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Research paper

BIM Implementation in Asia Towards Functionalities: A Systematic Review

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Abstract

Building Information Modelling (BIM) becomes the important tools for architectural, engineering and construction (AEC) firms. BIM has been regarded as one of the growing requirements in the construction industry, as BIM provides a variety of facilities to assist in the smooth running of the project. The implementation of BIM in the construction industry has been identified by the researchers to determine the functionalities itself. Even though BIM has been implemented since decades ago, not all of the countries adopted BIM fully. This will influence the level of maturity of BIM for these countries. As Malaysia moves towards a vision of a high-income economy target, BIM provides the influence of information technology in the construction sector and the implementation of BIM leads to successful construction. This paper presents BIM implementation in several developed countries in Asia, as well as the functional issues of BIM will be highlighted. A systematic review of 42 journals and publications focusing on BIM functionalities in Asian region has been conducted and discussed. The finding shows publications about the functionalities of BIM in Asia have been growing rapidly. This paper is part of ongoing research into preparing a level of maturity for the Malaysian construction industry and its prediction.

Keywords: *BIM Adoption, BIM Implementation, Building Information Modeling, Malaysia, Maturity Level.*

1. Introduction

The technology of BIM has expanded around the construction industry in the world, due to the successful improvement of the projects. BIM offers an important improvement to the cost estimating, visualisation, advanced schedule before the appointed time, information store and so on [1]. The analysis of BIM has developed to integrate the software performing rapidly [2]. There had been enthusiasm from the construction players in using BIM in the recent times, as 3D modelling progress has been developed in many industries. Functionalities in BIM discover the informational data exchanges between the stakeholders, either as basic in nD or connected to the BIM expert [3]. The importance of BIM should have started from the level of education. In recent years, there has been an increasing interest among AEC teachers and lecturers to organise BIM into degree programs [4]. Various involvements for the BIM in the education exclusively reported in the literature from the countries where BIM is currently most implemented and some analysis about the BIM introduction in the university's curriculum has been discussed [5]. The main barrier to integrating BIM is the lack of BIM skilled personnel. Therefore, workshops and conferences should be arranged [6].

The adoption of BIM has been expanded and generate into the implementation of BIM, as well as various modernisation and addition for building construction, budget, facility maintenance, building performance analysis, and so forth. The companies are also eager to promote BIM in all lifecycle management. BIM functionalities comprise of the lifecycle management that can share the knowledge and report [7]. Research shows the functionalities in BIM have been changed from the store and network to the lifecycle knowledge and it will be the benefit to the stakeholders in the project [8].

BIM and automated quantities technologies provide both opportunities and challenges for the project cost management profession. BIM technology is usually defined as having three dimensions (3D), but this technology has more than 3D (model object). Among BIM dimensions are 4D (time), 5D (cost), 6D (facility management), 7D (sustainability) and 8D (security) [9]. Table 1 shows BIM dimensions and descriptions for each dimension.

Table 1: BIM dimension and its explanations

Dimension	Explanation
3D (model object)	Visualization of design results allows tracking of geometric issues and visual validation through technical solutions, also shows quality designs for customers, materials, finishes, lights, etc.
4D (time)	The planning process for linking the construction activities represented in the timeline with 3D models to develop real-time graphical simulations for the development of co-construction with time.
5D (cost)	Immediate budget generation reduces time-consuming estimates of quantities, improves estimation accuracy, reduces the incidence of disputes from the distortion of CAD data, and enables cost consultants to put more time in project value increases.
6D (facilities management)	Provides an integrated description of a building
7D (sustainability)	Allows the designer to meet the carbon target for an element of a project, validate the design or test and

	compare different options.
8D (safety)	Combine security aspects in both the design and construction process

Taylor and Bernstein reveal that most companies using BIM within their organisation will take a simple step in the process of acceptance by enhancing their experience. BIM is also useful in integrating supply chains and assisting them in the construction project analysis work. By drawing a visual representation of the model and its design using BIM, they will benefit from project coordination [10].
Therefore, this paper aims to overview at a global literature review of BIM implementation, adoption and functionalities in the project. The scope includes Asian countries that have been used BIM in the research or practice. Over 100 journals and publications were reviewed and listed as Asian research publications and expanded into its functionalities. Some of the publications discuss the research by its adoption, as the practice from the industrial players and governments are also considered. Methodology stage used in this paper is earch related to the study of literature. At this stage, the information about BIM implementation from last ten years publications such as journal articles will be arranged and classified into four different functionalities, based on Volk et al. described. Four different functionalities are built environment and the processes in AEC or facility management, civil engineering informatics in the construction, remote sensing, computer vision and surveying, and life cycle and waste management [3].

2. BIM implementation and adoption in Asia

A variety of meaning is used to describe BIM and its scope of allied technology [10]. BIM is a 3D modelling tool that cooperates with the companies to cut down the time and costs for their projects. It allows the involved parties in the construction to figure out better construction design, early problem detection, and improve work planning and project coordination [11]. BIM has been recommended widely as a platform to boost information communication and cut down the project's costs and duration in the construction industry. The practitioners in construction typically communicate with several parties involved in the project, and this way affects the project's productivity, quality and time [12]. For the current years, the BIM usage has been applied to achieve advantages in the construction aspects [13].
As we know, BIM is the technology that process of modelling and analysing. This technology must be taught to the students in the universities [14]. Barison and Santos stated that most universities had taught the BIM into the students by single-course – means that the students only have learned about one subject of BIM, i.e. engineering or architecture [15]. The BIM academic core defines that the content for students to study during the university life to be graduates who cope BIM in the construction and architecture [16].
Singapore is a leading country for BIM implementation and standards development in Asia or global [10], most of them have covered modelling approach and component presentation style and data management [17]. Since 1997, Singapore has begun bolstering the operation of BIM by the introduction of e-PlanCheck for the building plan submission for approval [18]. The Singapore Building and Construction Authority (BCA) are also implemented a strategy to have BIM on public projects by 2015 [19]. BCA led a multi-agency effort in 2007/2008 to implement the world's first BIM electronic submission (e- submission), called Construction and Real Estate Network (CORENET) [20].
The Ministry of Land, Infrastructure and Transport (MLIT) in Japan declared the inauguration of BIM pilot projects in authority buildings and reconstructed in 2010, as the first commitment of the Japanese government to BIM adoption in this country. From that point, more MLIT departments began to adopt BIM in their projects. However, development of BIM guidelines is relatively slow in Japan as there has been no national BIM standard released by government bodies in Japan [17].
Even though the level of BIM adoption in South Korea in 2012 is higher than in Western Europe in 2010 and North America in 2009, it is still under than North America in 2012 [21]. In January 2012, the Korean Ministry of Land, Transport & Maritime Affairs (MLTM) released a BIM implementation roadmap. Government agencies in Korea are active in planning and publishing BIM guidelines [17].
BIM implementation in Chinese construction industry is in the early stage, based on the survey taken that there were only 15% of the Chinese construction industry have used BIM [22]. In early 2012, the Ministry of Housing and Rural-Urban Development announced a program to begin establishing two BIM-related national standards, and China Institute of Building Standard Design & Research (CIBSDR) together with other research institutes, design firms, contractors, software vendors, and universities prepared also. Some local governments are also draft their local standards, for example, the Beijing authority released Building Information Modeling Design Standard for Civil Building in 2013 as its own BIM standard [17].
The implementation of BIM technology in Hong Kong has been started but it still not widespread. The public sector and some non-profit professional organizations have actively implemented and tried to examine the BIM potential. The Hong Kong Authority BIM standards are the first set of BIM standards that are widely accepted in the Hong Kong AEC industry [17]. The Hong Kong Housing Authority (HKHA) that has started adopting BIM since 2006 – is handling BIM technology in the public sector of Hong Kong for its public housing projects. A BIM centre was built in 2009 at the headquarters of the HKHA [19][20].
Even the building economy in Malaysia is quickly shifting to a thriving industry, it still suffers from an ineffective grasp of BIM concept in its approach because BIM is a new technology in the Malaysian construction industry and fewer companies have adopted BIM in their construction projects. Since 2009, the progress of BIM has been operated mainly by the private sector and has made a little growth in promoting BIM systems. Construction Industry Development Board (CIDB) organised Malaysia BIM Steering Committee in 2013 to assist the adoption and implementation of BIM in Malaysia and developed a Malaysia BIM Roadmap to roll out the construction industry for wider adoption of BIM by 2020 [23]. Table 2 shows the BIM implementation in several countries in Asia.

Table 2: BIM implementation in Asia

	BIM standard	Organization
Singapore	Singapore BIM Guide	Building and Construction Authority
South Korea	BIM Standard	Ministry of Land, Infrastructure and Transport
Japan	No standard	Ministry of Land, Infrastructure and Transport
China	BIM National Standard	Ministry of Housing and Rural-Urban Development
Hong Kong	Hong Kong Authority BIM Standard	Hong Kong Housing Authority
Malaysia	Malaysia BIM Roadmap	Construction Industry Development Board

3. Methodology

Due to the benefit and opportunity of BIM in the construction and management, the functionalities issues of BIM have been multiplied. BIM implementation in research covers some aspects of challenge in construction and building [3]. Functional issues will be reviewed in

this paper based on almost 50 journals and publications. Some papers do not mention or discuss BIM and its implementation. By developing the BIM technology is not only to the practitioners in the construction industry but also the students in the university, the best strategy to integrate BIM into the education system and introduce to the students as early as their academic life.
According to the functionalities of BIM itself, around 42 journals and publications have discussed BIM implementation. The remaining publications either do not mention the implementation of BIM, such as the statistics of BIM, or the research in the education system that does not belong to the functionalities. Clearly, it also shows that the most BIM publications about the implementation had been increased with the interest of the researchers. Practices from the countries to implement the government projects are also eager the researchers study about BIM functionalities. To make cost estimation easier in the building project, China researchers had introduced the cost estimation based on building quantity method with BIM-based design result [24]. China also focused on applying the BIM education to the universities students to develop the AEC industry needs. Compared to the countries like USA as the developed country for BIM technology, BIM education is in an early stage and need exposure to the students as they will face AEC market demands [25].

4. Findings: functionalities issues of BIM in Asia marketing

Based on Volk. et al. (2014), functionalities in BIM implementation can be divided into the built environment, civil engineering informatics, remote sensing, computer vision and surveying, and life cycle and waste management [3]. BIM has a special application for the architect, engineer, and contractor to help the building maintenance environment. Concerning the environmental effect due to construction, other technologies or systems can prevent big economic losses and incidents by combining with BIM to defect diagnosis better [26]. Several countries have the BIM initiatives that are classified into the technology, policy, and process. Moreover, the countries that have been discussed cover a depth range of scale of BIM implementations, like the USA produces a better BIM technology in North America and Scandinavian region is regarded as the earliest adopters of BIM technology [27].
Due to the BIM publications based on its implementation, some Asian countries have its scope of functionality – either it is a research publication or new practice in the construction industry. Since not all the AEC field is familiar with the BIM, as well as the AEC practitioners to understand its technology and the characteristics. By identifying the BIM implementation in the construction field through survey and analysis, it is more efficiently accepted by the architect, engineer, and contractor to identify the information technology and reversal the perception of them [28]. Masood et al. (2014) in their survey about BIM practice concluded that the BIM adoption in Pakistan is in a not adequate state, based on almost one-quarter of AEC constructions in Pakistan are involved in BIM technology [29]. Wong et al. (2011) explained the importance of BIM implementation in education for tertiary students. Based on the survey taken by the Department of Building and Real Estate in Hong Kong, the BIM implementation in education may be profitable, and it showed positive reaction towards the BIM training [30].
Most of the publications about BIM implementation in Asia published about civil engineering informatics as the main functionalities of BIM. The authors and researchers studied the benefit of BIM for AEC firms to implement a conceptual model that can improve the evaluation process and meet the industry requirements. By using BIM for sustainable design, the computer-aided design (CAD) is used to build a model, and the simulation engine will run the thermodynamic regulation. The designers are also can customise any features and test the impact of energy. But the BIM technology for this practice is about the complex integration that changes in building features over its lifecycle because of the activities took [31].
The most important thing that the AEC participants know is the knowledge and the experience of the project. Even that the BIM technology can encourage the engineers to increase the productivity and cut down the uncertainty, collaboration is the important component in the innovation. In the computer vision as the BIM functionalities, some information such as digital model, simulation, and parametric modelling were managed. 3D model for the bridge structures can extend the quality of design and 3D design method for the AEC industry was expanded [32]. Road structures design is also one of the BIM education that focused on the computer vision and surveying in the BIM implementation. It is important to establish a BIM research and development to achieve the value of BIM itself [33][34]. In Japan, MLIT had acquired to use network technologies, share the information and electronic data among public sectors, construction companies, and other institutions. But the result of the implementation of sharing data did not succeed, and other activities of data delivery and maintenance only partly succeed. The main issues are the information needed for major maintenance. By implementing BIM as the sharing media for construction information, the cost of the maintenance can be reduced with some increasing cost only for designing [35].
A lifecycle in BIM is the current developing practice of green building within the AEC industry. By adopted an integrating approach and focus on both BIM implementation and sustainable design, it shows an ideal framework to figure out the critical factors that dominate the BIM implementation in green building [36]. Asian researchers have focused on the civil engineering informatics as the major functionalities of BIM implementation, whereas life cycle and waste management is the least functionalities to be reviewed. The waste management in Asia has been deployed before the BIM implementation itself, and the researchers have been studied the importance of BIM only focus on other functionalities.
The AEC industry has put into action of implementation of BIM since the education system to enhance the level of adoption and maturity in the countries. The main problem is the use of BIM takes a long time to adapt itself, such as the lack of technical expertise and the professional. The government has provided the knowledge of BIM by workshop, meeting, and open day and established the committee as the reference of BIM in Malaysia to expose the BIM technology into the students. The committee has published the guideline to the practitioners to achieve the higher level of maturity and implementation of BIM, as well as the metrics of measuring the maturity of BIM in the country. Currently, the Asian journals and publications have focused on the research of BIM compared to the BIM practice in the construction field. This may be due to the lack of support from the government to do a practice, or the AEC firms reluctant to apply the BIM technology.

5. Functionalities of BIM in Malaysia

BIM is a new technology used in planning, designing, construction and management of clarity. This technology provides an object-oriented database consisting of 3D smart models. This technology also develops information systems that are easily accomplished centrally. This technology is seen to be able to help reduce the cost and time faced during construction of a project and once the project is completed. This clearly shows that this technology can help the construction industry become more efficient, effective and flexible.
BIM has emerged as a very powerful method that allows BIM users to visualise the project and provide a visual prototype of the buildings before the work starts. In Malaysia, the development of BIM was adopted in the private sector since 2009 before the government

sector adopted this technology a year later. The first project by the government sector using BIM is the National Cancer Institute in Putrajaya.

CIDB has seriously strived to develop BIM's interest in the construction industry, with the aim of providing a sustainable environment in which BIM can run. Initial efforts include providing awareness programs such as seminars and workshops with industries in the country to obtain feedback and views on BIM. The CIDB also took steps in setting up the BIM National Committee to coordinate the BIM movement in the country.

The global construction industry is moving forward in line with rapid change, which makes it important to use high technology. In applying BIM's practice of national practice is the regulatory and policy standards for industry, benefits and competitive advantages, as well as economic demand in the AEC industry [37].

It is an important thing to apply the functionalities from the BIM, whether it is used in the industry or not. Many lessons can be learned, and many experiences can be obtained by analysing, testing and then adopting some of the terms of maturity, achievement goals and quality assurance being widely used. BIM Maturity Index has five different levels, namely Initial, Defined, Managed, Integrated and Optimized. The following terms have been selected through a comparison of terms adopted by some maturity models [2].

Software should have multiple data interchange and handle multiple crates for cloud storage. Also, the software should be easy to understand and learn, as well as provide accurate information about the model such as quantitation. Good software can also save energy in its use to ensure that the life cycle is enhanced. Mature software should also be able to visualise the planning and development. The software is also capable of working with models and storing data continuously in the model. The facility management system should also be fully utilised in all BIM data [38].

According to the Honorary Secretary of the Association of Consulting Engineers Malaysia (ACEM), Ir. Looi Hip Peu, BIM is often imagined as easy as buying any software, and this causes BIM technology not being used effectively. He added that local contractors from the smallest class of classes were still not ready to apply for BIM in the country due to the low use of IT, in addition to BIM's standard format which has yet to be fully explained to the public. However, ACEM's expectations of which BIM can be practised in a manner appropriate by all players of the construction industry, which can enhance and facilitate the implementation of construction projects more efficiently and efficiently [39].

A study about examining the relationships of several constructs involving the BIM usage in Malaysia has recommended enhancing grey areas such as awareness, co-operation among construction professionals, and proof of return on investment and training. Using a four-part study instrument such as workers, process, technology and BIM acceptance, the ongoing drafting of which BIM policies are encouraging is recommended. Advanced study models can be used in assessing perceptions of stakeholders in the construction industry [40].

This study also makes comparisons between Malaysia's construction industry and the Hong Kong Polytechnic University, which has emphasised that BIM software knowledge, inadequate reference materials and component databases as a challenge to BIM's education at the university. Similarly, with the construction industry in Malaysia, which is far behind the sophisticated information technology and project management in Hong Kong. In summary, there is a significant relationship between the people involved, processes and technologies, which can be grouped as the use of BIM with BIM acceptance as shown in Figure 1.

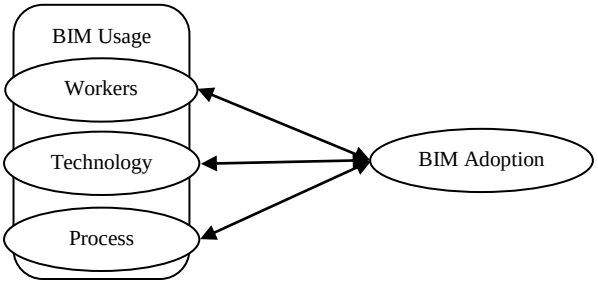

Fig. 1: BIM adoption model by Enegbuma et al. (2011)

As Malaysia moves towards a vision of a high-income economy target, BIM provides the influence of information technology in the construction sector. To address the challenges of increasing usage and usage, BIM promises a more sustainable and competitive construction process in all its impact [41]. The use of BIM as a facilitator in the work process has increased at a rapid pace in recent years. With the current of the economic affairs, the use of BIM has become another way for companies to market themselves and stand on top of their competitors. However, with the development of the BIM process and the ever-expanding technology, the level and quality of implementation among stakeholders vary dramatically throughout the organisation. At present, there is no standardisation of the BIM process or application. As a result, large diversity exists between stakeholders' BIM skills [42].

The implementation of BIM in construction projects can also lead to successful construction, but BIM has no significant value to the government. As a major customer, the government needs to be the earliest BIM technology, the user. The use of this BIM can reduce wastage and safety problems in construction, which indirectly leads to the completion of quality projects as well as improving the overall quality of the project and improving the image of the industry. Indirectly, the government's efforts to broaden the use of BIM technology in the country's construction industry [43].

BIM has been regarded as one of the growing requirements in the construction industry, as BIM provides a variety of facilities to assist in the smooth running of the project. The benefits of BIM's implementation depend on the efficiency and progress of the construction company. To achieve the highest level, BIM's maturity level of an organisation should be measured, and a tight strategy is also being developed to plan the implementation of BIM in line with the current maturity of BIM.

Therefore, different BIM maturity models have been developed to meet the needs of companies and organisations in BIM performance evaluation. To succeed in implementing this BIM, an effective strategy should be established about the current situation of a company and organisation in its use [44].

BIM's maturity model has become a useful way of distributing BIM worldwide, by showing users different levels of BIM development and offering a roadmap to this level. However, existing models do not recognise and measure the maturity of BIM in different analysis units, including individual projects, companies, or the construction industry as a whole [45].

6. Conclusion

BIM is one of the arriving technologies to be expanded in the planning, design, construction, and facility management. Based on the review of over almost 50 journals and publications from 2010, this study has provided an overview of the functionalities of BIM within BIM implementation in Asia. Even though the implementation of BIM in Asia developed fast, the research and practice among the industrial player are in the mediocre stage. The government agencies also have the contribution to introducing and research in BIM adoption and its challenge to the government projects. Lack of BIM players is also one of the challenges to implementing BIM into the projects, as not many construction players are not aware of this new technology. Some developing countries are ready to adopt BIM, and the players need the training as BIM can reduce the construction time and cost. This will help the government and researchers to study functionalities of BIM across the countries and bolster the practice among the players. Benefits of BIM implementation depends on the efficiency and progress of the construction company. To achieve the highest standards of construction, the BIM maturity level of an organisation should be measured, and a tight strategy is also being developed to plan the BIM implementation in line with the BIM maturity level.

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