbach's Alpha Coefficient
Design and visualisation	43.89	0.017	0.803	
Scheduling	44.89	0.723	0.743	
Quantity take-off and estimation	44.11	0.477	0.771	
Integration and collaboration of stakeholders	44.50	0.387	0.780	
Clash detection and coordination	44.22	0.341	0.783	
Constructability analysis	44.56	0.608	0.760	0.790
Quality and risk control	45.06	0.614	0.754	
Facility management	44.39	0.702	0.752	
Communication	45.06	0.623	0.752	
Human and material resource control	45.28	0.677	0.745	
Reduction of rework during construction	44.50	0.827	0.746	
Contract processes	44.89	-0.445	0.864	

The scale reliability and internal consistency of data from this phase of the study are shown in table 2. The scale reliability and consistency for the 12 items tested which is the alpha coefficient is 0.790 as shown in table 2. This implies that the internal consistency of the items is relatively high. It is important to note that the minimum acceptable reliability coefficient is 0.70.

3.3 Data Analysis:
The information obtained from the semi-structured interview were categorised and tabulated using content analysis. Descriptive analysis was used to describe the nature of the data before been analysed using SPSS 23. The response from the experts was interpreted using scaling method for easy coding. The scale which ranges from strongly agree to strongly disagree.

The responses were further analysed using exploratory factor analysis to show that the items a drawn from the concept being discussed as shown in Table 3. The Kaiser-Meyer-Olkin Measure of sampling adequacy was not performed on the items due to the number of respondents that participated in the semi-structured interview.

Table 3: Communalities of the items

BIM application	Initial	Extraction
Design and visualisation	1.000	0.849
Scheduling	1.000	0.800
Quantity take-off and estimation	1.000	0.867
Integration and collaboration of stakeholders	1.000	0.886
Clash detection and coordination	1.000	0.796
Constructability analysis	1.000	0.741
Quality and risk control	1.000	0.736
Facility management	1.000	0.873
Communication	1.000	0.910
Human and material resource control	1.000	0.705
Reduction of rework during construction	1.000	0.841
Contract processes	1.000	0.832

The communalities table represent the amount of variance accounted for by the factor solution for each variable. These shows whether if the variables meet an acceptable level. The minimum acceptable level for these variables is set at 0.50 variance which must be taking into account. In this phase of the study, the communalities were all above (0.50) as shown in Table 3 above.

Table 4: Total Variance Explained

Comp.	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cum. %	Total	% of Variance	Cum. %	Total	% of Variance	Cumulative %
1	5.492	45.766	45.766	5.492	45.766	45.766	3.051	25.429	25.429
2	1.826	15.217	60.983	1.826	15.217	60.983	2.862	23.852	49.280
3	1.364	11.366	72.349	1.364	11.366	72.349	2.684	22.369	71.649
4	1.154	9.615	81.965	1.154	9.615	81.965	1.238	10.316	81.965
5	.680	5.664	87.628						
6	.526	4.384	92.012						
7	.421	3.510	95.522						
8	.220	1.830	97.352						
9	.140	1.168	98.520						
10	.103	.854	99.375						
11	.064	.529	99.904						
12	.012	.096	100.00						

Extraction Method: Principal Component Analysis.

The communalities of all the variables were greater than 0.5 which allows them all (12 items) to be used for the factor analysis. Four components with eigenvalues greater than (1) were found. The eigenvalues

and total variance explained by the four components is shown in table 4 above. The Eigenvalues after Varimax rotation showed that the first factor explained (45.77 %) of the variance, the second factor (15.22%) of the variance, the third factor (11.37%) of the variance, while the fourth factor explained (9.62%) of the variance. These four components explain (81.97%) factor structure of the total variance among the items.

Table 5: Rotated Component Matrix[a]

	Component			
	1	2	3	4
Design and visualisation	-	-	-	.914
Scheduling	.743	.450	-	-
Quantity take-off and estimation	.917	-	-	-
Integration and collaboration of stakeholders	-	-	.913	-
Clash detection and coordination	-	.735	-	.454
Constructability analysis	.835	-	-	-
Quality and risk control	-	.655	.400	-
Facility management	.477	.694	-	-
Communication	-	-	.894	-
Human and material resource control	.537	-	.619	-
Reduction of rework during construction	.494	.537	.555	-
Contract processes	-	-	-	-

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

The "Varimax rotational matrix[a]" in Table 5 above shows the correlation of each of the items with the four components with eigenvalues greater than (1) that were selected. The correlation relationship ranges from (+1) to (-1) indicating the strength of the relationship. These components can be named after the items that show very high correlation with them when compared to the other items. The first component has its highest correlation with the item "Quantity take-off and estimation". The second component has its highest correlation with the item "Clash detection and coordination". The third component has its highest correlation with the item "Integration and collaboration of stakeholders". While the fourth component has its highest correlation with the item "Design and visualisation".

4. DISCUSSION

Twelve (12) items were identified from the literature to be the main applications of BIM in the management of construction projects. These items are design and visualisation, scheduling, quantity take-off and estimation, integration and collaboration of stakeholders, clash detection and coordination, constructability analysis, quality and risk control, communication tool, facility management, human and material resource control, contract process, and reduction of rework during construction.

These items were validated through the use of semi-structured interview which was further analysed using statistical methods (descriptive analysis, factor analysis). The analysis of the items using factor analysis showed that four items were the most important applications of BIM as they were selected as components. These items are quantity take-off and estimation, clash detection and coordination, integration and collaboration of stakeholders, and lastly design and visualisation. These findings can be referenced to researches conducted previously by different researchers.

The result of the study shows that quantity take-off and estimation is one of the main application of BIM in the management of construction projects. This concurs with the findings of [18-20], Lahdou and Zetterman [21], and Sabol, (2008) that stated that cost estimation and quantity take-off are the key applications of BIM in project management which are continuously developed.

The result of the research also showed that BIM is been applied in the management of construction projects to detect clash in designs and coordination of work. Bryde, Broquetas [3] stated that one of the most reported applications of BIM was is to improved coordination throughout the project life-cycle. More also, Farnsworth, Beveridge [22] stated that the applications of BIM to detect clashes in designs and coordinate activities reduces the time spent on construction and at the same time increases profitability and marketing.

The integration and collaboration of stakeholders was also identified as one of the main applications of BIM in the management of construction projects. The use BIM reduces waste and also

optimises efficiency throughout the project life-cycle as it supports integrated project delivery through collaborative process [23].

The application of BIM for design and visualisation in the management of construction project was also identified in the research. BIM is a great visualisation tool as it provides a 3D virtual representation of the facility [24]. Walkthrough, rendering, and sequence of the model (BIM) can be provided by the project manager during the project bidding for ease in communicating with the interested contractors. An outlook of the project when completed is provided through visualisation which solves the issues of having to combine the different 2D views of the proposed project to create a 3D view [25].

5. CONCLUSIONS

The adoption of BIM in the management of construction projects is rapidly gaining acceptance globally. However, Malaysia is not left out from these countries. The adoption rate in Malaysia has witnessed a great setback since the introduction of the alternative technology (BIM) in 2009. This is as a result of low research and active government and client participation in the adoption process. This research focused on the main applications of BIM globally to identify the current application in Malaysia. Four items were identified as the main applications of BIM in Malaysia, other uses of the technology are also used but not as much as the identified items. The findings of this research cannot be used to generalise the application of BIM in Malaysia due to the number of respondents used for the study and the limited time spent on the research.

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