A study on integration of building information modelling (BIM) in civil engineering curricular

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Abstract. Building Information Modelling (BIM) is a practical approach that can manage the construction projects’ life cycle activities and be used by the architecture, engineering and construction (AEC) to ensure the excellent quality of the projects, reduce cost and facilitate communication among contractor players. The development of the BIM uses in the construction industry has widely spread in many countries, unfortunately not in Malaysia even though it started in Malaysia since 2004. Several universities worldwide offer BIM courses in their program, while many others are under the process of integrating BIM into their curricula. Most of the universities lack the realization of the importance of BIM application, BIM teaching strategy, and plans to overcome the barriers to integration of BIM into the curriculum. This paper presents the current state of BIM education in the engineering program in the Faculty of Civil Engineering (FCE) as a case study. A detailed literature review and questionnaire survey performed for this purpose, followed by statistical analysis. The research presented the status of BIM education in FCE and formulated a framework that will provide guidelines for those universities which are not currently implementing BIM or just started developing BIM curriculum. More practical project-based class assignments that supported students with learning how to apply different formal project management methods to real-world project management problems will be adapt. The program in the universities will be able to produce graduates who are equipped with the necessary knowledge and skills of modern tools such as BIM before they enter into their professional careers.

1. Introduction
Building Information Modelling (BIM) is an approach to manage construction activities, which are project design, construction and facility management. Since the use of BIM in managing the construction project life cycle has been in place since 1970, its implementation has become more widespread in the construction industry for producing data-rich models of buildings and structures [1]. BIM is currently being used by the architecture, engineering and construction (AEC) industry in Malaysia. The use of BIM helps digital design models that allow the construction industry players to visualize the buildings before the physical implementation takes place.
The increasing number of companies that use BIM is causing universities to examine their curricula to create a system that has their students adequately prepared for the industry after graduation. Professionals, organizational and educational institutions have started to adopt BIM software tools and to adapt their existing delivery systems to satisfy evolving market requirements [2]. There have been several implementations of BIM classes in civil engineering curricula around the world [3]. It implies that BIM should be taught at the beginning of the basic civil engineering degree and improves student ability to empowering software used in BIM and comprehends the construction process more fully.

Even though BIM is becoming widely adopted in the construction industry, the lack of individuals with BIM skills and knowledge is a major obstacle in the implementation of BIM in the construction industry [4, 5]. Moreover, lack of proper training and effective inclusion of BIM education in the construction curriculum have cited as the major constraint about adopting the new technology and preparing the next generation of future employees. Regarding these challenges, it seems necessary that universities should adopt BIM as innovative technology to enable students to acquire new skills and prepare them for their future. The deficiency of skills and BIM in civil engineer graduates is because of the lack of awareness of BIM during their studies. The universities in Malaysia are not exposing students with programs related to BIM, such as the information and application of BIM in the construction industry.

Another problem in the implementation of BIM in education is the lack of lecturers with BIM knowledge and the training. According to [5-7], it is difficult to educate the teachers due to rapidly evolving technology. Without enough skilled lecturers to teach BIM courses in universities, the implementation of BIM cannot be done.

From the research done by [7], the incorporation of BIM into civil construction engineering education has faced many challenges. The main problem there is a lack of accreditation standards and requirements to guide the implementation of BIM within a curriculum. BIM demands the new teaching methods, and there is a lack of BIM-specific materials and textbooks as well as other educational resources for students. Other than that, to implement BIM more widely in education, students should be teaching not only about the theory of BIM application, but students also should be exposed to the expensive software of BIM. For people with weak general IT skills, it will be a problem to implement BIM.

Moreover, it will be a problem in the aspect of insufficient or lack of room in the existing curriculum for additional classes. Therefore, this paper aims to study the integration of BIM into Civil Engineering curricula in the Faculty of Civil Engineering, Universiti Teknologi MARA Selangor, Malaysia, as a case study. The awareness and current status of BIM in Civil Engineering curricula in UiTM Shah Alam are determined to define clearly the barriers in implementing BIM education in Civil Engineering curricula. The significance of this research is to prove the civil engineering students' awareness of BIM regarding its advantageous in the design and construction industry and the currents status of BIM in civil engineering curricula. As some of the countries have implemented BIM in their academic institution, another significant of this research is to determine the provision of BIM education into civil engineering curricula in UiTM Shah Alam.

1.1 Implementation of Building Information Modelling (BIM) in the construction industry

BIM is one of the most effective technological advances in building design and construction industry [8]. The application of BIM has become a demand in the construction industry. BIM, for instance, is a revolutionary technology that initiated to present the building process of construction projects virtually before building it physically, in producing good results and benefits in construction induction in reducing time, saving cost and detecting any conflicts. According to research done by [9], with the implementation of BIM, the design, construction and operation processes can be better restructured to improve efficiency and effectiveness of the projects. Hence, nowadays, it seems necessary that BIM education as an innovative technology to enable students to acquire new skills and prepare them for their future activity in a more competitive world as BIM is gaining full acceptance and recognition.
BIM helps to increase construction project efficiency and effectiveness as a collaborative tool used by AEC industries based on the number of software solutions that have been suggested by the government, such as Autodesk tools. BIM also became been seen as great action in collaboration between construction players such as architects, engineer and contractors; therefore in 2007, BIM is implementing in the Malaysia construction industry.

BIM represents a new generation of virtual models, and in response to this magnificent technology and industry needs for relevant skills, the educational institution is exploring strategies and approaches to incorporate BIM education in their curricula. Universities from countries such as the United States of America, the United Kingdom and Australia have achieved different levels of implementation. In Malaysia, the application of BIM in building design and construction industry has to become a demand since its existence in 2007. According to [9], the Malaysia government encourages construction players such as Architecture, Engineering and Construction industry (AEC) to apply BIM into the construction project. The implementation of BIM in education is still low due to a lack of awareness and experts of BIM in the construction industry.

1.2 Benefits of implementing Building Information Modelling (BIM) in the construction industry
The construction visualization tools like BIM that can improve estimating skills will make an impact on the effectiveness of construction management students to do estimating on their jobs. Similar research was done by [10] BIM is gaining popularity in the global built environment sector, and it has impressed governments around the world especially in a developed country, to encouraging BIM implementation in the construction industry. BIM not only can save the cost of design by benefiting from earlier access, but it can also cut the time of design by half. It does not merely save money by cutting both time and cost, and it also does reduce the time taken for BIM to be introduced in the construction industry market. BIM also changed the process of design and built other than improves technology. It is believe by most users of BIM that BIM can reduce dependency on human resources during the entire operation phase as BIM creates obtainable concurrent information on the performance of the project and in economic aspects. According to [11-12], the application of BIM by construction players in the construction industry is encouraged by the Malaysian government as it can overcome construction problems such as delay, clash of design and construction cost overrun. It is believed that BIM helps in increasing construction project efficiency and effectiveness of project management and communication and collaboration between construction players can be improved. Besides, BIM is a boost technology that may help in the design building and construction industry in improving its productivity.

1.3 Implementation of Building Information Modelling (BIM) in curricula
By now, it is widely accepted the use of the high technology of BIM in construction industries, and as a matter of fact, most of the universities lack realization of the importance of BIM application [13]. Rendering to the researched done by [11], many universities around the world have started to integrate BIM into their academic programs of AEC to satisfy the industry demand for engineers with BIM skills. According to [14], construction management programs in several universities worldwide have offered BIM courses, while many others still under the process of implementing BIM in their curricula.

Some countries such as Australia, United Kingdom and the United States of America have successfully implemented BIM while the others are in the process of integration. Many of the UK universities have started integrating BIM concept into AEC education to satisfy the industry requirement. In the US, a research study done by [6] highlighted that very few of the several degree programs at various levels to support AEC industry have incorporated BIM content into their curricula.

According to [15], researches identified that engineers with BIM skills as a means to help achieve the successful uptake of BIM within the AEC industry and the need to fit in BIM into university teaching is to equip engineering graduates with an adequate understanding of BIM
concepts. Research highlighted four different ways how to incorporate BIM into university education which are (i) introducing a BIM elective or organizing a workshop, (ii) introducing an advanced BIM focused degree program, (iii) restructuring the existing curriculum to include BIM and (iv) Integrating BIM into the existing construction management curriculum.

It is concluded that BIM is a helpful teaching tool in construction estimation and quantity take-off skills. Implementation of BIM also is highly contributed to design comprehension skills and understanding of construction materials, methods and processes to students rendering to research done by [16].

1.4 Benefits of implementing Building Information Modelling (BIM) in curricula
The benefits from the implementation of BIM are ever-evolving and improving to the construction industry. BIM skills are in high demand, and many construction and architecture schools are responding to this demand by restructuring the existing educational curriculum to incorporate BIM technologies. Many architecture and construction schools are beginning to integrate BIM into the current framework of courses offered. To properly equip students with the skills demanded by the construction industry, many schools are introducing BIM within their coursework and making new faculty selections based on BIM skills as a response to industry demands and future needs of the construction industry.

According to [9], the adoption of BIM in universities seems necessary as an innovative technology to enable the students to acquire new skills and prepare them for their future activity in a more competitive world. Some of the universities that have achieved a different level of implementation are universities from countries such as the United State of America (USA), the United Kingdom and Australia. The benefits of implementing BIM in university curricula to students will help them to be more prepared with the latest technology. It is an opportunity for some students who associated with BIM software and is relatively easy to take advantage of in the near term. For example, BIM permits students to conduct an energy analysis on a digital model that originated with a studio design. According to [16], it is believe that the construction management students' ability to read plans, develop an estimate, and comprehend the construction process more fully by using construction visualization tools within construction. The students are taught with the potential of BIM application throughout the project life cycle as well as knowledge and experience in adoption BIM in projects.

2. Research methodology
The primary data of this study comes from a pilot survey study where a questionnaire survey was distributed to the respondents from students Semester One until the end of semesters (Semester 9) of engineering students in FCE UiTM Shah Alam. A total of 405 students and seven lecturers Construction Business and Project Management (CBPM) responded to the questionnaire. The results obtained are compared among semesters to determine their awareness and the current status of BIM in curricula, besides determining the barriers in implementing BIM in curricula and the provision of BIM education in civil engineering curricula. Another set of the questionnaire distributed to selected lecturers who are the department in CBPM. By using Raosoft software, the minimum recommended sample size of students was determined. The calculation of the sample size is 5% of margin error (5% as is a common choice) with the confidence level in this is 95%. The minimum recommended sample size of this study is 302 respondents; while, the total number of students is 1405, and the number of lecturers in the Construction Business and Project Management (CBPM) department is 18.

The questionnaire designed subjected to the objectives stated in this study. The questionnaire divided into five sections, which are section A, section B, section C, section D and section E. Section A consists of five questions of demographic information. In this section, questions asked to students about their age, gender, current semester, education qualification and education status while questions asked to lecturers are about their age, gender, working experience, qualification and working status.
Section B consists of five questions regarding the awareness on the advantageous of BIM (eg: I am extremely aware BIM application can reduce overall project cost, I am extremely BIM application can improved design quality, I am extremely BIM application can improved conflict detection). Section C consists of seven questions on the current status of BIM in civil engineering curricula, section D consists 17 statements of barriers in implementing BIM in civil engineering curricula, and section E consists of 11 questions of the provision of BIM education in civil engineering curricula. The determination of the awareness on BIM, currents status of BIM in curricula, the barriers of BIM implementation in civil engineering in curricula and the acceptance in the provision of BIM in civil engineering curricula course in UiTM Shah Alam will be determined using Relative Importance Index. The completed questionnaires were checked to confirm that there was no specific pattern of ratings and that the respondents had rated on different points provided on the scale. It is noteworthy that all the results obtained from the respondents' answers were calculated based on the relative importance index (percentage) method. After the data has been analyzed, the proper discussion will be made on the result achieved from the study. The discussions will help in improving the understanding of the study that will be carried out.

3. Results and discussion

3.1 Characteristics of the sample data
The questionnaire was initiated in September 2018, peer-reviewed and revised through a pilot study in October, and finally sent out to students during November and December of 2018. The result obtained from the questionnaire responded by civil engineering students and lecturers based on the objectives of this research were expounded. Forty-five respondents among students from each semester were analyzed. The total number of respondents obtained is 405, which is higher than the minimum recommended size derived from Raosoft software. Thus, the number of respondents needed to answer the questionnaire is successfully achieved. The respondents from students consisted of 127 males (31.4%) and 278 females (68.6%). More than half (70.4%) of the respondents are 21-23 years old, and 55% of the respondents from the background of diploma, 26% from Matric and 19% from polytechnic. The total of the questionnaire distributed to lecturers major in CBPM is 7. Table 1 shows the demographic of lecturers.

| Respondent  | Gender | Working experience | Qualification | Working on BIM |
|-------------|--------|--------------------|---------------|---------------|
| Lecturer 1  | Male   | >10 years          | PhD           | Yes           |
| Lecturer 2  | Female | >8 years           | PhD           | Yes           |
| Lecturer 3  | Male   | >10 years          | Master        | No            |
| Lecturer 4  | Male   | >10 years          | Master        | Yes           |
| Lecturer 5  | Female | >10 years          | PhD           | No            |
| Lecturer 6  | Male   | >10 years          | PhD           | Yes           |
| Lecturer 7  | Male   | >7 years           | Master        | No            |

The majority of respondents, 71.4% (5 respondents), had more than ten years working experienced. And 57.1% (4 respondents) had experience of using BIM application, but 42.9% (3 respondents) had some knowledge of using BIM application both in professional and amateur settings.

3.2 Awareness on the advantageous of BIM among civil engineering students
The awareness of the benefits of BIM in civil engineering curricula among students is increasing by the early semester up to the end of the semester. Almost all students in Part 1, Part 2 and Part 3 are ‘Extremely not aware’ with the advantages of BIM due to no exposure at all on what is BIM. Part 4 shows that they are ‘Not aware’ with beneficial of BIM. As compared to the students at the end of the semester (Part 7 and above); they ‘Aware’ with the advantageous of BIM. All seven CBPM lecturers are ‘Extremely aware’ with the benefits of BIM.

3.3 Current status of BIM in civil engineering curricula

Based on the questions asked to the respondents, the result shows the implementation of BIM in students’ education or awareness of BIM information in faculty curricula still very low. From the result, it is shown that students are mostly not aware of the BIM program and only a minority of Part 8, 9 and above aware of this program. Also, a minority of civil engineering students have participated in the BIM program, and only two students form Part 9, and above students have used BIM software during their internship.

As can be seen from the result ranked by the lecturers regarding the current status of BIM in civil engineering students, it is shown that lecturers are mostly aware with BIM programs (85%), but the only minority of lecturers involved in any projects that use BIM (45%). The result shows that the lecturers not sure about the high current status of BIM in civil engineering curricula (85%). Also, the average index shows lecturer ‘Disagree’ they teach or discuss BIM in the curriculum (25%).

3.4 The barriers in implementing Building Information BIM in civil engineering curricula

Both students and lecturers were asked to rank the barriers of BIM implementation in the curricula. This section is identifying the causes of reluctance to assimilate knowledge and information concerning BIM technology and software. Based on the viewpoint of students, the three major barriers were; (1) lack of professional trained BIM in faculty for students to refer, (2) lack of advance computer lab for BIM software, and (3) difficult get access to BIM software.

When it comes to lecturers’ opinions on major barriers, they believed; (1) lack of professional trained BIM in faculty for students to refer, (2) Inadequate funding for BIM program to the civil engineering faculty (high cost) (3) BIM software is expensive.

From these both viewpoints, it can be concluded that if the university has the allocation on this software, they willing to learn and practice BIM in the syllabus. Regarding the provision of BIM education in civil engineering curricula in UiTM Shah Alam, the majority of the lecturers ranked there are ‘Strongly agree’ with the provision of BIM education.

Some factors affect the successful implementation of BIM into civil engineering curricula in UiTM Shah Alam which are regarding the software of BIM as students find that there is a lack of advanced computer lab with BIM software and it is difficult to get access to the software. This factor is agreed upon by the lecturers from the result obtained. The lecturers agreed that the BIM software is costly and there is inadequate funding for the BIM program to the civil engineering faculty. Also, students agreed on the barrier to implementing BIM in civil engineering curricula is because and it will take time and resources for faculty to develop a new course. Students also believed too much time is needed for learning BIM software and there is a limited number of courses they can take if they want to grad on time, which is in 2 years and half time. The lecturers also agreed there is a lack of professional trained BIM in faculty for students to refer. From the result of the distributed questionnaire, it seems that students understand the BIM concept to be a future need, and they strongly agree with the provision of BIM education in civil engineering curricula. Most of the randomly selected lecturers also agreed with the opinion of the provision of BIM education in civil engineering curricula.
4. Conclusions and Recommendations

From this study, the result indicates that AutoCAD is the most commonly used software in both education and practice. In contrast, BIM software is found to be less widely used by the students. This BIM software, however, does receive positive feedback from the students for its benefits. This could indicate a prospect to embrace BIM technology into the syllabus.

As the civil engineering students still lacking the BIM knowledge, there should be a plan to create awareness on the integration of BIM into civil engineering curricula. Therefore, BIM programs such as seminars, conferences, workshops should be arranged by civil engineering faculty which will not impart knowledge to civil engineering students but will also provide knowledge to the lecturers. The civil engineering curricula in UiTM Shah Alam need to be revised.

The implementation of BIM education may take time and resource by the faculty, but the impacts of the implementation BIM in universities’ curricula has proven it is beneficial to students, lecturers, faculty and future. The majority of the students issuing the time needed to learn about BIM software does take much time.

The recommendation to this issue is that the implementation can be slowly implement in students' assignments and projects. This implementation can be infused in students' education during their early semester and continues to the end of the semester. By introducing this method of teaching in curricula, the time needed is enough to learn BIM education during their studies and expose all students in every semester to the usage of BIM software. Other than that, respondents are mostly issuing the limitation of the courses they can take if they want to grad on time in two years and half of the studies. Therefore, if the development of a new course for BIM education is implemented in civil engineering curricula, they have to add their credit hours or take many courses in one semester. The beneficial recommendation to this issue is that faculty may provide BIM education course as one of the elective courses in curricula. Elective course in civil engineering faculty usually is taken in semester seven up to the end of the semester.

Every civil engineering student may have to choose three elective courses listed by the faculty starting in semester seven. The implementation of BIM education as one of the elective courses may give a big opportunity to students to learn about BIM instead of adding their credit hours or taking many courses in one semester to learn about BIM in curricula. Supports from the universities is a must in spread the awareness of BIM to students and to allow students to acquire new skills in the use of BIM software to prepare them for their future activities in a world that is ever more competitive.

Further studies may be applied in determining the methods in determining the way of implementing BIM education in civil engineering curricula and the impact on graduate students in the implementation of BIM education in studies.

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