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The Use of BIM Technology in Construction Design Phase

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Abstract

Building Information Modelling (BIM) is a digital information technology used to transmit information involving architecture, engineering, and construction as a set of interactions in the construction industry. When BIM technology is used as a management system in communication, the delivery of information is more accurate, clear, and detailed. However, problems occur when the construction industry lacks cost in the acquisition of such technology, in addition lack of knowledge and skills to use BIM technology process in project management. Therefore, this study identifies the factors use of BIM technology, the level of absorption, and the measures to increase the users of BIM technology in construction design phase. The method used in the data collection process is the questionnaire method. The population involved in this study includes architects and engineers, with a total of 80 distinguished populations. However, only 55 sets of questionnaire forms were recovered. The respondents involved in this study were architects and engineers. The result of the data analysis obtained shows that knowledge and skills need to be improved in the process of operating BIM technology. However, small-scale organisations cannot afford to own this technology because of the high cost and the need to undergo training in managing the technology. In an effort to coordinate the policy on the use of BIM technology, CIDB provides a centre as a reference for all parties involved in the industry to know the true concept of BIM technology and to undergo courses offered related to the use of BIM technology. These findings benefit those involved in achieving a more systematic use of BIM technology in organisational management involving the construction design phase.

Keywords: Building Information Modelling (BIM), design phase, BIM technology, construction industry

1.0 INTRODUCTION

Building Information Modelling (BIM) is a digital technology that can be used to design buildings and to determine the cost and duration of construction projects (CIDB, 2017). The construction industry faces challenges in the design phase as this phase involves complex construction structure design works. The use of BIM technology can help the construction industry because it has information that covers the phases of planning, construction, after construction, and up to management of the building life cycle with the production of quality work (Hallowell et al., 2016). BIM is also the key planner used in the construction industry because it has three main components, namely cost, quality, and time, whereby these three components are very important in improving the quality of work in the construction industry (Chen et al., 2014).

Design is the arrangement of work made according to the needs and regulations based on the concept that is appropriate to the product produced. Whereas technology is the knowledge and skills of human effort in using tools, resources, techniques, and systems in management in addition to expanding human potential in the exploration of modern technology (Enegbuma et al., 2014). BIM technology is a digital technology in the construction design phase, apart from facilitating all parties involved in the construction industry to obtain information more systematically (Liu et al., 2017). In addition, BIM technology also simplifies the management of operations in an organisation because the coordination of tasks and activities can be performed more systematically. BIM can save cost and time. In fact, BIM technology is not just a technology that has three-dimensional (3D) software, instead it acts as a set of interactions between policies, processes, and technology in the production of a method to manage the importance of building design and project data in digital form through building life cycle (Rahimian et al., 2020). Therefore, the use of BIM technology in the construction design phase is seen as extremely important in helping the management of construction projects to run smoothly.

2.0 RESEARCH PROBLEM

Building Information Modelling (BIM) is a technology used in the project management process, starting from the planning stage to the building life cycle management (Ahmad, 2015). When BIM technology acts as a model that provides innovation towards increasing

productivity and value improvement towards economic growth in the construction industry, then there are challenges and issues that need to be faced in the construction industry. Moreover, according to Ahmad (2015), BIM technology is a major centre in information acquisition. However, the construction industry initially still maintained the use of two-dimensional (2D) drawings which is a traditional method that is different from the architects, engineers, and consulting and government agencies involved in the project management setting process. Still, there are various problems that occur when it involves costs due to the project journey that is very complex and complicates situations. As a result, there are issues of difficulty to read problems, misconstruction at the project site, changes in the construction structure after the design phase is completed, and inaccuracy in the delivery of information.

As the construction industry shifts to the use of BIM technology, there are also obstacles due to the lack of knowledge of developing countries in the use of BIM technology (Wang & Chong, 2015). According to Rogers et al. (2015), when modern technology is used in a country that lacks knowledge and skills in the process of technology operation, then there are difficulties in the process of coordination and management. Thus, this will affect the management of the project to be carried out, apart from the fact that the use of BIM technology requires a high cost investment in technology acquisition.

Even so, the use of BIM technology in the design phase is in high demand because complete information specifications can be obtained from three-dimensional (3D) drawings that are capable to provide a detailed picture of the shape, materials used, dimensions, overall cost of the project, accurate building structure, timeframe for completion, and building life cycle management (Palos et al., 2014). Therefore, the use of BIM technology in the construction design phase can overcome the problems encountered in project management as well as improve the quality of work production in organisations involved in the construction industry.

■3.0 LITERATURE REVIEW

3.1 Building Information Modelling (BIM)

Various definitions can be elicited to illustrate the meaning of BIM from different perspectives in the construction industry. Nonetheless, BIM is a tool that can help the construction industry to solve problems that occur in construction planning, because it is not just a technology, but it also includes the process used through the correct and appropriate technology (Rahimian et al., 2020). BIM was more focused on pre-planning, design, construction, and delivery of integrated building and infrastructure projects, but it has shifted to building life cycle research such as maintenance, overhaul, improvement, and complex structuring (Wu et al., 2018). In addition, in the construction design phase, BIM technology can identify the risks that will be faced in construction by conducting analysis before the construction design is carried out (Dawood & Vukovic, 2015). BIM is very helpful in terms of delivery of building information in general, obtaining detailed data on the components installed and necessary equipment such as service zone, date of installation, type of installation, manufacturer, geometry, and exact location, materials and composition, physical characteristics, warranty, and also maintenance (Stanley & Thurnell, 2014). In fact, BIM is not just a technology, it is also used in the early stages of construction to determine the suitability of the construction site.

According to Golabchi et al. (2016), BIM is a digital representation tool that encompasses physical features and serves as a facility for information acquisition. BIM is also a source of knowledge of information shared to form a solid foundation in determining decisions on a building during its life cycle, defined as the existing from initial concept to demolition (Liu et al., 2017). BIM is the collaboration of various stakeholders that are different at various phases of the building life cycle to enter, output, update, or modify information in BIM technology to support and illustrate the role of stakeholders. Therefore, the use of BIM technology in the construction design phase can form a more systematic management organisation in the initial process of construction. The design phase is very important in determining whether the construction project runs smoothly during the construction phase or otherwise. In addition, at the design phase, it will also determine whether the cost, time, and quality of the product produced become successful or otherwise.

3.2 Factors of BIM Technology Use in Design Phase

BIM technology is like a social networking model. With the use of BIM technology, the management system in the design phase can be arranged in a more organized manner (Abubakar et al., 2014). This can be seen through the information delivery system. For example, in the design phase, if there is a change in the drawing of the model produced, it can be communicated directly through the updated data in the BIM technology used. This has a very positive impact on the production of construction design of a project. In fact, BIM technology does not only has a traditional design process, but it also consolidates construction information throughout building life cycle. Almost all information at each stage of a construction project are generated, processed, and shared electronically until the construction period can be shortened and risks can be reduced. Nevertheless, there are factors that hinder the use of BIM technology in the construction design phase (Arayici et al., 2018).

Among the factors that influence the use of BIM technology in the design phase is that the time to draft the design can be reduced and can directly continue to do the design in BIM technology because if there is a design change, it can be done directly with the use of BIM technology (Ding et al., 2015). Even developers also asked to use BIM technology because the design created can be displayed in three dimensions (3D), so the picture is clearer on behalf of the clients. In addition, changes in communication also occur between clients and the parties involved in project management, whereby the information presented is clearer and more detailed with a picture that can be seen by the clients themselves (Kullvén & Nyberg, 2014).

In addition, changes in document version also occur when using BIM technology. The use of BIM technology also increases knowledge and skills in the construction industry when the involvement of the use of modern technology is used in the management of a project (Tulenheimo, 2015). Even the reduction in terms of construction costs involving the design phase can be achieved with the use of

BIM technology. The use of BIM technology can also identify critical parts in construction, identify errors that occur, make cost estimates as well as form an effective project management organisational structure. However, the lack of management, knowledge, and skills on BIM technology in the construction industry in Malaysia has resulted in the use of BIM technology being less popular.

3.3 Level of BIM Technology Use

The level of use of BIM technology is measured through level 0 (Manual), level 1 (capitalization), level 2 (collaboration), and level 3 (consolidation) (CIDB, 2017). Level 0 represents manual, that is 2D CAD/organised CAD. Both computer-based documents and manuals are used such as CAD pictures and spreadsheets. A large amount of project information such as pictures and written documents are handled manually. Design formation cannot be communicated effectively. Level 1 is capitalization that includes discipline-based 3D models. The use of BIM technology (if used) to coordinate design or construction activities is addressed internally. There are no significant model-based changes between the differences. The implementation of BIM takes place in an isolated situation in an organisation.

Level 2 represents the collaboration that includes the visualization of the model in 3D along with the digital information required. Construction information will be handled in an arranged manner in a 3D environment. Information can be shared and communication can be performed by using specialized and general platforms. The use of multidisciplinary models that promote collaborative processes. The use of general standards for collaboration between various fields. Level 3 is integration/unification, of which 3D models and digital information are integrated through network-based applications. The use of chain-based BIM technology strengthens collaborative progress and coordination throughout the construction process. The use of a single source of information in a chain.

3.4 Strategies in Enhancing the Use of BIM Technology

The construction process is not easy, it requires skills in work layout from initial planning to submission of the project to the owner. Therefore, it is appropriate to use BIM technology in the construction industry which helps in the aspect of determining cost, time, and quality. Strategies can be done in increasing the use of BIM technology in the design phase are through integrated management method, management scope, time management, cost, quality, human resources, communication, risk, and procurement can be implemented. In addition, improving knowledge and skills in the use of BIM technology in the design phase can improve the quality of work (Porwal & Hewage, 2013). In organisational management, it can be coordinated with the improvement of policies, processes, and technology.

In addition, the use of BIM technology can also improve the budget management system and work schedule and can establish good cooperation in the design team through virtual internal communication method (CIDB, 2017). CIDB is also in the process of organising various programmes to increase the use of BIM technology in the construction industry. CIDB also provides training and courses on the use of BIM technology. BIM technology is not just a modern technology that is capable to provide a picture in 3D, but it also solves problems involving risks at the construction site, planning, scheduling, site conditions, materials used, costs, and so on through digital technology method.

3.5 Implementation of the Use of BIM Technology in Design Phase

Technology is the main medium in conveying information electronically without having to meet each other. It is seen as a combination of one party with another to send the required information directly and accurately. Technology is an infrastructure in communication that also helps to enhance collaboration between internal and external parties in conveying information, online marketing and sales, construction, and support in terms of design, operation, and maintenance (Hallowell et al., 2016). In the construction industry, the technology used can enhance skills and knowledge in the use of modern technology. BIM is an advanced technology that transfers information and acts as a communication medium. BIM technology is used at an early stage which is the building design stage.

In the construction industry, various parties are involved: customers, consultants (architects, engineers, and materials surveyors), contractors, construction managers, and labourers (CIDB, 2013). A common understanding of BIM technology from a practical point of view is that a model acts as electronic data that contain all the information available on the building and can be accessed by any parties (such as architects, contractors, owners, or project managers) who want to find information and add or remove any information from the model at any time for construction management use. By using BIM technology, it can improve the quality of detailed and accurate information transfer. This can also prevent any misunderstandings and misconstructions from occurring during the construction period.

■4.0 RESEARCH METHODOLOGY

This study utilises a quantitative method which is a set of questionnaire forms prepared. The questionnaire form is divided into four parts, namely part A demographics of respondents, part B factors influencing the use of BIM technology in the design phase, part C level of use of BIM technology, and part D measures in increasing the use of BIM technology in the construction design phase. Based on the data obtained from the respondents, the analysis of the study was done using the Likert scale measurement method, the data was then entered into the SPSS Data Editor for statistical procurement and the result of the analysis was displayed in the SPSS Output Navigator. This study focuses on professionals consisting of architects, engineers, and also the Malaysian Construction Industry Board (CIDB).

A total of 83 respondents is the target population of the researcher in this study which includes architects and engineers. This population is obtained from the official website of the Johor Public Work Department in the list of registered engineers and architects. Whereas the sample size corresponding to the study population is 66 respondents based on the table of Krejcie and Morgan (1970).

However, the responses obtained from respondents were only 55 sets compared to the 70 sets of questionnaire forms distributed, hence the percentage received was 78.6 percent for all respondents.

■5.0 RESEARCH ANALYSIS

5.1 Respondents' Demographic Data

Based on Table 1 below, the respondents involved in this study consisted of architects and engineers. However, there were respondents in other positions such as assistant engineers and also materials surveyors. A total of 47.3 percent of the respondents consisted of 26 respondents who hold the position of architect, while 38 percent of the respondents consisted of 21 respondents who hold the position of engineer. However, 15 percent of respondents who hold positions other than architects and engineers also answered this questionnaire. These respondents were also involved in the use of BIM technology in the construction design phase. In addition, the researcher also posed questions related to the categories of projects previously handled by the respondents, qualifications in academics, and length of service in the construction industry to see the extent of the knowledge of respondents on the use of BIM technology in the construction design phase.

Table 1 Respondents' demography

Items	Frequency	Percentage (%)
Respondents		
• Architect	26	47.3
• Engineer	21	38.2
• Other positions	8	14.5
Project Categories		
• Industrial	11	20.0
• Residence	10	18.2
• Infrastructure	11	20.0
• Social facilities	2	3.6
• Landscape	4	7.3
• Other projects	17	30.9
Academic qualifications		
• SPM	0	0.0
• STPM	5	9.1
• Bachelor's Degree	38	69.1
• Degree	7	12.7
• Other qualifications	5	9.1
Period of service in the construction industry		
• <1 year	5	9.1
• 5-10 years	29	52.7
• 11-20 years	17	30.9
• >21 years	4	7.3

5.2 Factors that Influence the Use of BIM Technology in Design Phase

Based on the literature review, the researchers formed a set of questionnaire forms that posed questions related to the factors of the use of BIM technology in the construction design phase. This question is divided into six factors, namely changes in communication medium (1), cost estimates (2), changes in document version (3), improvement of knowledge and skills (4), formation of organisational structure (5), and client demand (6) for the use of BIM technology in the design phase. Table 2 shows the index average data analysis obtained based on the questionnaire forms.

Table 2 Factors influencing the BIM technology use in design phase

Factors	Average Index (AI)	Interpretation	Ranking
Improvement in knowledge and skills	4.08	Agree	1
Change in the medium of communication	4.06	Agree	2
Change in the version of documents	3.99	Agree	3
Establishment of the organisational structure	3.98	Agree	4
Requests from clients/customers	3.96	Agree	5
Estimated construction costs	3.94	Agree	6
The total average index		**4.00**	**Agree**

5.3 Level of BIM Technology Use

The use of BIM technology will involve changes in the management process of the construction organisation either due to internal factors or external factors. There are four levels in determining the ability to use BIM technology in an organisation. Whereby the levels are divided into Level 0 only with the use of CAD, Level 1 change from 2D to 3D, Level 2 use of BIM technology that combines models and materials, Level 3 which is divided into two parts, namely iBIM and building life cycle management that enables data and processes to be included. The result of the data is shown as in Table 3 below.

Table 3 Level of use of BIM technology

Questions	Mean	Interpretation
The level of usage will be assessed based on the project that uses BIM technology, whether it is in cost control and completed within the scheduled time.	3.84	Unsure
Based on the knowledge and skills in the use of BIM technology, the level of use of BIM technology in the delivery of information to all parties involved can be classified.	3.92	Unsure
Engaging oneself in BIM technology handling courses.	4.05	Agree
Level assessed through accreditation/certificate from a university or learning centre in the field taken.	3.85	Unsure
Information delivery system through BIM technology that is more accurate can do the job according to the specifications and timeframe set..	3.87	Unsure
BIM technology enhances systematic work management procedures.	3.91	Unsure
Total Average Index	**3.91**	**Unsure**

5.4 Strategies to Enhance the Use of BIM Technology

Multiple strategies are taken in an effort to increase the use of BIM technology in the construction industry. However, if the involvement of the industrial parties in the use of this technology is still lacking, the government cannot coordinate the use of BIM technology in the construction industry. CIDB as the driver in realizing the use of BIM technology in the construction industry by 2020, must strive to increase knowledge and skills among the industrial parties involved in the construction design phase. Among the measures presented by the researchers in this study and the data obtained based on the questionnaire forms are as below (refer Table 4).

Table 4 Strategies to Enhance the Use of BIM Technology

Strategy	Average Index (AI)	Interpretation	Ranking
Enhance knowledge and skills on BIM technology	4.29	Agree	1
Establish policies in the construction industry	4.11	Agree	2
Implement the use of BIM technology	4.11	Agree	3
Implement the process of coordinating the use of BIM in the construction industry	4.10	Agree	4
Introduce the technology used in the construction design phase	4.10	Agree	5
Enhance innovation in the use of technology in the construction industry	4.01	Agree	6
Total Average Index		**4.12**	**Agree**

■6.0 DISCUSSION

Based on the analysis of the data obtained, the main factor influencing the use of BIM technology in the design phase is for the improvement of knowledge and skills. BIM technology has become a new phenomenon in increasing the use of technology in the design phase because it is able to increase productivity, quality, and high collaboration value in the involvement of many parties (Rogers et al., 2015). However, the construction industry parties need to know the concept and theory of BIM to improve knowledge and undergo BIM skills courses so that organisational management can run smoothly. Therefore, the initial exposure related to BIM has an impact on the effectiveness of the use of this technology because BIM technology affects the use of modern technology with the production of digital information that facilitates the management of all parties in project management. In addition, changes in communication medium, changes in document version, formation of organisational structure, client demand, and cost estimates are among other factors that make the use of BIM technology important in the design phase. The delivery of accurate, clear, and detailed information makes BIM technology as a medium of communication to the project management parties. Whereby all the required information can be obtained in BIM technology whether information related to design, materials used, position or illustration of the structuring of the building, and building life cycle for maintenance purposes can also be obtained in the technology. Changes in document version in question are changes from paper to digital technology. In the use of BIM technology, all the required documents can be easily obtained. In the event of a change in project management, it can also be done directly. In addition, the formation of an arranged organisational structure is capable of an approach to integrating people, systems, structures, and practices in a common process that leverages the advantages and views of all parties involved in optimizing project production, increasing value to owners, reducing waste, and maximizing efficiency through all design, fabrication,

and construction phases. Clients' demand to use BIM technology is also higher when clients learn about the advantages of BIM in project management. In addition to the construction design can be depicted in the form of 3D, BIM technology is also able to provide documents related to the cost and duration of the construction project.

Nonetheless, the factors that influence the use of BIM technology in the design phase will help to increase the level of absorption of the use of such technology in the construction industry in Malaysia (CIDB, 2017). There are four levels of measuring the use of BIM technology, namely levels 0, 1, 2, and 3. Malaysia makes the UK as a reference in setting the level of use of BIM technology. Data analysis shows that the exposure to BIM technology is still at level 0, whereby project management organisations are still using CAD method for the design process. The majority of respondents were not sure how the level of use of BIM technology is measured. Looking at the data analysis done, the respondents agreed that involvement through courses on the process of operating BIM technology will increase the level of use of the technology in the construction design phase. In BIM technology management system, it can be classified into three phases. The first phase is moderator, coordinator, and manager. Disclosure of BIM technology needs to be done, to find out the extent of the country's economic progress in the construction industry in Malaysia. It is certainly not easy to make existing changes in the construction industry, but changes to modern technology will further help to improve the quality in productivity production produced in the construction industry (Porwal & Hewage, 2013).

Nevertheless, each field has its advantages and disadvantages as well as the tools used. Not everyone has the same knowledge of a certain matter. The information in the BIM model can support the everyday operations and planning required to ensure the building continues operating efficiently and effectively (Reddy, 2012). Therefore, strategies can be taken to increase the level of use of BIM technology in the design phase is to improve the key knowledge and skills about BIM, then implement policy, implement coordination of the use of BIM technology, introduce the types of BIM technology used in the design phase such as AutoCAD, Revit, Naviswork, and Cost - X, in addition to enhancing innovation in the use of BIM technology in the construction industry. BIM operates on a collaborative basis in a construction project and in this environment, all stakeholders in the construction process including owners/developers, project managers, consultants, contractors, subcontractors, and facility managers have access to the same design, cost, and schedule information at the same time. In Malaysia, myBIM Centre was established to be a reference centre for all groups involved in the construction industry to be exposed to the latest technology. CIDB is also in the process of increasing the use of BIM technology in the ecosystem, facilities management, providing training, and issuing guidelines as key steps in upgrading the skills of professionals.

■7.0 CONCLUSION

The purpose of this study is to see the extent to which the country's economic development moves in line with the development of modern technology that can be used in the construction industry. Based on the study conducted, it can be seen that the use of BIM technology in the design phase greatly helps the construction industry in improving the knowledge and skills of the parties involved in project management by using this facility as best as possible. The collaboration established is able to increase the level of absorption of the use of BIM technology in the industry. In fact, the disclosure of BIM technology introduced by CIDB through myBIM Centre is also very helpful to public works department, consultants, and developers in establishing joint collaboration. In addition to exposure to concepts and theories related to BIM, myBIM Centre also provides courses on the operation of technology to the public. This provides a very positive impact on the government's efforts in coordinating the use of BIM technology in the construction industry. In addition, the construction industry is able to move more effectively with the use of BIM technology because digital technology is able to provide detailed information of a project. Along with the country's economic development, the use of BIM technology also needs attention from all parties. In fact, all parties should unite towards the implementation of the use of BIM technology in the construction industry in this country.

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