Review of BIM literature and government initiatives to promote BIM in Malaysia

S S Sinoh¹, Z Ibrahim¹, F Othman¹ and N L N Muhammad¹
¹ Department of Civil Engineering, Faculty of Engineering University of Malaya, Lembah Pantai, 50603, Kuala Lumpur, Malaysia
E-mail: saznizam@um.edu.my

Abstract. The purpose of this paper was to review the current state of building information modelling (BIM) literature in Malaysia. A detailed description of the history and definition of BIM was also presented. A literature search was carried out on the Web of Science Core Collection (WoS CC) on BIM research in Malaysia. Results showed that Malaysian output of BIM research peaked in 2016 and has shown a steady decline since. Most of the research from local affiliations were published in conference proceedings as opposed to academic journals. Also, a search among non-academic sources was conducted to reveal government efforts to promote BIM in Malaysia. Generally, the strategies used by the government to promote BIM include spreading awareness through roadshows, increasing competency through workshops and encouraging higher education institutes to include BIM in their curricula. Current focus should now be shifted to increasing collaboration among construction industry players using BIM as a medium for cooperation. Implications include the need for more peer-reviewed studies and a systematic nationwide study of BIM implementation in Malaysia to facilitate its growth on the national level.

1. Introduction
The construction industry in Malaysia contributed to 6.7% of the country’s economy in 2017 and is critical for the development of social and economic infrastructure [1]. This industry is currently undergoing a transformation phase into widespread implementation of building information modelling (BIM). It is a move which is seen as a revolution in this industry and fully supported by the government of Malaysia. BIM is one of the latest technologies revolutionizing the architectural, engineering and construction industry worldwide. It goes beyond a technological advancement and represents a shift in the traditional building delivery process towards an integrated workflow. The aim of the study was to analyze the literature to identify BIM studies relating to Malaysia. This study also examined the efforts made by the Malaysian government to promote BIM.

1.1. Origins of BIM
Construction projects are heavily paper-based, and any documents related to the project must be printed out on physical media. In fact, most of the construction industry relies on physical specifications and drawings. The path to digitization in the construction industry began when the first software packages for computer-based design of buildings were developed in the 1970s. The concept of BIM was created in the early 1970s by Charles Eastman. He proposed the Building Description System (BDS) which is the precursor to modern BIM as we know it today [2]. In BDS, the system performs a few functions
which are similar to what BIM is capable of: (1) a graphical user interface to store and display complex element shapes; (2) an interactive graphic language to arrange different elements in a design space; (3) it can produce perspective or orthographic drawings and; (4) the database can be sorted by attributes such as material type. Since then, BDS has evolved over several stages to become what BIM is today as shown in figure 1.

In 1977, Graphical Language for Interactive Design (GLIDE) had been introduced which improved on the features of BDS and offered more accurate drawings [3]. In 1989, Building Product Model (BPM) was introduced and offered more features such as estimation [4]. In 1995, the Generic Building Model (GBM) was introduced which defined the building type in the model and allowed a higher degree construction management to be achieved [5]. Beginning in the early 2000s, the concept of BIM took off among the architecture, engineering and construction (AEC) industry when parametric 3D modelling was developed [6]. It is this amalgamation of different features that spanned more than 40 years of development which defines modern BIM.

![Figure 1. Evolution of BIM from the 1970s to the present day.](image)

### 1.2. Definition of BIM

Many different definitions of BIM have appeared in the literature throughout the lifespan of BIM. Despite these different definitions, there exists certain common keywords which represent the essence of BIM. These keywords will become apparent by examining the different definitions of BIM. Firstly, BIM is often viewed as a computer software, a collection of software or simply as a tool. Van Nederveen and Tolman [7] defined BIM as “a model of information about a building that comprises complete and sufficient information to support all lifecycle processes and which can be interpreted directly by computer applications. It comprises information about the building itself as well as its components, and comprises information about properties such as function, shape, material and processes for the building life cycle”. In early research on BIM, it was viewed as a tool to digitize the depiction of a building as a computer-generated model and allows important information to be embedded in these models.

Gu and London [8] expands on this definition further by framing BIM as a database for any parties in a project to refer to at any stage in construction as stated here: “building information modelling (BIM) is an IT-enabled approach that involves applying and maintaining an integral digital representation of all building information for different phases of the project lifecycle in the form of a data repository”. By being a database, the collaborative capabilities of BIM become apparent and different parties can have a single reference point for any information related to a construction project.

This definition of BIM would be expanded to consider BIM as a methodology or process which Azhar [9] defines as “a virtual process that encompasses all aspects, disciplines, and systems of a facility within a single, virtual model, allowing all design team members (owners, architects, engineers, contractors, subcontractors, and suppliers) to collaborate more accurately and efficiently than using...
traditional processes”. Instead of being thought of as a tool used in a project workflow, in this definition BIM is considered as the actual workflow.

This is more holistic as it considers the use of BIM throughout the entire project lifecycle. Going further, BIM can be regarded as a combination of both process and software. Indeed, for BIM to be fully effective, it must be used as a combination of technology, process and policy which is another layer added onto the BIM definition by Succar [10] who states BIM is “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”. The definition of BIM has come around full-circle and blends the different definitions of BIM into a comprehensive one. Succar’s [10] definition of BIM is widely used in various academic studies and technical reports related to BIM.

1.3. BIM maturity
BIM Maturity refers to the quality, repeatability and degree of excellence within a BIM capability [11]. In other words, it is a measure of BIM use within an organization. Two scales are frequently used to measure BIM Maturity namely the Bew-Richards model [12] and the Succar model [10]. The Bew-Richards model is more detailed compared to the Succar model, but both use similar descriptions to define the boundaries between Levels. Level 0 (i.e. Pre-BIM) is characterized by traditional building delivery methods which use paper-based mediums for all documents and technical drawings. Level 1 represents object-based modelling with the use of 2D or 3D digital objects to represent structural elements. Level 2 is where model-based collaboration occurs between different parties involved in a construction project. Level 3 signifies network-based integration and is the step that precedes integrated project delivery as the long-term objective of BIM implementation. Figure 2 depicts the Bew-Richards model of BIM Maturity.

![Bew-Richards model for BIM Maturity](image)
1.4. History of BIM in Malaysia

Malaysia is a country open to technological innovations as can be seen in the implementation of a computer chip-equipped national identification card known as MyKad and the first RFID-equipped passport in the world in 1998. Therefore, it can be said that Malaysia is also open to technological innovations in all sectors including construction. It follows that the government is very keen on adopting new technologies in the construction industry. However, the level of BIM Maturity in Malaysia has lagged those of other developed countries and its neighbors such as Singapore. In 2013, Zahrizan, Ali, Haron, Marshall-Ponting and Hamid [13] determined that BIM Maturity in Malaysia was between Level 0 and Level 1. In 2014, Enegbuma, Aligha and Ali [14] found that the Maturity level had risen to between Level 1 and Level 2. The government intends to reach a BIM Maturity of Level 2 by 2019 which is network-based integration of BIM across the construction industry [15]. In 2019, the PWD has enforced the mandatory requirement for any public construction projects valued above MYR 100 million (approximately USD 24 million) to use BIM [16]. Currently, there is no legal framework to enforce the use of BIM in private construction projects. The use of BIM in private projects mainly relies on the requirement of the client [13]. On the other hand, public construction projects fall under the jurisdiction of the PWD which is able to impose requirements for BIM. The CIDB has proposed that BIM be used in certain private construction projects beginning 2020 [17]. Though it is yet to be seen if a legal framework to support the enforcement of BIM will be created.

Private construction companies began using BIM in the early 2000s, but on a smaller scale than today [18]. BIM was formally introduced to Malaysia by the Public Works Department (PWD) in 2007 with the publication of their BIM Standard Manual and Guidelines [19]. The PWD was also responsible for establishing a BIM committee for BIM training tools and drawing a BIM Roadmap. However, the PWD is not the sole government body responsible for promoting BIM. The Construction Industry Development Board (CIDB) developed a BIM Portal and formed the first BIM Steering Committee. The Multimedia Super Corridor (MSC) initiative allocated grants for BIM training and awards BIM training certificates. The Construction Research Institute of Malaysia (CREAM) provides training and education on BIM. Figure 3 summarizes the key events in BIM implementation in Malaysia. There were 3 pilot projects which used BIM in Malaysia by the PWD which are (1) National Cancer Institute, Putrajaya, (2) Healthcare Centre Type 5, Pahang and (3) Malaysian Anti-Corruption Commission Administration Complex, Selangor. These pilot projects served to provide the PWD with the experience necessary to formulate a framework for nationwide implementation of BIM.

2. Literature Review

2.1. Global literature

Van Nederveen and Tolman [7] proposed an approach which uses so-called ‘aspect models’ to model building information in a simple and natural way. This was the first mention of any sort of BIM model in the literature. Since then, the number of published articles regarding BIM has increased. Zhao [20] searched all articles in the Web of Science Core Collection (WoS CC) database for any articles related to BIM and produced a comprehensive scientometric analysis of the subject. The author found that growth into BIM research grew rapidly from about 2010 onwards. In fact, it was in 2012 that global BIM research really took off and the number of BIM articles increased by approximately 50% every year. In another review of BIM literature, Santos, Costa and Grilo [21] point out that from the period between 2005 and 2015, more than 90% of all BIM-related papers included in their study were published from 2011 onwards. This shows the increasing attention that BIM has received in recent years and that the period between 2011-2012 was when BIM research grew rapidly.

A key article by Succar [10] received the most citations according to WoS. In this paper, Succar [10] laid out the theoretical framework relating to BIM application in the construction industry using a combination of ontology and visual knowledge models. This landmark paper was the influence on many subsequent papers in the field of BIM. Another authority on BIM is the previously mentioned Charles
Eastman who has produced important publications on BIM and his ‘BIM Handbooks’ series represent key textbooks in the study of BIM, receiving the most co-citations [20].

![Figure 3. Timeline of BIM in Malaysia.](image)

2.2. Malaysian literature
In the present study, a literature search was carried out in the WoS CC using a similar methodology proposed by Zhao [20]. The following code was entered into the Advanced Search field of WoS: TS =
(building information model* AND BIM* AND Malaysia*). This search was conducted in September 2019. Here, “TS” denotes an article subject and “*” represents a fuzzy search. The time span of the search was between 1999 and 2019, but the earliest paper to appear in the search results was published in 2012. A total of 69 bibliographic records were obtained from the initial search. After discarding 3 documents that were deemed unrelated to the scope, a total of 66 records were obtained.

The number of publications was the same for 2012 and 2013 but increased each year after 2013 and peaked in 2016 after which it decreased. The decrease from 2016 onwards suggests that quality BIM research is slowing down in Malaysia as shown in figure 4. In total, the publications included 39 conference papers and 27 journal articles. Table 1 shows the breakdown of subject areas of BIM literature in Malaysia. Most of the papers addressed issues related to the AEC industry in general with 28 publications. BIM studies related to quantity surveying and higher education were the second and third highest at 7 and 6 publications respectively. The 3 most cited papers in the WoS search results were Rogers, Chong and Preece [22], Takim, Harris and Nawawi [23] and Shoubi, Shoubi, Bagchi and Barough [24] with 14, 12 and 10 total citations respectively. Universiti Teknologi Malaysia (UTM) is affiliated with 24 out of 66 publications which is the highest among the higher education institutions in the country. Ali, K. N., Embi, M. R., Latiffi, A. A. and Enegbuma, W. I. were the most productive authors with 7, 6, 5 and 4 documents produced respectively.

Table 1. Subject areas of BIM literature in Malaysia between 2012 and 2019.

| Subject Area                        | Number of Publications | Percentage |
|-------------------------------------|------------------------|------------|
| Construction industry (in general)  | 28                     | 42.4%      |
| Quantity surveying                  | 7                      | 10.6%      |
| Higher education                    | 6                      | 9.1%       |
| Industrialized building system      | 3                      | 4.5%       |
| Housing development                 | 3                      | 4.5%       |
| Interior design                     | 3                      | 4.5%       |
| Automated safety rule checking      | 2                      | 3.0%       |
| Decision support                    | 2                      | 3.0%       |
| Finance                             | 2                      | 3.0%       |
| Green buildings                     | 2                      | 3.0%       |
| Data management                     | 2                      | 3.0%       |
| BIM governance                      | 2                      | 3.0%       |
| Facilities management               | 1                      | 1.5%       |
| Transportation                      | 1                      | 1.5%       |
| Architecture                        | 1                      | 1.5%       |
| Cultural heritage management        | 1                      | 1.5%       |
| **TOTAL**                           | **66**                 | **100%**   |
3. Government Efforts to Promote BIM

3.1. Increasing BIM competency

Many studies state the importance of BIM training among the construction industry for increasing BIM adoption in the country. The National Construction Industry Transformation Plan (CITP) shows BIM adoption in the country as being at only 10% [25]. Thus, they suggest increasing knowledge of BIM through training can increase BIM adoption. Mamter, Aziz and Zulkepli [26] showed that increased BIM training for new employees can lead to enhanced BIM manager capabilities of staff. Results show that software training for employees is needed to make them experts in BIM software. This situation leads to positive reinforcement in BIM manager competencies and finally lead to the creation of more BIM managers. Thus, the argument put forward is that for something to be widely adopted, information about it must be spread to as many people as possible to dispel any misconceptions.

Latiffi, Brahim and Fathi [27] found that respondents understand BIM as being a process (improving construction activities and sequence of work) and a technology (medium of communicating information in construction projects). However, the other categories of design, performance and productivity were not understood well by the respondents and they did not attribute these to BIM. The study revealed that the understanding of BIM among construction industry players was lacking. More training into BIM can clear up any misconceptions and lead to a higher adoption rate.

Another study by Latiffi, Brahim and Fathi [28] suggests that BIM competency among construction players is important for the development of BIM adoption in the country. In fact, only 2 out of the 28 respondents reported using BIM in the post-construction phase. This shows that the understanding of construction industry players towards BIM is as a pre-construction tool. Roughly half of the respondents used BIM because of their own initiative while the other half used it because of client demand. This suggests that a ‘push and pull’ is required from both clients and contractors for BIM to take off. They suggest that simply the use of BIM technology is not enough for its successful implementation, but also the competencies of the players involved. Thus, a tool must be used with accompanying expertise for it to be fully effective.
Qin [29] reported that companies that heavily use computer technology are more open to accepting new technologies such as BIM. In fact, the findings indicate the most important issue in implementation of BIM is the lack of training and awareness on BIM. They conclude that people are the key factors for determining the adoption of BIM. Thus, educating people on BIM may help increase uptake of BIM. As a conclusion, this situation is similar to how computer aided design (CAD) was first introduced in construction where a great deal of effort to train and prepare staff to use the new technology. Therefore, in preparation for widespread adoption of BIM, the groundwork for a new technology must be laid by educating and training staff.

3.2. Spreading BIM awareness

Since 2014, CIDB has organized a BIM Day every year except in the year 2017. This event is held as part of its annual International Construction Week (ICW) to promote and spread awareness of BIM. The first BIM Day was held on 22 September 2014 at the Putra World Trade Center and the latest one on 20 March 2019 at the Sunway Putra Hotel. Although a BIM Day was not held in 2017, the ICW for that year did include a variety of BIM-related seminars and workshops. These large-scale events are beneficial for the publicity of BIM to both the construction industry and the general public. Another effort by the CIDB is organizing regular BIM roadshows all over Malaysia and moving from state to state [30]. In fact, CIDB has also made efforts to promote BIM through digital means as well, most notably through social media.

CIDB has taken to social media to spread awareness of BIM through the hashtag “#letsBIM”. A hashtag is a word or phrase preceded by a hash sign (#) used on social media to identify messages concerning a specific topic. Interestingly, “#letsBIM” was not created by CIDB, but by a Twitter user named David Delgado Vendrell with the Twitter username @daviddelven. The first Twitter post to use the hashtag was on 27 February 2015 [31]. CIDB first started using the hashtag in a Twitter post on 8 January 2016 [32]. Since this first post, CIDB has been consistently using the hashtag to identify BIM related content that it posts to social media including on Facebook and Twitter.

In conjunction with BIM Day 2018, CIDB decided to organize an Intervarsity BIM Marathon from 19 to 22 March 2018. In this competition, student representatives from 9 higher education institutes in Malaysia competed to produce a 3D BIM model. The competition lasted for 66 hours non-stop and was recognized by the Malaysia Book of Records as the longest BIM Modelling Competition [33]. Overall, CIDB has shown to produce creative efforts to promote BIM in Malaysia especially the younger generation.

CIDB has invested MYR 2.5 million (approximately USD 600,000) for the establishment of myBIMcentre on 20 November 2017 which is a one-stop referral centre that hosts training courses for developers, contractors, consultants and suppliers [34]. The centre is used to provide BIM software training and is used alongside the National BIM Library Portal. In fact, these companies can apply for BIM training courses under the CIDB Transformation Fund programme of which MYR 1 million (approximately USD 240,000) has been allocated as financial incentive for construction firms to adopt BIM [35].

3.3. BIM in higher education

Yusuf, Embi and Ali [36] emphasize the importance of competency in BIM among students in higher education. By establishing a foundation for BIM early, it allows new graduates entering the workforce to either (1) influence the company to move to BIM or (2) adapt to companies that already use BIM. The construction industry in Malaysia needs competent graduates with ready knowledge on BIM. Including BIM into the curriculum of engineering graduates can help solve this problem. However, several challenges must be overcome. First, the lack of BIM training for academic staff in BIM-related departments. Organizations such as CREAM have been providing training on BIM to industry participants for some time. Thus, it would not be difficult to adapt the curriculum used in these training programs for academic purposes. Second, the amount of resources needed to set up laboratories, purchase computer hardware and BIM software is a big investment. However, engineering faculties are
equipped with computer labs for the learning of CAD software. Therefore, such labs may be able to be used for the teaching of BIM. Only the BIM software needs to be purchased for this to occur. Third, there is a lack of standard BIM curriculum. The question arises as to who the relevant authority shall be to establish such a curriculum. Feedback from students, academics and industry can help improve such a course and become the basis for a national BIM curriculum.

There is a debate between business BIM and academic BIM. Business oriented BIM is aimed at making a profit and it is appropriately named due to its business nature. Academic BIM is geared towards the knowledge development of BIM and is regulated by a governing body [37]. This also creates conflict between teaching-oriented universities and research universities. Teaching universities are more focused on preparing the graduate for the work environment and providing the skills necessary for them to operate in such environment. Research universities are more geared towards the advancement of learning and discovery of knowledge. Thus, there needs to be a balance between teaching and research as is with any subject, not just BIM. Eadie, Solan, Magee and Rice [38] studied pedagogical strategies of teaching BIM in the UK Higher Education setting and found that a constructivist approach is best used when teaching software elements of BIM. A constructivist approach is one where knowledge is constructed through experience and reflection of those experiences. Mamter, Aziz and Zulkepli [26] also found that graduates equipped with BIM knowledge and skills can increase uptake of BIM among companies in the industry. Not only that, but knowledge in BIM for graduates increases quality and employability of said graduate. Some HEIs including Universiti Tun Hussein Onn (UTHM) and Universiti Malaysia Pahang (UMP) have offered elective courses on BIM as part of a pioneer project to start the teaching of BIM in a higher education setting [33]. This is a good start for the widespread education of BIM among higher education students to produce graduates who are BIM-capable when entering the workforce.

4. Conclusions
As an agent of change, the PWD, CIDB and CREAM have been critical for the dissemination of BIM-related knowledge for the past 5 years and their efforts continue to pursue the aim of widespread BIM adoption in the country. They are more open to use new methods to promote BIM that resonate with the younger generation of today. The Malaysian government has shown effort to increase awareness of BIM among construction industry players and assist in capacity building for the use of BIM in individual firms. However, to achieve Level 2 BIM Maturity (model-based collaboration), efforts should be made to increase the collaboration between key players in the construction industry using BIM as a medium for cooperation.

Review of the literature published in WoS related to BIM in Malaysia has shown decline since 2016. Studies on BIM adoption in Malaysia have a very small number of respondents although these studies are meant to be qualitative in nature. Furthermore, these studies do not indicate which state they are conducted in. Construction activities vary greatly from state to state. Thus, different states may have different levels of BIM adoption. This is especially true with the difference in construction activities between East and West Malaysia. At the time of this writing, there is no systematic nationwide survey on BIM in Malaysia. Comprehensive nationwide studies such as by Ding, Zuo, Wu and Wang [39] for China and Hong, Hammad, Sepasgozar and Akbarnezhad [40] for Australia should also be carried out in Malaysia. Further research in Malaysia should be aimed at getting a better understanding of the current state of BIM in the country before appropriate plans can be made for the widespread implementation of BIM.

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