Volume: 7 Issues: 41 [July, 2022] Special Issues pp. 18 - 29
International Journal of Accounting, Finance and Business (IJAFB)
eISSN: 0128-1844
Journal website: www.ijafb.com
DOI: 10.55573/IJAFB.074103

A SYSTEMATIC LITERATURE REVIEW OF BIM ASSESSMENT MODELS FOR BIM-BASED PROJECTS

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Article history

Received date	**:**	1-3-2022
Revised date	**:**	2-3-2022
Accepted date	**:**	25-6-2022
Published date	**:**	1-8-2022

To cite this document:
Wan Mohammad, W. N. S. (2022). A Systematic Literature Review of BIM Assessment Models For BIM-Based Projects. *International Journal of Accounting, Finance and Business (IJAFB)*, 7(41), 18 - 29.

Abstract: *Building Information Modeling (BIM) is an important technology enabler for digital transformation in construction. It is a highly collaborative process that allows architects, engineers, contractors and other construction professionals to plan, design and construct a building or facility in the form of a 3D model-base. Recently, various BIM assessment models have been established either from developed and developing countries to assess the BIM performance for construction professionals and BIM-based projects. Nevertheless, the adoption level of BIM among construction professionals in developing countries, particularly Malaysia remains lower than expected. Hence, the aim of this paper is to explore the BIM assessment model either from developed and developing countries via Systematic Literature Review (SLR). Subsequently, it is to determine the trends and key elements from the identified models. A Systematic Literature Review (SLR) was conducted on BIM assessment model articles published in three databases (i.e., Web of Science, Science Direct and Scopus) from 2007 until 2019. The results revealed that BIM assessment models from developed countries were dominant compared to developing countries. These models also vary according to their assessment framework and evaluation mechanisms. Other than that, the results also highlighted four (4) main elements from the BIM assessment models. These are; BIM objectives, BIM uses, BIM adoption components and project performance criteria's'. Thus, the study provides a positive insight of the practitioners either from developed and developing countries to be considered in the trends and key elements while assessing BIM in their projects.*

Keywords: *Building Information Modeling (BIM), Assessment, Models, Systematic Literature Review (SLR), BIM-based projects.*

Introduction

Recently, Building Information Modeling (BIM) is one of the most influential construction trends. BIM is a process of managing information that enables the real-time collaboration between all the construction professionals (i.e., architects, engineers and contractors) that are working on a building throughout its lifespan. Through this process, BIM allows all the construction professionals (i.e., architects, engineers and contractors) who are involved in BIM-based projects to create a virtual information model to communicate among the teams with each of them adding specific data to the single-shared model. Other than that, BIM is able to reduce the information losses as compared to the traditional method that occurs especially when a new professional team takes over a project (Sacks et al., 2018). Consequently, the adoption of BIM in construction projects results to a higher quality of works, greater speed of delivery and lower cost. Despite, the advantages of BIM (i.e., higher quality of works, greater speed of delivery and lower cost) the adoption level of BIM among construction professionals in developing countries, particularly in Malaysia remains lower compared to developed countries. As reported by (CIDB, 2019), the adoption level of BIM in the Malaysian Construction industry is 49% in 2019, whereas the adoption of BIM among developed countries are more than 70%. These countries are the United States (79% in 2015), Australia (71% in 2015) (Gerges et al., 2017), United Kingdom (73% in 2020) (CIDB, 2019), Denmark (78% in 2016) (Malleson et al., 2016) and Canada (86% in 2019) (Zhang et al., 2019). The adoption of BIM is rapidly increasing in US, UK and other European countries due to BIM being mandated.

In developing countries such as China, Singapore, and Japan, the adoption of BIM is gradually increasing. According to (Jin et al., 2015), the adoption of BIM has reached 67% for the year 2014 in China, while in Japan the adoption of BIM has increased from 27% in 2013 to 43% in 2015 (McGraw et al., 2014)). Singapore also shows the highest adoption with more than 50% and requires all projects to be submitted via BIM e-submissions (Othman et al., 2020). Similarly, in South Korea, BIM has been made compulsory for public projects which are more than S$50. However, for other's countries such as Indonesia, Sri Lanka, Thailand and India the adoption of BIM is still in the infancy stage as most of these countries are still in the transition stage (from the conventional process to BIM-based technology).

Thus, the BIM assessment models are required to assess the performance of BIM among construction professionals (i.e., architects, engineers and contractors) who are involved in BIM-based projects. The BIM assessment models allow BIM-based project teams to determine the current BIM performance and benchmark against the industry target and improve it to move on to the next level. Hence, the objectives of this study are (1) to explore the BIM assessment models either from developed and developing countries via SLR process and (2) to determine the trends and key elements from the identified BIM assessment models.

Methodology: Systematic Literature Review (SLR)

The Systematic Literature Review (SLR) is a method to identify, evaluate and summarize given topics that fit with the pre-specified eligibility criteria in order to answer the formulated questions (Mengist et al., 2020). SLR allows the collection from the databases restrictively and allows an analysis to avoid from bias as compared to traditional views. According to (Briner & Denyer, 2012), five steps are used to perform SLR; 1) Formulation of questions, 2) location of study, 3) Selection and evaluation of identified studies, 4) analyzing and evaluating results and finally reporting the outcome.

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Step 1: Formulation of questions

The first step involves the formulation of research questions. The research questions in this study are related to the BIM assessment models. Two research questions formulated were: R1) What are the trends of BIM assessment models derived from developed and developing countries? and R2) What are the key elements identified from these BIM assessment models

Step 2: Location of study

The second step encompasses the search strategy to identify relevant studies related to the research questions. The results are greatly influenced by the database and keywords used in this study. In this study, journal articles and conference proceedings with empirical evidence are selected for review. Three (3) main databases (i.e., Scopus, Science Direct and Web of Science) were used to obtain the desired articles. While the keyword, synonyms and the combinations with the meaning such as ‘Building Information Modeling’, ‘BIM’, ‘BIM performance’, ‘BIM Assessment Model’, ‘BIM assessment Tool’, ‘BIM Maturity’, ‘BIM Capability’ with (AND/OR) were also focused in this study. The selection articles also cover the year range from 2007 until 2019 as the development of BIM is tremendously increasing.

Step 3: Selection and evaluation of identified study

The third step involves the selection and evaluation of identified studies. Overall, from 1,846 identified articles; 42 out of 167 articles from Scopus, 208 out of 1,478 articles from science direct and 66 out of 201 articles from Web of Science databases were identified after the removal of duplicated articles. Next, the selected 316 articles were screened and checked accordingly to suit with the research. 44 articles were selected during this phase. The following step, the remaining 44 articles applies the inclusion and exclusion criteria. The inclusion and exclusion criteria was suggested by (Ahmed & Kassem, 2018); (Shahruddin et al., 2020). The inclusion criteria include; 1) Academic writing, 2) Publication records (2007-2019) and 3) English preferable, whilst the exclusion criteria are: the articles from book chapters, master dissertations, reports, generic publications and not in the English language.

As a result, 25 articles were selected, checked and evaluated using the quality assessment (QA) criteria (Ahmed & Kassem, 2018). The quality assessment (QA) criteria emphasised as follows: 1) QA1) Population, QA2) Key elements, QA3) Assessment models/tool or maturity model/tool, QA4) Methodology and QA5) Outcome. The 25 selected articles were assessed using the two-point scale; 1 (Yes, with 1 mark) for fulfilling the criteria and 0 (No, with 0 marks) for not fulfilling the criteria. The SLR results revealed that, several recent papers have extended the existing models or have applied the existing models in their study. For example, (Lu et al., 2018) adopted the model from (Liang et al., 2016) to examine the BIM maturity among organisations and BIM-based projects in Hong Kong. Meanwhile, (Herr & Fischer, 2018) also extended Bew & Richard’s ‘‘BIM Wedge” ‘model in their assessment of BIM adoption in the Chinese Construction Industry. Similarly, (Hamdi & Leite, 2012) used the NBIMS-CCM to measure the level of a project’s BIM maturity and related it to the lean construction principles to show the company’s improvement. As the study focused on BIM-based project contractors in the US, it found ten (10) improvement areas linked to BIM/lean practices that shaped company capabilities.

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Table 1: Quality Assessment (QA) checklist

At	Year	QA1	QA2	QA3	QA4	QA5	QA Score	QA%	R
1	2019	1	0	0	1	1	3	60	x
2	2018	1	1	1	1	1	5	100	√
3	2018	1	1	0	0	1	3	60	x
4	2018	1	0	1	0	1	3	60	x
5	2018	1	0	1	0	1	3	60	x
6	2018	1	1	1	1	0	4	80	x
7	2018	1	0	1	0	0	2	40	x
8	2016	1	1	1	1	0	4	80	x
9	2016	0	1	1	1	1	4	80	x
10	2016	1	0	0	1	1	3	60	x
11	2016	1	1	1	1	1	5	100	√
12	2016	1	1	1	1	1	5	100	√
13	2016	1	1	1	1	1	5	100	√
14	2015	1	1	0	1	0	3	60	x
15	2014	1	0	1	1	1	4	80	√
16	2014	1	1	1	0	0	3	60	x
17	2013	1	1	1	1	1	5	100	√
18	2012	1	0	1	0	0	3	60	x
19	2010	1	1	1	1	1	5	100	√
20	2010	1	1	1	0	1	4	80	√
21	2009	1	1	1	1	1	5	100	√
22	2010	1	1	1	1	1	5	100	√
23	2008	1	1	1	0	1	4	80	√
24	2009	0	1	0	1	1	3	60	x
25	2007	1	1	1	0	1	4	80	√

Sources: 1) (Khan, 2019); 2) (Siebelink et al., 2018); 3) (Fadoul et al., 2018); 4) (Mollasalehi et al., 2018); 5) (Xue et al., 2018); 6) (Lu et al., 2018); 7) (Herr & Fischer, 2018); 8) (Zeng et al., 2016); 9) (Giel & Issa, 2016); 10) (Shang & Shen, 2016);11) (Liang et al., 2016); 12) (Azzouz et al., 2016); 13) (Mohd et al., 2016); 14) (Wong et al., 2015); 15) (Won & Lee, 2016); 16) (Xu & Liu, 2014); 17) (Chen et al., 2016); 18) (Hamdi & Leite, 2012); 19) (Rizal et al., 2014); 20) (Alaghbandrad, 2013); 21) (Kam et al., 2013); 22) (Succar, 2010); 23) (Jayasena & Weddikkara, 2013); 24) (Hijazi et al., 2009); 25) (McCuen et al., 2012)

Likewise, (Mollasalehi et al., 2018) proposed and integrated BIM and the Lean Maturity Model as a basis of assessing the BIM project and lean together. Subsequently, (Xue et al., 2018) also measured the BIM maturity of an organisation and predicted that the BIM learning tendency of the organisation was based on its current resources and strategies. As a result, the BIM maturity Prediction (BMP) model was developed based on the existing BIM CMM and learning curve model to produce a strategy management tool to help managers in making decisions for BIM development. Meanwhile in China, (Zeng et al., 2016) and (Xu & Liu, 2014) used the BIM capability maturity model to create the BIM maturity evaluation index system. As the model was to determine the benefits and weaknesses of BIM projects, the evaluation would later provide a reference for the BIM-based projects' capability to promote the application of BIM. Even though the score for the article was 80% and fulfilled the quality assessment checklist, because it used existing models, this type of article was excluded from the final articles selected for this study.

(Khan, 2019) assessed the structural design capabilities by using the professional BIM software tools Revit and Robot Structural Analysis that are used for designing and analysing structures. ETABs software was also used to cross check the design. As a result, the differences between designs can be compared. Designs using the BIM tools Revit and Robot Structural Analysis provided advantages in terms of time taken as well as producing a comprehensive and simple design model. However, the ETABs software does not support drawing designs, is less interconnected and the extraction of cost estimations is time consuming due to the design modelling that does not change automatically. Since (Khan, 2019) presented the use of BIM software tools, they differed from the purpose of this study which is to assess the adoption of BIM through BIM-based projects by using technical and non-technical components. Therefore, the article is excluded from this study. In Malaysia, the BIM capability of the Quantity Surveying practice is based on studies by (Wong et al., 2015). As the BIM capability for QS practices is identified, the relationship with project performance (cost, time and quality) is established. This relationship shows how these BIM capabilities affect the project performance and which of these QS practices promote BIM. Despite the extensive distribution of the questionnaire survey in Malaysia and four (4) other countries: Singapore, New Zealand, Hong Kong and Australia and also the data analysis explained in the article, there is a lack of emphasis on model development to assess BIM capabilities among QS practices. Therefore, the article was not selected for this study. On the other hand, there is a model developed by (Giel & Issa, 2016) for evaluating BIM competencies of Facility Owners. Despite the model having three (3) measuring divisions, 12-sub-divisions and 66 measures and an extensive measuring scope which covers all the aspects of BIM application, the model was excluded due to its focus on the operation and maintenance (O&M) phase.

The model developed by (Fadoul et al., 2018) aimed to assess the design's constructability and help the designers to obtain feedback to improve their design solution. This was done by using a model-based approach which is able to employ current information technology to assess design constructability. By using a Knowledge-Based System (KBSs) and Qualitative Modelling analysis, the model examined twelve (12) constructability assessment items. This assessment is similar to (Hijazi et al., 2009) who introduced a new methodology to assess the constructability of building designs through a 4D simulation which produces a virtual construction of the building thereby allowing every design component to be tested and evaluated. This assessment of constructability depends on three (3) main attributes: the design, construction and external impact. Moreover, the assessment method of this model is based on the Analytic Hierarchy Process (AHP) technique and the Simple Multi-Attribute Rating Techniques (SMART). Even though these assessments are new in measuring constructability, these models are not suitable for this study as the main purpose of the assessment is different. Another application of 4D Model assessment is suggested by (Shang & Shen, 2016) to overcome spatial-temporal issues of construction (measures related to workspace per time period) and (Hosny et al., 2013) which resulted in safe working conditions with lower productivity benefits. The developed 4D BIM-based safety assessment model is used to evaluate the construction sites' safety risks that arise from spatial-temporal construction conflicts between on-site moving and/or non-moving objects. Despite, the drawback of this assessment model, it must be excluded from this study as the purposes of the studies differ.

From Table 1, it can be deduced that the rejected articles focused on the combination of BIM models with lean studies (Mollasalehi et al., 2018); the BIM learning curve model (Xue et al., 2018) and applying existing models such as (Lu et al., 2018); (Herr & Fischer, 2018); (Zeng et al., 2016); (Xu & Liu, 2014) and (Hamdi & Leite, 2012). Most of these articles used NBIM-

CMM as their main reference model. Hence, an existing NBIM-CMM is selected for the study even though the model had already been published since 2007. Another reason for rejecting an existing article is due to different studies of assessment such as (Khan, 2019); (Fadoul et al., 2018); (Giel & Issa, 2016); (Shang & Shen, 2016); (Wong et al., 2015) and (Hijazi et al., 2009). Finally, twelve (12) articles were selected for further discussion in this study.

Analysis of results

Over a twelve (12) year period (2007-2019), the United States contributed the highest number of published articles (4), followed by the United Kingdom and the Netherlands with two (2) each. China, South Korea, Malaysia and Australia each produced a single publication. It is seen as predictable as the US dominated in producing BIM assessment models. This influence started since 2007 when The General Serviced Administration (GSA) introduced BIM in the office of the Chief Architect of Public Building Service (PBS) (Smith, 2014). Moreover, most of the scholars and researchers who are involved in BIM are from the US (Bryde et al., 2013). Recently, the UK has become the leader in BIM publications. The formulation of the UK BIM standard and Guidelines such as ISO BIM standards (Shahruddin et al., 2020) encouraged a positive feedback from UK researchers. In developing countries such as China and South Korea, the encouragement from their government (i.e., release BIM policies with supporting documents) allows their researchers to accomplish more research and development in the countries. Similarly in Malaysia, even though there is no mandating of BIM from the government, the encouragement of research by CREAM and CIDB to enhance the development of BIM has affected the number of publications by researchers (Construction et al., 2018). Hence, the final twelve (12) articles selected will be explained in the following section and analysed using the content analysis.

BIM assessment models

Based on table 1, twelve (12) BIM assessment models were identified (√) through the SLR process. It is found that nine (9) BIM assessment models are from developed countries (i.e., United States, United Kingdom, Netherland and Australia), and three (3) from developing countries (i.e., China, South Korea and Malaysia). The following section discusses the trends and key elements identified from the BIM assessment models.

Trends of BIM assessment models

The identified BIM assessment models vary in term of their assessment framework and evaluation mechanisms. As such, the National Building Information Modelling Standard Capability Maturity Model (NBIMS-CMM) (2007) and the BIM Maturity Level (2008) merely focused on information management. The SLAM-BIM is limited to assess the performance of a project based on a Key Performance Indicator (KPI), whilst the Building Information Modelling (BIM) Maturity Level for Design Stage (2015) emphasizes on key action of improvement. The remaining eight (8) models assess the performance of BIM either in technical or non-technical elements.

The Organisational Building Information Modelling (BIM) Assessment Profile (2010); The Building Information Modelling (BIM) Quick Scan Model (2010); The Building Information Modelling Maturity Matrix (BIM^3) (2010) and The BIM Maturity model by (Siebelink et al., 2018) were developed to assess the performance of BIM for the organisation-based. While, The Virtual, Design and Construction (VDC) Scorecard (2009); The SLAM-BIM (2014); The Building Information Modelling (BIM) Maturity Level for Design Stage (2015); The Building Information Modelling Maturity Measure (BIM-MM) (2016); The BIM Maturity Model (2016)

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and The Multifunctional BIM Maturity (2016) were developed to assess the BIM-based projects performance. In addition, The National Building Information Modelling Standard Capability Maturity Model (NBIMS-CMM) (2007) and The Building Information Modelling (BIM) Quick Scan Model (2010) are also able to assess the individual BIM performances.

In terms of evaluation mechanisms, The VDC scoreboard (2009) takes several mechanisms in to account to evaluate BIM performances. As such, the mechanism uses the survey method in the form of multiple choices, quantitative blank fillings and open-ended questions. Whilst The BIM Quick Scan Model (2010) uses multiple-choice questions to evaluate the organisational BIM performance. Three models (i.e., The National Building Information Modelling Standard Capability Maturity Model (NBIMS-CMM) (2007); The Organisational Building Information Modelling (BIM) Assessment Profile (2010) and The Building Information Modelling Maturity Measure (BIM-MM) (2016) developed an Excel Spreadsheet form to assess the performance of BIM. While, the BIMMM (2010) developed a multi-methods of evaluation form for organisational scales, competency granularity levels, capabilities and maturity stages. The following models such as The BIM Maturity Model (2016), The Multifunctional BIM Maturity Model (2016) and The BIM Maturity Model (2018) uses various scale levels (from 0-4/6/7) to assess the organisations and projects performance. Finally, The BIM Maturity Level (2008); The SLAM-BIM (2014) and The BIMM level for Design Stage (2015) provide a conceptual model to be used for individuals' project and organisational BIM self-evaluation.

It is found that three (3) BIM assessment models from developing countries (i.e., The SLAM-BIM (2014); the Building Information Modelling (BIM) Maturity Level for Design Stage (2015) and The Multifunctional BIM Maturity (2016)) focuses on measuring the BIM-based projects performance. However, these models face several limitations. As such, The Building Information Modelling (BIM) Maturity Level for Design Stage (2015) is specific on the assessment during the design stage, and the SLAM-BIM (2014) is at the early stage of development. On the other hand, currently the Multifunctional BIM Maturity (2016) has already been tested in the Hong Kong Construction Industry and has found several challenges. For example, 1) highly subjective assessment; 2) limited to assess the components of technology, processes and protocols and 3) limited to selected Autodesk BIM project database. Thus, the limitation of these three (3) BIM assessment models from developing countries are able to provide insight to others researchers by providing a valuable guideline for the future development of BIM assessment models.

Key elements identification

Table shows four (4) key elements of BIM-based projects that were identified from various BIM assessment models. These are; 1) BIM objectives, 2) BIM uses, 3) BIM adoption components (i.e., a) technology, b) organisation, c) environment, and d) information management), and 4) project performance criteria. The first element is the BIM objective. Three models (i.e., The VDC Scoreboard, The Organisational BIM assessment profile, and the SLAM-BIM) highlighted BIM objectives in their models. According to (Won & Lee, 2016), BIM objectives are the measurable targets that BIM-based projects target. They revealed that one of the most important steps in evaluating the success of BIM-based projects is to define the BIM objectives for the project.

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Table 2: Key Elements Identification

MODELS CODE	KEY ELEMENTS						
	1	2	3				4
			a	b	C	d	
DEVELOPED COUNTRIES							
UNITED STATES							
1. NBIMS-CMM						√	
2. VDC Scoreboard	√		√	√			√
3. The Org. BIM Assessment Profile	√	√	√	√		√	
4. BIM Maturity Model			√	√		√	
UNITED KINGDOM							
1. BIM Maturity Level						√	
2. BIM Maturity Measures			√	√		√	
NETHERLAND							
1. BIM Quick Scan			√	√		√	
2. BIM Maturity Model			√	√		√	
AUSTRALIA							
1. BIM Maturity Matrix (BIM^3)			√	√	√		
DEVELOPING COUNTRIES							
SOUTH KOREA							
1. SLAM-BIM	√	√					√
CHINA							
1. Multifunctional BIM Maturity			√	√		√	
MALAYSIA							
1.BIM Maturity Level for Design Stage				√			

Remarks: 1) BIM objectives; 2) BIM uses; 3) BIM adoption Components; a) Technology; b) Organisation; c) Environment; d) Information Management; 4) Project Performance Criteria.

The second element is the BIM uses. Out of twelve models, two (2) models (i.e., The Organisational BIM assessment profile, and The SLAM-BIM) addressed the BIM uses in their model. The BIM uses are the set of tasks that are associated with identifying BIM objectives (Rojas et al., 2019). In addition, the identification of BIM uses in BIM-based projects depends on the capabilities of the BIM-based project teams to adopt it in their projects. The third element is the BIM adoption component. Four (4) components; technology, organisation, environment, and information management are highlighted. Based on Table 2, nine (9) models identified the organisation as the most important component in the element. Organisation component refers to top management support, budget allocation, staff expertise, leadership, vision, and perceived risks (Kam et al., 2016), (Succar, 2010).

Six (6) models (i.e., The Organisational BIM Assessment Profile, the BIM Maturity Model from the US, the BIM Maturity Measures, the BIM Quick Scan, the BIM Maturity Model from Netherland, and the Multifunctional BIM Maturity) highlighted the technology and information management components. The technology component denotes hardware, upgrading hardware, software, interoperability, and data network. Following thereon, information management stresses on the characteristics of BIM models. The NBIM-CMM identified eleven (11) items of information management; data richness, life-cycle views, roles and disciplines, change management, business processes, timelines, delivery methods, graphical information, spatial capability, information accuracy, and interoperability. Similarly, The Organisational BIM

Assessment Profile, the BIM Quick Scan, and the BIM Maturity Measures emphasised on model breakdown, level of development, information flow & structure, open standard deliverables, and model referencing. The environment component comprises of government policies, guidelines, and external support (Succar, 2010). The final (fourth) element is the project performance criteria. Based on Table 2, two (2) models highlighted the project performance criteria's (i.e., cost, time, and quality). The project performance criteria's are the outcome of performing BIM in the projects.

Based on Table 2, it found that there is a balance (at least 1 tick) of key elements identified from both countries except the component of environment. The organisation component has been repeatedly mentioned by previous nine (9) models. This implies that the organisation component (i.e., top management support, budget allocation, staff expertise, leadership, vision, and perceived risks) is well recognized by previous models. However, the environment component gained less attention from previous models, the elements of BIM objectives, BIM uses and project performance criteria also obtained the minimum (< 4 tick) from previous models. This is due to the previous BIM assessment models that merely focus on assessing BIM adoption components (i.e., technology, organisation, and information management) and neglected others elements. As a result, the BIM assessment models that were developed in separated manners became too fragmented and caused difficulty to the user. Hence, given the above situation, various key elements identified from previous assessment models will be taken into consideration to develop a new BIM assessment model. These elements are; 1) BIM objectives, 2) BIM uses, 3) BIM adoption components (i.e., a) technology, b) organisation, c) environment and d) information management), and project performance criteria.

Conclusions

In a nutshell, this paper explores the BIM assessment models from developed and developing countries. From the SLR process, nine (9) BIM assessment models were derived from developed countries (i.e., United States, United Kingdom, Netherland and Australia) and the remaining three (3) from developing countries (i.e., China, South Korea and Malaysia). The identified BIM assessment models were developed to assess the performance of BIM either for individuals, organisations and project-based. Four (4) key elements were revealed (i.e., 1) BIM objectives, 2) BIM uses, 3) BIM adoption components (i.e., a) technology, b) organisation, c) environment and d) information management), and project performance criteria from previous models.

In developing countries, there is still a lot of work to do with BIM assessment models to assess the BIM performance of BIM-based projects. As such, there is a dearth of studies from the developing countries that focuses on the elements of BIM objectives, BIM uses, project performance criteria as well as the environment component. As such, the importance of the BIM objective is the main target to adopt BIM in the projects. It will also allow the selection of BIM uses in projects, as well as the adoption components (i.e., technology, organisation and information management). However, the environmental component is a component that exists outside the BIM-based projects internal environment which can affect the adoption of BIM. The BIM-based projects can keep track of the environmental component so they can identify and resolve the issues and make appropriate changes when required. Despite the lack of study proofs on the tangibility of the project performance criteria (i.e., cost, time and quality), the assessment for this element is crucial. The project performance criteria will act as a baseline for BIM-based projects to achieve the level of project achievement (i.e., cost, time and quality), impact, effectiveness and efficiency.

Acknowledgment
The author would like to thank Universiti Teknologi MARA, Cawangan Perak for their continuous support on this study.

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International Journal of Accounting, Finance and Business (IJAFB)
eISSN: 0128-1844
Journal website: www.ijafb.com
DOI: 10.55573/IJAFB.074103

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