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Implementation of Building Information Modelling (BIM) Education for Construction Management Students: The Case of Malaysia

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ABSTRACT

The construction industry is continuously evolving, and the adoption of Building Information Modelling (BIM) has become crucial for efficient project management. BIM can be defined as a collaborative process among various construction players by providing information in digital format throughout the project's lifecycle. Its potential in the industry, such as clash detection between elements will improve project efficiency and operational processes. However, there is a shortage of BIM skills in the Malaysian industry, resulting in low implementation compared to other developed countries. As a result of this lack of skills and high demand for BIM professionals, institutions should integrate BIM education effectively. Although several institutions in Malaysia have incorporated BIM into their academic programs, and some are still working to do so, it still needs improvement. Therefore, there is a need to understand its challenges and strategies for implementing it in the academic system. This study employed quantitative research as the primary method of collecting data with questionnaires were distributed online to 86 active Construction Management (CM) students enrolled in the BIM course in UiTM. Only 54 students responded to the survey (62.79% response rate). The findings reveal that the inadequate facilities to implement BIM properly (technology aspect) is the most challenging factor when learning BIM. Besides, it was found that the best way for institutions to implement BIM is to work with BIM professionals. Thus, it is hoped that the outcome of this research will help institutions and educators identify areas of improvement for enhancing the quality of BIM learning.

1.0 INTRODUCTION

The world is undergoing substantial transformations as a result of the swift advancement of technology. Due to that, the introduction of Information and Communication Technology (ICT) has resulted in an enhancement of communication and operational methods through the establishment of systematic and organized processes for each aspect (Beer & Mulder, 2020). The application of ICT is very significant in a variety of industries, not leaving behind the construction industry. Digitizing all construction-related information is gaining the attention of a number of individuals and organizations as a way of reducing various problems and improving business processes as a result of the trend of globalization (Ismail et al, 2020). An important information technology tool for the construction industry has been introduced, known as Building Information Modelling (BIM). BIM is described as a digital approach that facilitates collaboration and integration between construction professionals in order to manage construction projects throughout their life cycle (Al-Ashmori et al., 2020). This innovative technology method has been widely employed in the Architecture, Engineering, Construction and Operation (AECO) sector and is believed to have increased project management quality, efficiency, and effectiveness (Moreno et al., 2019).

A growing number of countries are using BIM to plan, design, construct, monitor, and control their construction projects (Mohammad et al., 2018). In addition, the rate of utilization among the government and private sectors is increasing as the need for BIM rises globally (Al-Sarafi et al., 2022). However, it is found that there is a shortage of BIM skills in the industry in Malaysia, resulting in low implementation compared to other developed countries (Farooq et al., 2020). Because the demand for BIM-competent workers has increased due to emerging technology, this shortage of competent workers will be detrimental to the market, project effectiveness, productivity, and performance (Othman et al., 2021). The emergence of BIM in construction management has influenced the level of knowledge and awareness, technical capabilities, and education of people in the industry. The industry recently needs people with BIM skills and knowledge to integrate BIM into the construction work processes successfully (Hodorog et al., 2019). For that, educational institutions play a pivotal role in imparting BIM knowledge to the construction industry, serving as both sources of information and knowledge hubs.

The introduction of BIM has given various advantages to the construction industry. Many nations, including the United States of America (USA), Singapore, Australia, and other developed nations, utilise BIM in their projects (Ismail et al., 2020). Several initiatives are made to boost BIM use in the building sector and one of the approaches is through education. According to Yi & Yun (2018), 11 universities in Australia have demonstrated the most BIM adoption in their undergraduate programs, and the CM programme appears to have the greatest rate of BIM education course implementation. However, in Malaysia, there are too few higher education institutions with a department dedicated to preparing graduates for careers in BIM for the construction sector (Yusoff et al., 2021). According to Manoharan (2017), most construction management students in higher education had inadequate awareness towards the use of BIM in the Malaysian construction industry. Hence, it is imperative to recognize the challenges in BIM education in construction management implementation in order to provide the best means in maximising its effectiveness.

2.0 LITERATURE REVIEW

2.1. Innovation in Construction Industry

The construction industry is described as a sector of the manufacturing and trade industry that involves the operation of constructing, erecting, renovating, repairing, and maintaining facilities (Hussain et al., 2022). An important facet of this sector is its contribution to socioeconomic advancement, bolstering tourism and manufacturing, generating employment opportunities, enhancing quality of life, and fostering potential for international business ventures. From a global viewpoint, the output of this industry is typically expressed by its value-added and frequently represented as a percentage of GDP which with an annual average share of 3.9 per cent as suggested by Economic Outlook 2023 (2022). While its individual contribution might be modest, the construction industry exerts a valuable multiplier effect on the overall economy due to its extensive interconnections with various sectors through both backward and forward linkages. Looking at the situation of Malaysia, according to Vision 2020, the construction industry must contribute an average of 6.0% of GDP annually to the country's transformation from a developing to a developed nation. However, Dehdasht et al. (2022) in his study declared that the country's construction sector had not managed to achieve the target.

For that, the government is working towards establishing a sustainable future for this industry by taking proactive steps to help it recover from the effects of the financial crisis. For instance, strategies for enhancing efficiency of projects and raise building quality in the direction of digitalization has been published by Malaysia called the Construction 4.0 Strategic Plan 2021 – 2025 (CIDB, 2020). The industry would evolve to adapt to economic changes through the implementation of automation, digitization, ecological, societal, and regulatory changes, and the development of the necessary talent and knowledge (Jalil, 2022). Hadzaman (2020) stated that the cornerstones of timeliness, cost, and quality for a project are crucial in Construction 4.0 since they serve as the primary indicators of project success. The concepts of sustainability and circular economy are incorporated into Construction 4.0 and IR 4.0 (Sawhney et al, 2020) which also include BIM, 3D printing, 3D visualisation, virtual reality, and other cutting-edge innovations are creating a significant shift, enhancing our capabilities for managing projects systematically at a much higher efficiency (Casini, 2022). Besides, it was specifically mentioned by Hadzaman (2020) that Industry 4.0 has encouraged the built environment sector to adopt BIM as a centralized database for digitalized project information. The BIM process has thus become a prominent influence in the Architecture, Engineering, and Construction (AEC) field. Hence, to meet Construction 4.0 and to support the initiatives outlined above, BIM education will be the central medium for ensuring the successful use of BIM in the AECO industry.

2.2. BIM Education in Malaysia and its challenges

Malaysia started introducing BIM at the beginning of 2007 despite BIM software has started to exist in 2002 (Sinoh et al., 2020). Moreover, BIM technology has been integrated into higher education institutions to cultivate graduates who possess the skills to effectively implement BIM in the forthcoming professional landscape. Currently, most industries prefer to hire workers with specific skills and an understanding of BIM (Hodorog et al., 2019). In response to the needs of the industry, which has embraced BIM-based digital construction, the education system in Malaysia has also initiated the incorporation of BIM-based learning methods. For instance, in 2018, a Memorandum of Understanding (MoU) was binded between the government Public Work Department (PWD) with Universiti Malaysia Pahang (UMP) in promoting the comprehension and efficacy of BIM in the building sector (Yusoff et al., 2021) which aims to formally establish a strategy formulation for the application of BIM through three (3) channels: academic, research, and negotiating (Brahim, 2018).

Although there exist numerous advantages linked to BIM utilization, the effective integration of BIM into higher education faces several challenges. In the present day, BIM education poses several challenges to Construction Management (CM) curricula, the Architecture, Engineering, and Construction (AEC) sector, as well as academic institutions (Huang, 2018) and being summarised in table 1.

First and foremost, BIM adoption challenges are associated with people. Tanko & Mbugua (2021) in their studies found that the understanding of the topic of BIM learning is low in colleges and universities. Shelbourn et al. (2017), as cited by Belayutham et al. (2018) have also expressed concern about instructors that treat BIM as a software program. This barrier not only causes misconceptions among students but also produces BIM graduates who are not specialists. The research also revealed that there is a shortage of teaching staff who are talented, knowledgeable, and experienced enough to teach BIM (Palis et al., 2022). According to Tanko & Mbugua's research from 2021, this issue will continue to lower the number of qualified BIM professionals and utilization in construction projects. Lack of BIM skills has become a significant issue throughout the world, especially in Malaysia (Huang, 2018; Yusoff et al., 2021). Moreover, the low level of interest among students and teaching staff is a barrier to BIM learning and teaching, which in turn leads to poor motivation and understanding of the subject (Huang, 2018; Besné et al., 2021).

Besides that, the barriers for implementing BIM education properly are also associated with the information and process aspects. Based on a survey carried out by Belayutham et al. (2018), the process of amending the current syllabus structure takes a large amount of time, and there is a lack of understanding of how the BIM procedure works. In addition, when BIM education was initially incorporated into the construction management curriculum, the limited availability of course materials, exercises, or models presented a critical limitation (Huang, 2018). This statement is also in line with Belayutham et al. (2018) and Palis et al. (2022). Yusuf et al. (2017) also added that due to the inadequate resources needed for information, knowledge, cost, and time, as well as the impacts on project delivery processes, BIM is a new technological sector that poses several challenges today and is being seen as a deterrent to academicians.

Table 1. Challenges to BIM education implementation

No.	Challenges to BIM education implementation	Author
	People	
1.	Poor understanding of BIM knowledge.	Tanko & Mbugua (2021).
2.	Instructors treat BIM as a software program.	Shelbourn et al. (2017), Belayutham et al. (2018).
3.	A shortage of qualified staff who are knowledgeable and experienced enough to teach BIM.	Shelbourn et al. (2017), Belayutham et al. (2018), Huang (2018). (Yusoff et al., 2021), Palis et al. (2022).
4.	Lack of interest in learning BIM among students.	Huang (2018), Besné et al. (2021).
	Process & Information	
5.	The process of amending the current syllabus structure takes a large amount of time.	Belayutham et al. (2018), Huang (2018).
6.	A lack of understanding of how the BIM procedure works.	Belayutham et al. (2018).
7.	Limited availability of resources, course materials, exercises, or models.	Huang (2018), Belayutham et al. (2018), Yusuf et al. (2017), Palis et al. (2022).
	Technology	
8.	Inadequate equipment and tools to adopt BIM properly.	Belayutham et al. (2018), Palis et al. (2022).
9.	Students have limited accessibility to BIM software for education.	Belayutham et al. (2018).

Furthermore, the technology aspect is also one of the challenges for BIM education. Based on the findings of a previous study, higher learning institutions have inadequate equipment and procedures to adopt BIM properly, and students have limited accessibility to BIM software for education (Belayutham et al., 2018). According to Palis et al. (2022), the insufficient hardware and software provided by the university become a barrier to implement BIM subjects. The insufficient use of BIM in higher education's programmes does not fulfil industry competitiveness standards (Yazid et al., 2020; Hjelseth, 2017) since BIM technology must be compatible to be used, or else, it can detrimentally affect the performance and expenditures of the institution.

Based on the above, BIM adoption faces significant challenges primarily related to people, processes, and technology. Previous research indicates a low understanding of BIM in educational institutions, with instructors often treating it merely as software, thus leading to graduates lacking specialization. Besides, there is other pressing issues such as shortage of qualified teaching staff, reducing the number of skilled BIM professionals, especially in countries like Malaysia. Furthermore, amending current syllabus to include BIM is time-consuming, and there is a lack of sufficient course materials and understanding of BIM processes. For that, it is not wrong to put forward that technological barriers include inadequate equipment and limited access to BIM software in higher education, hinders the competitiveness and effectiveness of BIM education. Therefore, it is inevitable that the way forward to improve the issue need to be addressed.

2.3. Way forward for BIM Education in Malaysia

Academic institutions play a crucial role in equipping students for the ever-changing landscape of the construction industry. Due to the rising demands for BIM talents, institutions should implement BIM education effectively into their construction management programmes. The initiatives should include introducing cross-disciplinary courses is one method of incorporating BIM (Hailer et al., 2019). The program will allow students from different academic disciplines to take part. It will combine expertise related to industrial AEC. For example, building and architectural courses can combine to open BIM laboratories (Yap & Aziz, 2020). Furthermore, project-based coursework for students is also among the strategies for implementing BIM education (Besné et al., 2021). According to Hernández et al. (2017), students learn better when they relate BIM knowledge through a task or assignment in form of a project rather than as a mere managing tool, which can be achieved by incorporating BIM requirements into the project syllabus. Another strategy for BIM education is to implement BIM training that is pivotal for institutions to expose BIM implementation practices that might involve collaborative efforts among teachers and professionals from the industry (Besné et al., 2021). Lastly, the institution's management needs to offer adequate resources for BIM tools and equipment, such as opening lab, upgrading computer hardware, providing BIM software for students and educators (Palis et al. (2022).

3.0 METHODOLOGY

The quantitative method is selected as the research approach for this study by means of close-ended questionnaire that has been distributed online. The quantitative approach in research can be described as a method that comprises the gathering and analysis of numerical data that focuses on measurement, and on discovering relationships between variables (Bhandari, 2020). The research focuses on public universities that have construction management courses in Malaysia since these institutions produce an increasing number of graduates than polytechnics and private universities (Belayathulam et al, 2018). The chosen respondents are students from the field of construction management who are presently enrolled in or have studied BIM as a subject or syllabus at their respective learning levels, which in turn enables them to provide a perspective based on their own experiences and knowledge. For that reason, UiTM was chosen as the study area because it fulfils the research requirement as UiTM is a public university that offers BIM course in the lesson plan for the Construction Management degree program at level 6 (Universiti Curriculum Management, 2022).

According to the online database UFuture, the breakdown of the number of students who are currently enrol in the course by Semester 6 is 55. Meanwhile, the number of students that have taken the BIM subject by Semester 7 is 47. Therefore, the population size is 102. Based on the sampling frame in Krejcie & Morgan table, the sample size for 102 population size is 86. In order to analyse the data feedback from respondents, this research employed the Average Index method that provide ranking of the variables at hand. This method is the most appropriate for measuring answers from respondents using Likert Scale.

4.0 RESULT AND DISCUSSION

4.1. Response Rate

The online questionnaires were distributed to 86 students from the Construction Management program who are presently studying BIM and previously enrolled in the BIM courses at UiTM Shah Alam. the response rate for the survey was 62.79%, with 54 out of 86 sets of questionnaires completed and returned. The response rate exceeds 30%. Thus, it is considered appropriate and acceptable for analysis (Chung, 2022).

4.2. Challenges to BIM Education Implementation

Table 2 reflects the top three challenges to BIM Education Implementation in higher academic institutions that are linked to people, process and information, and technology as per discussed earlier in the literature review section. Based on the result, the most challenging factor is from the technology category, C8 'Inadequate facilities to adopt BIM properly' (4.13). The second challenging factor is C7, limited availability of resources, course materials, exercises, or models (4.09), followed by C3, the shortage of qualified teaching staff with sufficient experience to teach BIM courses (4.06).

The primary barrier to BIM adoption in educational institutions is the technological aspect. According to respondents, inadequate facilities to adopt BIM properly (C8) is the biggest challenge in the educational institution. According to Montenegro (2023), BIM technology can be expensive and make it challenging for the institution to afford. This problem contributes to inadequate equipment and tools. Plus, respondents might experience difficulties learning BIM due to the lack of physical facilities equipped with appropriate equipment and hardware that is aligned with study by Belayutham et al. (2018). According to Palis et al. (2022), it can be seen that practising and learning the BIM system effectively requires special and adequate space, such as a BIM laboratory. This insight underscores the need for educational institutions to prioritize the creation and maintenance of BIM laboratories to enhance the quality of BIM education.

Table 2. Challenges to BIM Education Implementation.

Question No.	Challenges To BIM Education Implementation	Average Index	Rating Scale	Description	Ranking
C8	Inadequate facilities to adopt BIM properly **(Technology).**	4.13	4	Agree	1
C7	Limited availability of resources, course materials, exercises, or models **(Process and Information).**	4.09	4	Agree	2
C3	There is a shortage of qualified teaching staff with sufficient experience to teach BIM courses **(People).**	4.06	4	Agree	3

The second significant obstacle that affects the BIM academic implementation is the process and information category, which is the limited availability of resources, course materials, exercises, or models to learn BIM (C7). This finding is aligned with a statement by Huang (2018) that the limitation hinders the process of learning BIM. In this part, respondents might feel that the tutorials, educational materials, and practical experience given by teaching staff were not enough, outdated, or may have experienced inadequate access to them. This has influenced their perception and has made it difficult for them to properly connect with the learning environment.

The third-ranked is C3, shortage of qualified teaching staff with sufficient experience to teach BIM courses. It has been discussed by Yusuf et al. (2017) that the biggest obstacle to implementing BIM at institutions was a shortage of lecturers with adequate BIM experience and expertise. This finding also aligned with Palis et al. (2022), in which the lack of competent BIM lecturers was ranked as the third-highest limitation of implementing BIM courses. The shortage of qualified teaching staff poses a significant challenge, as effective BIM education relies heavily on instructors with extensive knowledge and practical experience in the field. In fact, without skilled lecturers, students may not receive the comprehensive training needed to develop proficiency in BIM technologies that may lead to a diminished quality of education, resulting in graduates who are less prepared to meet industry standards and demands.

4.3. Future Directions for BIM Education in Malaysia

Table 3 shows a mean score and rating scale of the strategies for implementing BIM education. The variables were arranged following the calculated average score from the most significant to the lowest. As shown in Table 3, the strategies with the highest score of 4.46 are D2, to collaborate between institutions and BIM professionals to overcome the lack of BIM training among teaching staff and D5, to create standardization of BIM practices across institutions. Next, with a 4.43 average score falls under D4, provide intensive BIM training to teaching staff and D6, the institution needs to offer adequate resources for BIM tools and equipment, computer hardware and BIM software. Next, followed by D3, which is to conduct project-based coursework for students (4.37). The last ranking is D1, ‘Implement BIM in cross-disciplinary courses’ with a mean score of 4.33.

Based on Table 3, the most significant strategies for implementing BIM in the CM program are D2, cooperation or collaboration between an academic institution with BIM experts and D5, creating a standardization of BIM practices across institutions. These appear to be consistent with the finding results of Challenges to BIM Education Implementation as the second and third-ranked were related to the limited availability of resources and qualified teaching staff. The university can overcome the lack of BIM training among teaching staff by collaborating with academic institutions or BIM professionals. Besides, developing standards or guidelines for universities can help increase the effectiveness of BIM education. Besné et al. (2021) highlighted that creating standards would streamline the process and strengthen their belief in executing BIM learning with best practices.

Table 3. Strategies for Implementing BIM Education

Question No.	Strategies For Implementing BIM Education	Average Index	Rating Scale	Description	Ranking
D2	Collaborate between institutions and BIM professionals to overcome the lack of BIM training among teaching staff.	4.46	4	Agree	1
D5	Create a standardization of BIM practices across institutions.	4.46	4	Agree	1
D4	Provide intensive BIM training to teaching staff.	4.43	4	Agree	2
D6	The institution needs to offer adequate resources for BIM tools and equipment (computer hardware and BIM software)	4.43	4	Agree	2
D3	Conduct project-based coursework for students.	4.37	4	Agree	3
D1	Implement BIM in cross-disciplinary courses, including opening a BIM laboratory.	4.33	4	Agree	4

The second highest ranked strategies are D4, which provides intensive BIM training to teaching staff and D6, the institution needs to offer adequate resources for BIM tools and equipment (computer hardware and BIM software). These appear to tally with findings in Table 2. as the first, and third challenges were lack of BIM facilities and experienced teaching staff. In order to address this limitation, focused efforts to attract, train, and retain experienced BIM professionals in academia are vital, ensuring that the next generation of BIM practitioners receives the high-quality education necessary for their future careers. For that, BIM training for lecturers will produce more competent educators with proficiency to use BIM successfully as highlighted by Meana et al. (2021) in their research. Yap and Aziz (2020) also expressed that one of the teaching approaches is that educators have to undergo BIM certification training in order to properly integrate BIM into the academic program. Besides that, it is crucial for the institution to provide sufficient BIM resources, particularly updated hardware and software, because the most challenging factor based on respondents' feedback was the lack of BIM tools and equipment and limited access to the software. According to experts in the industry, being able to use BIM software is one of the most crucial skills graduates should be able to acquire during their academic years (Yap & Aziz, 2020). Thus, the provision will ensure that students can master the use and understanding of BIM in terms of technical aspects.

5.0 CONCLUSION

The mean analysis reveals that CM students admitted that all the listed barriers existed when implementing BIM education in the institution including the lack of facility, limited resources and course materials, and shortage of qualified teaching staff. Although there were many challenges associated with BIM education, the technology barrier concerning inadequate BIM facilities became the main issue that CM students experience during BIM learning. It is essential to address these challenges to raise alertness among the institution, educators, students, and the general public so that appropriate steps are taken to overcome them. Besides, the findings reveal that the best ways of implementing BIM education are that institutions need to collaborate with BIM professionals and establish standardised academic practices. Fostering cooperation between academia and industry can help bridge the gap occurring in BIM learning, such as the deficiency of qualified lecturers with BIM experience and the lack of resources. Hence, such participation and collaboration would assist in overcoming those problems by exposing students to actual practice applications, industry insights, and networking opportunities. Moreover, a uniform guideline or standard will act as a benchmark for HEIs to design their curriculum and program aligned with the current industry's conditions and criteria. A uniform standard may include a consistent framework, teaching procedures, and learning outcomes. The standardization process may involve cooperation between certain parties, such as industry experts, academic institutions, and governing authorities. The positive impact of this uniformity is that it fosters a shared comprehension of BIM concepts and streamlines knowledge transfer among students, thus leading to the production of graduates who are skilled with BIM competence. Due to the fact that the construction industry and BIM technology will continue evolving, continuous research regarding BIM education and implementation is vital to consistently keep up with the ever-changing industry requirements and ensure future graduates stay ahead with the latest advancements and innovations in the construction sector. Even though the study was only conducted in UiTM, the findings and outcome of this research can also be used for other higher education institutions to improve their academic practices regarding BIM education.

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