An Exploratory Study of Building Information Modelling Maturity in the Construction Industry

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Abstract

Despite the benefits of Building Information Modelling (BIM), the adoption level of BIM remains much lower than expected. Construction companies should appraise the existing condition in the BIM implementation to ascertain the applicable progress avenues that fit the user's traits. To achieve this aim, the objectives of this paper are i) to identify the trends of BIM maturity studies ii) to conceptualise what is BIM maturity; iii) to identify the existing models of BIM maturity iv) to identify the indicators for measuring BIM maturity in the company, the project and the industry. A systematic review was conducted on BIM maturity articles, published in the Scopus database from 2008 to April 2018. The results reveal that most BIM maturity studies are dominated by authors from the United Kingdom and the United States, but the top three authors highly-cited were from Australia, Canada and the United Kingdom. The results highlight four aspects in the conceptualisation of BIM maturity: quality of use, the extent of use, the context of use and stages of the processes. The four most frequently quoted BIM maturity models are the National BIM Standard Capability Maturity Model, BIM maturity, BIM proficiency matrix and BIM implementation models. The results revealed seven major indicators for assessing BIM maturity namely information, people, policy, process, technology, organisation and BIM output. The findings advance the practitioners' understanding of important indicators that must be considered to initiate or increase the BIM maturity levels in their respective companies or projects.

Keywords: BIM maturity; BIM maturity models; Indicators; Construction industry

1. Introduction

With increasing demand from various stakeholders for better performance, managing construction projects has become more complex and challenging (Dubois and Gadde, 2002; Blayse and Manley, 2004; Almeida and Soares, 2014). Building Information Modelling (BIM) is considered as an innovative way of

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addressing the many problems that arise in the design, construction and maintenance of buildings. BIM refers to "a set of interacting policies, processes and technologies generating a methodology to manage the essential building design and project data in digital format throughout the building's life cycle" (Succar, 2009, p. 357). BIM is considered as a part of Industry 4.0 (Oesterreich and Teuteberg, 2016). The visionary idea of Industry 4.0 is to create a value-added chain that enables integration between products, their environment and business partners, and consequently, to increase productivity and improve the performance of the enterprise through digitization and automation (Brettel et al., 2014). BIM can be utilised in all phases across the project life cycle: the owner can use BIM to appreciate the needs of the project, designers can use BIM to examine, design and advance the project, the contractor can use BIM in managing the construction processes, and the facility manager can use BIM in the operations and maintenance phases (Grilo and Jardim-Goncalves, 2010).

Recently, there was a growing interest within the industry players to use BIM due to its advantages in increasing project performance (Ghaffarianhoseini et al., 2017; Brettel et al., 2014). Despite the benefits of using BIM in the construction industry at all stages of the project life cycle, the adoption level of BIM remains much lower than expected in most developing countries (see Addy et al, 2018; CIDB, 2017; Ramanayaka and Venkatachalam, 2015). Construction companies should appraise the existing condition in the BIM implementation to ascertain the applicable progress avenues that fit the user's traits (Won et al., 2013; Liao and Teo, 2018).

The above scenario raises several questions in the study – What is the trend in BIM maturity studies? What is BIM maturity? What are the BIM maturity models currently available? What are the indicators used for assessing BIM maturity? At the time of writing this article, scholars have not yet agreed on the indicators for assessing BIM maturity. To address these questions, a systematic review is conducted using bibliometric analysis with the objective of identifying the trends of BIM maturity studies, defining the meaning of BIM maturity, identifying BIM maturity models and indicators for assessing BIM maturity. Practically, the results are significant for BIM personnel, companies and project teams to determine their current BIM performance and benchmark against the target of the industry for prioritisation and improvement to progress to the next level. Theoretically, the identified indicators can be used as a basis for future studies on BIM maturity. Next, the methodology of the paper is presented.

2. The methodology of a Systematic Review

A systematic review involving a four-stage process was conducted. Stage 1: searching for titles, abstracts and keywords using the words 'BIM maturity' or 'building information modelling maturity'. The search involved all the articles published in the Scopus database. Using the document search 'BIM and maturity', 'building information modelling and maturity' and 'information modelling and maturity', article titles, abstracts and keywords resulted in 97 articles. Stage 2: selecting relevant articles that include only articles published in English journals or conference proceedings, as well as articles related to the architecture, engineering and construction sectors. This exercise resulted in 75 articles. Stage 3: Profiling of the selected articles. The objective is to identify the general trend in BIM maturity studies, such as the volume of research and the contributors in terms of authors, sources and countries. Stage 4: using content analysis to categorise and conceptualise BIM maturity, identify BIM maturity models and indicators for BIM maturity.

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3. Results and discussions

3.1 *Profiling of BIM maturity studies*

The profiling of the 75 articles on BIM maturity aimed to identify the general trend in BIM maturity studies. analyses both the quantity and quality of BIM maturity articles. In terms of quantity, the number of articles published from 2008 to 2018, the source title, the most productive authors and the country of origin of the articles were analysed. The analysis revealed that the article on BIM maturity was first published in 2008, indicating that the research topic is relatively new. However, the number of articles on BIM maturity began to increase exponentially after 2011, where 92% of BIM maturity was published between 2012 and 2018, indicating that BIM maturity model is still prevalent among researchers. Figure 1 depicts the number of BIM maturity articles that were published in the Scopus database from 2008 to 2018.

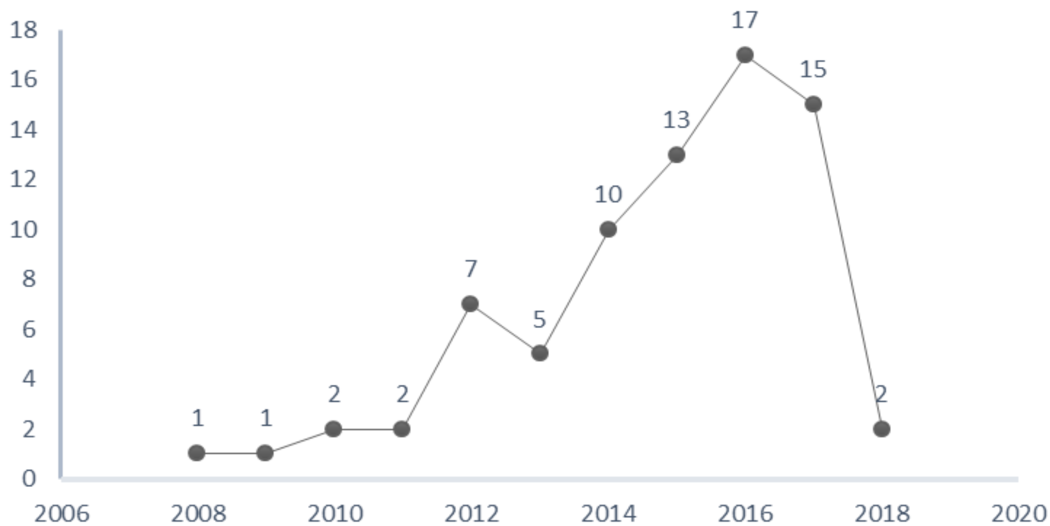

Figure 1. Articles on BIM maturity published in the Scopus database

Regarding the source of the publications, 52% of the BIM maturity articles were conference proceedings and another 48% were journal articles. Most of the articles were published in the Proceedings of the Annual Conference of Association of Researchers in Construction Management (ARCOM; 5 articles), followed by Automation in Construction, Journal of Construction Engineering and Management, Proceedings of the European Conference on Product and Process Modelling (ECPPM) and Procedia Engineering, with 4 articles each during the last 10 years. The most productive author of BIM maturity is Succar (2009b), who published four articles, followed by Chen et al. (2014) that published three articles on BIM maturity. The contribution of the BIM maturity articles according to the country of origin where the studies were conducted revealed that 23% of BIM maturity articles are based in the United Kingdom, followed by 17% from the United States and 6% each from Australia and China. Most BIM maturity studies are concentrated in these two countries, where other countries are obviously far behind. Table 1 shows the source title, author's name and country of origin of BIM maturity articles.

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Table 1: The source title, author's name and country of origin of BIM maturity articles

Source title	**Number**
Proceedings of the Annual Conference of Association of Researchers in Construction Management (ARCOM)	5
Automation in Construction	4
Journal of Construction Engineering and Management	4
Proceedings of the European Conference on Product and Process Modelling (ECPPM)	4
Procedia Engineering	4
Journal of Information Technology in Construction	3
IGLC 2017: Proceedings of the 25th Annual Conference of the International Group for Lean Construction	3
ICCREM 2016: BIM Application and off-Site Construction: Proceedings of the 2016 International Conference on Construction and Real Estate Management	3
Architectural Engineering and Design Management	3
Journal of Management in Engineering	2
Construction Innovation	2
Author's name	
Succar, B.	4
Chen, Y.	3
Cox, R.F.	3
Dib, H.	3
Ahmed, V.	2
Azzouz, A.	2
Giel, B.	2
Issa, R.R.A.	2
Kassem, M.	2
Mahamadu, A.M.	2
Merschbrock, C.	2
Penn, A.	2
Tang, L.C.M.	2
Country	
United Kingdom	21
United States	15
Australia	5
China	5
Netherlands	4
Norway	4
South Korea	4
Canada	3
Malaysia	3
Czech Republic	2
France	2
Hong Kong	2
Italy	2
Taiwan	2
United Arab Emirates	2

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The quality of the BIM maturity articles was analysed according to the number of citations received by the authors and the source title. In total, there were 829 citations. The top three authors highly cited were first, Succar (2009b), who received 335 citations or 40%, followed by Porwal and Hewage (2013) with 115 citations or 14%, and Farzad and Yusuf (2012) with 67 citations or 8%. Figure 2 shows the percentage of citation count by authors.

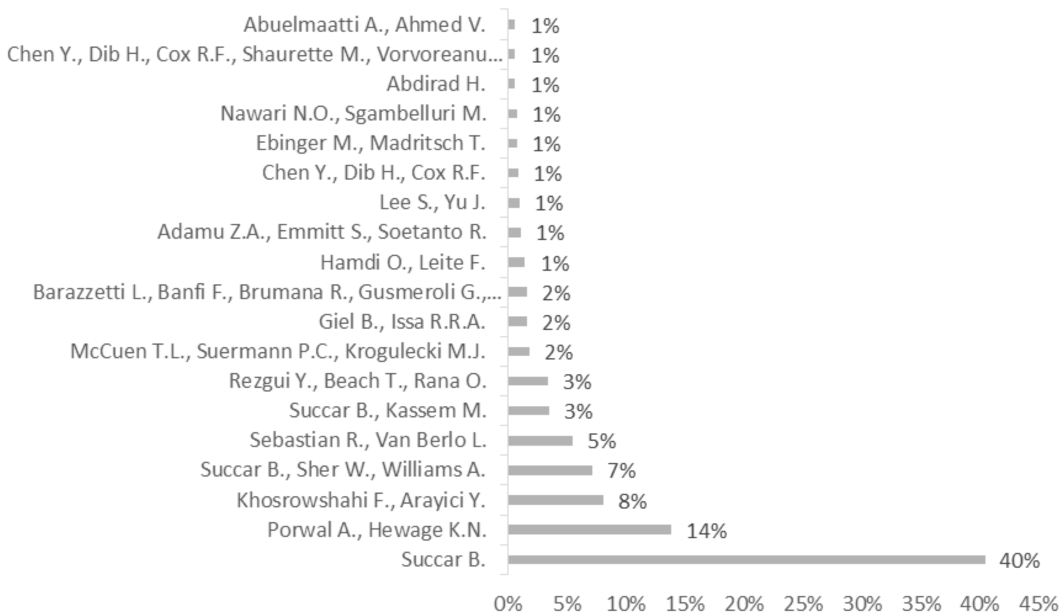

Figure 2. Citations by authors

The top three highly-cited source titles were first, Automation in Construction, which received a whopping 480 citations (58%) from four articles published from 2009 to 2017; the second was Architectural Engineering and Design Management with 109 citations (13%) from three articles; and third, Engineering, Construction and Architectural Management with 67 citations (8%) from a single article. Next, are Journal of Civil Engineering and Management and Journal of Management in Engineering, both with a total of 28 citations (3%). It is important to note that the articles from conference proceedings received low citations from the academic community, the highest of which was IGLC 2017 - Proceedings of the 25th Annual Conference of the International Group for Lean Construction; only with 12 citations (1%), despite the fact that majority of articles on BIM maturity were conference proceedings. Table 2 shows the citations according to the source title.

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Table 2: Citations by the source title

Journal Title	Citations	Percentage (%)
Automation in Construction	480	58
Architectural Engineering and Design Management	109	13
Engineering, Construction and Architectural Management	67	8
Journal of Civil Engineering and Management	28	3
Journal of Management in Engineering	28	3
Journal of Information Technology in Construction	17	2
Journal of Construction Engineering and Management	14	2
International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives	13	2
IGLC 2017: Proceedings of the 25th Annual Conference of the International Group for Lean Construction	12	1
Total	829	100

3.2 Defining BIM maturity

To conceptualize BIM maturity, first, a keyword search of 'maturity' was performed on the 75 articles. This exercise resulted in 26 articles; however, only 16 articles were available in full text. These articles were analysed using content analysis and the following aspects emerged; quality of use, the extent of use, the context of use and stages of processes. The word 'maturity' refers to the characteristics of BIM-able or quality of use, where it specifies the 'must have' features or areas for BIM implementation (Chen et al., 2014). The 'must have' features or areas of BIM-able denotes a specific standard or 'degrees of excellence in performing a task' (Succar, 2009b, p. 10) in delivering BIM services or products where the implementation of BIM is 'defined, managed, integrated and optimized' (Succar, 2010, p. 84). A mature company is evidence of better projection, control and performance (Chen et al., 2014). Mature information refers to the highest stage of information stability, preciseness and completeness (Zou et al., 2013). The immature stage is considered to be the initial point before progressing until achieving the highly mature stage (Sackey et al., 2013).

BIM maturity also means the extent of use of how BIM is implemented (Morlhon et al., 2015), where each BIM process advances in sequential stages of the advancement process from the early stage to the excellence stage (Ebinger and Madritsch, 2012; Liang et al., 2016). Before progressing to the desired status, the current status is the point of BIM application (Mohd et al., 2016). The identification of the current status will help identify the areas of prioritisation and improvement. An assessment of the current maturity status allows comparisons across companies, disciplines, projects, and countries to distinguish between mature and immature entities (Succar, 2009b). The assessment acts like a ranking system that identifies important areas and characteristics of each maturity level to effectively deliver BIM products or services (Chen et al., 2014). The presence of a BIM champion; an excellent BIM performance at any BIM maturity level, will guide companies or projects to advance their BIM implementation to the subsequent BIM maturity level (Azzouz and Hill, 2017).

BIM maturity also describes the context in which BIM is implemented or context of BIM use; 7 articles focused on the BIM maturity in the project, 6 articles on BIM maturity in construction companies and one article focused on the company and the industry (Khosrowshahi and Arayici, 2012), on company and project (Jung and Lee, 2016) or in all three contexts– company, project and industry (Liang et al., 2016), respectively. Actual advantages of BIM can only be realised if BIM maturity goes beyond a single entity;

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signifying the existence of coordination and integration between disciplines, companies and projects (Sackey et al., 2013). Through BIM cooperation, contractor companies can be integrated into the design phase to enhance the performance of the project (Porwal and Hewage, 2013).

BIM maturity is also a stage in the processes of how BIM evolves in a company, project and industry (Liang et al., 2016). The BIM maturity for the company refers to the extent of knowledge that a company possesses to proceed with BIM implementation (attitude) based on its capability (action) throughout the project or the life cycle of the building (Succar et al., 2012). The BIM maturity for the project specifies six maturity levels from 0 (non-existent), 1 (initial), 2 (managed), 3 (defined), 4 (measured) and 5 (optimised) with the aims of evaluating how BIM is actually implemented in the project, comparing the BIM maturity across projects, and improving the project's BIM abilities by identifying the internal and external factors that are significant for the BIM implementation (Azzouz et al., 2016; Chen et al., 2016). A narrow scope of the BIM maturity for the project is an assessment of the BIM implementation in the design phase used to evaluate the capability of the design team to carry out the BIM project. BIM maturity in the design phase identifies five maturity levels: awareness of BIM, development of the BIM strategy, implementing the BIM, assessment of BIM, and sustainability of BIM implementation (Mohd et al., 2016). In the context of the construction industry, BIM maturity denotes process stages that offer a systematic framework for the classification of BIM application from pre-BIM, BIM Stage 1, Stage 2 and Stage 3 maturity levels, where it allows comparison and benchmarking of BIM implementations in various countries (Khosrowshahi and Arayici, 2012).

The above discussion showed that regardless of the context of BIM implementation, BIM maturity can be considered as a specific standard of BIM usage, which evolves through the stages of the processes from the initial immature stage to the advanced level of providing services or products.

3.3 BIM maturity models

To identify BIM maturity models, a search using "maturity model" and "BIM maturity model" was performed on the 75 articles and 17 articles were generated, with 14 full-text. The top four most frequently quoted BIM maturity models are the National BIM Standard Capability Maturity Model (NBIMS-CMM), BIM maturity (BIMM), BIM proficiency matrix and BIM implementation models. Content analysis of the 14 full-text articles was performed to explore the details about the models.

The commonly adopted maturity models originate from the capability maturity model (CMM) used in the manufacturing sector to assess and enhance software development (Chen et al., 2014; Dib et al., 2012). These maturity models follow a sequence of the distinct path with various stages (Liang et al., 2016). Two-thirds of the above full-text articles reported about the NBIMS-CMM, developed by the National Building Information Model Standard (NBIMS) for the construction industry. NBIMS-CMM is the first BIM maturity assessment model and aims to guide managers to access their business and processes to reach the threshold of BIM-able (Chen et al., 2014; Azzouz and Hill, 2017). The model is centred on the management and the data features in the BIM system (Dib et al., 2012). NBIMS-CMM measures the construction professionals' current BIM capabilities and how to progress to the subsequent maturity level (Wu et al., 2017). NBIMS-CMM consists of 11 capability areas. The total score of all capabilities will provide the maturity level of BIM users, ranging from non-certified (< 30), minimum BIM (30 – 49.9),

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certified (50 – 69.9), silver (70 – 79.9), gold (80 – 89.9) to platinum (90 – 100) (McCuen et al., 2012). Using NBIMS-CMM, Morlhon et al. (2015) identified the important factors and actions needed to successfully progress in BIM. NBIMS-CMM was used to evaluate the winners of the 2008 Architectural Practice BIM Award in the United States and found that the winners were at BIM level 1 or visualization (McCuen et al., 2012).

BIMM was quoted in 58% of the articles. Succar (2009b) introduced a comprehensive BIM maturity that consists of BIM capability, BIM stages, BIM competency sets and a roadmap to achieve the main goal of BIM implementation; integrated project delivery. BIM maturity begins with the pre-BIM level and the model can also be used to measure BIMM at the macro (market and industry), meso or the middle level; between the macro and micro (project teams) and micro (companies) levels (Succar, 2009b; Liang et al., 2016). Sackey et al. (2013) expanded the BIMM model to cover the vital processes of BIM implementation for construction companies in parallel with the maturity levels. The authors indicate two important stages – brainstorming and manifestation stages, and their work resulted in a micro level of the BIM implementation framework for construction companies. Using the BIM maturity assessment, Smits et al. (2017) analysed the impact of the BIM implementation on the performance of construction companies in the Netherlands. Their study revealed that only the BIM strategy is conceptualised as the company's mission and vision on BIM, top management commitment, BIM advocates, and the existence of BIM planning team is the determinant for the company's project performance. Azzouz and Hill (2017) used BIMM to identify BIM best practices in 1291 Arup's projects: a global group of architectural, engineering and contracting companies as a driving force for innovation across countries, disciplines and project teams.

The BIM proficiency matrix was identified by 42% of the articles. The BIM proficiency matrix was developed by the Indiana University in 2009 to measure the extent of BIM, developed and used by companies, or in simpler words: the extent to which companies adopt BIM (Chen et al., 2014; Jung and Lee, 2016). It emphasizes on information and BIM products (Chen et al., 2016). It comprises of 32 credit areas with 5 maturity levels: a score of 0 indicates the absence of BIM and a score of 1 demonstrates a complete implementation of BIM (Wu et al., 2017).

The BIM implementation model was acknowledged by 33% of the articles. It measures the BIM adoption rate in the construction industry on a countrywide scale and was used in surveys conducted in the United States, Canada, Western Europe and South Korea (Jung and Lee, 2016). One of the weaknesses of the model is that it measures the number of BIM users instead of the depth of the BIM implementation in the industry, and the information can be misleading if the survey excludes non-users (Jung and Lee, 2016). The BIM implementation model is not suitable for assessing BIM maturity at the company and project team level, since the model cannot guide a company or project team to improve its BIM output or to progress to the next BIM level (Succar et al., 2012).

It is worth mentioning that most BIM maturity models have not been evaluated for their contents' accurateness, inclusiveness and superfluous (Abdirad, 2017). Both empirical and practical evidence of the models' predictive ability will be valuable in guiding the practitioners on how to increase their project's and company's BIM maturity levels. Except for BIMM, most models were developed for specific purposes, ignoring the entire construction supply chain; therefore, they are only available to specific users

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(designers, quantity surveyors or clients). As a result, these models cannot be used for benchmarking or comparing BIM maturity between project teams and companies. Another drawback of the models is that the weights of each indicator were adjusted based on the countries where the tools were developed (Kassem and Succar, 2017; Kassem et al., 2013). Taking into account that most of the construction players in developing countries have not yet implemented BIM and that BIM projects are mostly concentrated in public megaprojects (Latiffi et al., 2015; Ramachandran, 2016), only models that consider pre-BIM maturity such as NBIMS-CMM, BIMM and the BIM Proficiency Index are suitable for assessing BIM implementation in these developing countries. The following section discusses the indicators for measuring BIM maturity.

a. Indicators for measuring BIM maturity

Several authors emphasise the importance of identifying BIM maturity indicators to facilitate the assessment of the extent to which projects, companies and industry have implemented BIM and how BIM implementation can be improved and progressed. At the moment, authors are not in agreement on the BIM maturity indicators where various indicators were proposed due to the multidimensional of BIM usage (Chen et al., 2016). McCuen et al. (2012) identified 11 items for measuring BIM maturity in winning BIM projects using the NBIMS-CMM, namely i) data richness, ii) life-cycle views, iii) disciplines, iv) change management, v) business process, vi) response, vii) delivery method, viii) graphical information, ix) spatial capability, x) information accuracy and xi) interoperability. These 11 items are related to information and do not cover the other facets of BIM such as people and organisation. Succar (2009b) and Liang et al. (2016) identified three indicators for BIM maturity; Technology, Process, and Policy or Protocol, Chen et al. (2014) identified four indicators; Information (information management and delivery), Process (process definition and management), People (training) and Technology, while Wu et al. (2017) acknowledged five indicators; Technology, Process, Policy, People and Organisation. A review article by Abdirad (2017) identified the BIM inputs, the BIM process, the BIM output and the BIM performance at the organisational, project and industry level as the indicators for measuring BIM maturity. The author conceptualises BIM input as BIM Technology (general BIM technology, software, visualization tools) and BIM Users (competencies, motivation, training and satisfaction). The BIM Process consists of two types of interactions – human to human and human to computer; BIM output measures the quality and quantity of the project's performance (time, cost and standard) and the life cycles of the facilities (durability, cost and function).

Technology refers to software, hardware and data network (Succar et al., 2012). Process denotes the resources, actions, workflows, management and leadership that plan, design, execute and deliver BIM products and services (Succar, 2009a). Policy or protocol means written or unwritten standards, rules, specifications, contracts, guidelines, risk-sharing agreements and supervision (Liang et al., 2016; Succar et al., 2012; Wu et al., 2017). People mean the qualities of BIM staff, such as their competencies, attitudes and training (Wu et al., 2017). Information represents information guarantee, conveyance method and management, including work flow, life cycle process and geospatial ability (Chen et al., 2014), while the organisation measures the organisational support, leadership commitment, BIM culture and strategies (Wu et al., 2017). The BIM output is the outcome of performing BIM. In the context of the project, cost reduction, speedy completion, improvement of sustainability and functionality are examples of BIM output indicators in the project (Abdirad, 2017). In the context of the company, the examples of BIM output are the actual cost of investment, return on investment, ability to deliver on time, stakeholder satisfaction, and ease of use (Abdirad, 2017). In the context of the industry, growth in BIM implementation, investment, BIM training, and knowledge are some examples of indicators for BIM output (Abdirad, 2017).

The author identified different indicators for assessing BIM maturity for the context of BIM use; the personnel, the company, the project and the industry. All seven indicators (Information, People, Policy, Process and Technology, Organisational and BIM output) were proposed for assessing BIM maturity in the company and the project. Six indicators were identified for assessing the BIM maturity in the industry, and Policy, Process and Technology indicators were used to assess BIM maturity in the personnel.

In short, there are seven major indicators for assessing BIM maturity, namely Information, People, Policy, Process, Technology, Organisation and BIM output. Table 3 summarises the indicators used by the authors and context for assessing BIM maturity. The table shows that the majority of the authors identified Technology and Process as the first top indicators for measuring BIM maturity, followed by Information, People and Policy.

Table 3: Indicators for assessing BIM maturity

Author	**Indicators**						
	Information	People	Policy	Process	Technology	Organisational	BIM output
McCuen et al. (2012)	X						
Succar (2009b)			X	X	X		
Liang et al. (2016)			X	X	X		
Chen et al. (2014)	X	X		X	X		
Wu et al. (2017)		X	X	X	X	X	
Abdirad (2017)	X	X		X	X		X
Context							
Personnel			X	X	X		
Company	X	X	X	X	X	X	X
Project	X	X	X	X	X	X	X
Industry	X	X	X	X	X		X

Despite the many indicators, only a few studies validate the theoretical models of measuring BIM maturity. McCuen et al. (2012) used NBIMS-CMM to evaluate the BIM award winning projects in the United States for the year 2008 and acknowledged that Graphical Information, Data Richness and Interoperability are the top three important Information indicators to evaluate to what extent the projects implement BIM. Graphic Information measures the presence of graphics, 2D drawings plus intelligent or 3D object-based with time and cost data. Data Richness refers to the robustness of the information in BIM, while Interoperability refers to the ability to share information without data loss or misinterpretation. Chen et al. (2014) used a confirmatory factor analysis and verified that, although all indicators (Information, People, Process and Technology) were important, most of the BIM implementations were towards Process and Information. Subsequently, Chen et al. (2016) tested three indicators – Technology, Process and Information using structural equation modelling on BIM projects and identified that Process is the most important indicator for evaluating BIM maturity.

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4. Conclusion

This paper discusses the trends of BIM maturity studies, identifies the available models of BIM maturity and the indicators for measuring BIM maturity. Most articles on BIM maturity were published by authors from the United Kingdom and the United States, but the top three authors highly cited were from Australia, Canada and the United Kingdom. The result reveals four aspects of BIM maturity conceptualisation: the quality of use, the extent of use, the context of use and stages of processes and the four most frequently quoted BIM maturity models are NBIMS-CMM, BIMM, BIM proficiency matrix and BIM implementation models. The result highlights seven indicators for BIM maturity assessment, namely Information, People, Policy, Process, Technology, Organisation and BIM output, with Technology and Process as the two top indicators used by researchers. The results acknowledge that the indicators are not the same for assessing the personnel, the company, the project and the industry.

Clearly, more work is still needed to demonstrate if these BIM maturity models can assess the extent of BIM implementation and identify the important indicators for BIM to improve and progress in projects, companies and industries. Specifically, there is a dearth of studies from the developing world and that focus on People, Policy, Organisational and BIM output indicators. The People factor; essentially, the attitude of employees and project team members towards technology advancement and communication behaviour were identified as dominant in ensuring the progress of BIM (Bosch-Sijtsema et al., 2017; Ahmed and Kassem, 2018). The Policy factor, such as the client's contract statement for BIM-led project, where key project members have similar access and control over the information exchange process, has been proven to minimise rework and faster completion (Park and Lee, 2017). In a project where BIM implementation is concentrated in the design and construction phases, the success of BIM will depend to a large extent on the understanding and communication of project managers, architects and contractors (Arayici et al., 2011); to which Vass and Gustavsson (2017) postulate as intra and inter-organisational challenges. Similarly, people and organisational factors were acknowledged as the most challenging when implementing BIM (Porwal and Hewage, 2013). Equally important is the BIM output factor, which provides tangible proof of the actual benefits of BIM. Insufficient evidence of a positive impact of BIM maturity on project's productivity is argued to be one of the reasons for BIM's slow progress in construction projects and companies (Smits et al., 2017).

This study extends the literature on the BIM maturity assessment models by identifying the indicators for assessing the extent of BIM use by companies, projects and industries. The study points out the gap to guide future studies. The results act as a reference tool to assist BIM users or potential users in identifying the starting point for their BIM usage or to plan for the necessary improvement of BIM utilisation.

Several limitations can be found in the study; first, the review did not include the web of Science (WoS) database due to its inaccessibility to the authors. Future reviews should include the WoS database in adding to the breadth of the study. Second, the terms 'BIM and maturity', 'building information modelling and maturity' and 'information modelling and maturity' were used to search for articles for the systematic review. Future studies should include other terms such as 'BIM implementation assessment' or 'BIM matrix' to uncover the BIM models that may be practiced in the industry.

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