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Evaluation of BIM Education for Quantity Surveying: A Review of Teaching Approaches

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Abstract

Building Information Modelling (BIM) technology has become increasingly well-known among construction industry players throughout the world. It is known as a process that offers numerous benefits by the implementation in the industry. Almost 50% of practitioners in construction industry is using BIM. Quantity Surveyors (QS) are one of the important main professionals in construction industry who should have an adequate and sufficient BIM knowledge and skills. Equivalent to this, based on the educational perspective it is clear that there is a growing need for universities to provide their graduates with appropriate BIM-related skills. Although the educational frameworks that have been established for academic purposes in Malaysia, still, it is in doubt whether this framework is parallel with industry's demand and also whether the knowledge and skills provided sufficient with industry's requirements. It is crucial to recognize the applicable teaching approach for BIM educations in order to ensure students capable in applying BIM tools and meet the expectation of industry. This paper reviews the BIM teaching approaches and the BIM module applied in QS undergraduate program.

Keywords: BIM, quantity surveyors, QS education, teaching approach, Malaysia

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1. Introduction

Building Information Modeling (BIM) is an intelligent model-based design process that adds value across the entire lifecycle of building and infrastructure projects [1]. It presents both enormous opportunities and challenges for the construction industry [2]. It has been making waves in the construction industry. And for the last two years, everyone's effusive about BIM in building and construction expos [3]. BIM is extensively predicted to lead the changes in the performance of professional in the Architecture, Engineering and Construction (AEC) sectors, particularly with regards to architects and civil engineers [4]. Based on the Morton and Ramos [5] in the McGraw Hill Construction report, the current BIM owners plan to actively increase the share of their projects that involve it. In the

report, it is almost half, which is 38% in United Kingdom (UK) and 40% in United State (US) are saying that BIM will be used on more than three quarters of their work within two years. In Malaysia, the construction players are encouraged to implement BIM by the Construction Industry Development Board (CIDB) and Public Work Department (PWD) through several seminars and the BIM roadmap is prepared as the guideline[6;41].

The implementation of BIM technology has emerged as of the application tools to meet the objectives of escalating productivities in a construction project [7]. BIM is known as a process that could accelerate the project design process 70% faster than conventional process [8]. It can also increases the overall quality of projects, improves the image of construction industry, improves communication and collaboration among construction players [9;10; 11]. Thus, it is synchronized with the fact that BIM may be considered as current state of art in computer-aided drawings (CAD) developments [12]. The researchers had highlighted that BIM is currently being implemented by a significant number of architectural and engineering practices, and has the potential to revolutionize the quantity surveying profession. The current economic climate and significant decrease in the construction activity has directly affected employment levels and educational enrolment across construction profession including the Quantity Surveying (QS) profession [13].

From the educational perspective, it is clear that there is a growing need for universities to provide their graduates with appropriate BIM-related skills in architecture, civil engineering, building construction and construction project management programs [14]. While the industry is moving towards more collaborative and integrative paradigms, the education sector needs to start shaping the “pipeline” of graduates that it can better fit the changing industry [15]. To realize the full potential of such new skills, a parallel shift is required in the teaching approaches because it desired the concepts such as collaboration and integration [14]. Additionally, it must be practiced as well as preached.

However, incorporation of BIM technology in undergraduate curricula is taking place more slowly [17]. The lack of integration among different course curriculum presents a great challenge to implementing BIM pedagogy [18]. According to Perry Forsythe et al. [16], the curriculum development be based on an understanding that BIM is not a separate set of technologies across design, planning, property economics, and construction project management, nevertheless it is a means of facilitating integrated modelling and interdisciplinary decision-support as well as reflecting on its networked nature

Although there are educational frameworks that have been established for academic purposes, still, it is in doubt whether this framework is parallel with industry’s demand

and also whether the knowledge and skills provided sufficient with industry's requirements. It is crucial to synchronize between education framework and industry's requirement in order to ensure students meet the expectation of industry. Therefore, this paper is to review the BIM module applied in QS undergraduate program and the requirements of construction industry for graduate QS.

2. BIM Application for Quantity Surveyors (QS) Practice

Quantity Surveyors (QS) play an important role on providing cost management services in construction industry, where they are responsible for the cost management throughout the entire life span of project from the feasibility and design stage until building completion [19]. According to Zainon et al. [20], the cost and program are key performance indicates, in addition to the quality. Thus, with BIM the QS can provide detailed and accurate estimates, automate measurement, speed up traditional estimating process and better capture, manage and deliver project information.

BIM is capable of providing a more intensive and detailed drawing compared to the traditional 2D drawing where misunderstanding and wrong assumption may be made. The more comprehensive construction information and more precise bill of quantities (BQ) can diminish the gap among the project team members [20]. Olatunji et.al [21] discussed that BIM has the potential in automating the quantity measurement which might threaten client's requirements for QS services. It is due to the measurement and pricing of construction works are the important functions provided by the QS.

According to Khiyon [22], QS are one of the main professionals in construction industry who should have adequate BIM knowledge and skills. Within the context of quantity surveying, BIM contributes in the preparation of construction cost estimates, which is the most valuable quantity surveying practice in determining the project costs [23; 24; 22].

3. BIM Education in QS Program

3.1. Current BIM educational framework

An educational framework shown in Figure 1 has been proposed by Macdonald [25]. It comprises of four (4) stages in different levels of achievement that are Illustration, Manipulation, Application and Collaboration (IMAC). *Illustration stage* is an introductory

stage in delivering on knowledge/ comprehension by the lecturers/ tutors and receiving/responding by the students; *Manipulation stage* is an interactive stage to develop comprehensive and responses of the students; *Application stage* is a stage where students could apply the knowledge to solve discipline-related problems; and *Collaboration stage* is where students from different disciplines could work in one project team.

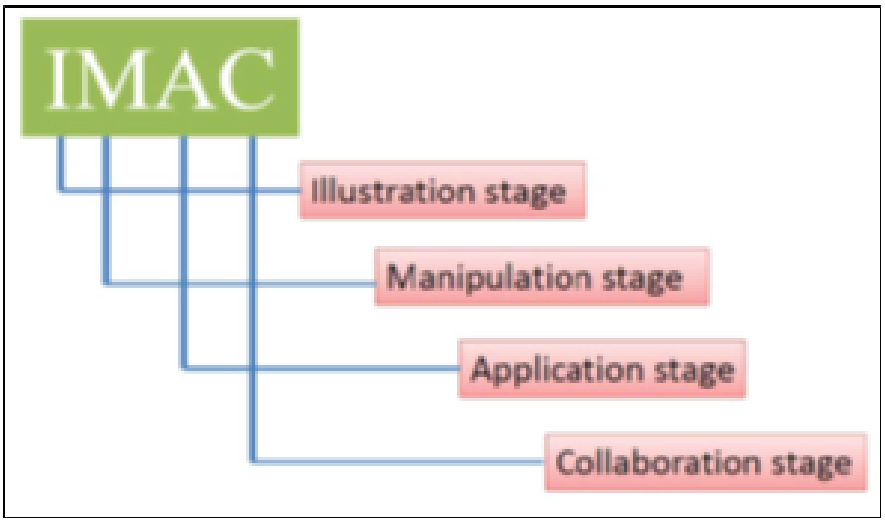

Figure 1: The four stages making up the *IMAC* framework (Source: [11]).

This framework had been reviewed in a research done by Suwal et al. [26] that the framework could be the base of mapping the current BIM education across the educational curriculum. Thus, the IMAC framework are applied in the development of current BIM education framework for QS in Malaysia by Ali et al.[23] and it is illustrates in Table 1.

TABLE 1: BIM education framework for Quantity Surveying students in Malaysia (Source: [22]; modified from [23]).

Visualization	Quantification	Planning & Scheduling	Management
Draughtmanship	Measurement	Cost Planning & Scheduling	Contract
Construction Technology	Cost Estimating	Cost Analysis	Professional Practice
Construction Services			Project Management

BIM education and development of educational framework is to assist and guide BIM based education are positive efforts happening around [26]. The researches highlighted that most of the implementations are still under the preliminary stages and are in the process of being implemented.

3.2. BIM teaching approaches

It is proposed that BIM supported education, understood as a collaborative process which is not simply a technology, has the potential to gradually evolve the industry towards improved efficiency, decision making ability, value generation and interdisciplinary understanding [14]. The construction education has broadly implemented construction laboratories to improve teaching effectiveness and overall student performance [27]. Through a research on the integration of BIM education for architecture, engineering and construction (AEC) programs, lack of trained BIM faculty; the absence of BIM faculty and traditional construction management (CM) education structure; the need for industry involvement—designers, constructors, and owners; shortage of BIM trained faculty and resources to develop a new course; lack of willingness to change the existing curriculum; and need of strong fundamental knowledge make it difficult for the AEC universities to have successful BIM integration [28].

Wu and Issa [29] stated that within the academia, different universities are rapidly integrating BIM as part of the curricula, creating course contents and experimenting BIM pedagogic approaches through dedicated BIM courses as well as BIM-embedded conventional courses. Miller et al. [30] proposed on the pedagogical approach in BIM educational framework in their study towards BIM in New Zealand. The pedagogical approach proposed is inclusive of elements from three (3) categories which are traditional or discipline-based approach, performance or system-based approach and cognitive approach.

In the application of BIM education for every QS program, it is still deficient of appropriate teaching approach to ensure the education framework developed has fulfill the requirement of construction industry. The Table 2 below shows the review of researches on the teaching approach that appropriate for BIM education.

3.2.1. Cross-disciplinary or multidisciplinary module

As BIM is more and more need of today's technologically triggered change, the educational institutes are progressively influenced to teach BIM so as to meet the growing demands of new AEC professionals with adequate BIM competencies [26]. Thus, they found out that most universities around the world are actively initiated multidisciplinary educational curricula in BIM education. It is supported by Barison & Santos [4] that cross-disciplinary or interdisciplinary module is a teaching concepts stimulating a real collaboration with students from two or more disciplines.

Table 2: Teaching approach in BIM educational framework.

Teaching Approaches	(Barison & Santos, 2010)	(Suwal et al., 2013)	(Khiyon, 2016)	(Shelbourn, Macdonald, McCuen, & Lee, 2017)	(C. M. Clevenger, Glick, & Porter, 2014)	(Mahbub, 2016)	(Mcgough, Ahmed, & Austin, 2013)	(Lee et al., 2013)	(Lucas, 2014)	(Salazar & Gomez-Lara, 2013)	(Azhar, Sattineni, & Hein, 2010)
Cross-disciplinary/ Multidisciplinary module	•	•	•	•		•	•	•			
Standalone/ single course	•				•	•		•	•		
Interactive teaching modules								•			
BIM capstone course or project								•		•	•
Collaboration	•	•									
Add BIM in existing courses					•						
Combination: standalone and add in existing course					•						

Through cross-disciplinary module, it may develop better understanding of roles and responsibilities of other disciplines, the complexity and variety of information between different disciplines and also collaborative work environment for the construction process [31]. Mahbub [32] emphasized that the BIM teaching shall considered on both traditional delivery methods (lectures and tutorials) and through group seminars, workshops, collaborative labs and work-camps. Such approaches provide a platform for open communication and inter-connected exchange of information amongst the construction industry professionals. Therefore, it will promotes the students from all disciplines to work and study together. Agreed by Mcgough et al. [33] where the future initiative after enhancing the students awareness of BIM, it shall be further incorporate BIM across the undergraduate courses with an aim students could taste the collaboration skills required for group works. This will ultimately smooth the learning curve as the students encounter BIM issues through their course.

Moreover, Shelbourn et al. [34] pointed out that if students are educated to work collaboratively and to learn the requirement of other disciplines before they graduate, this level of misunderstanding is likely to be removed in future and trust improved.

Whereas, BIM offers a great opportunity to engage students more effectively and to aid understanding of how building are constructed.

3.2.2. Standalone or single course

Reliable with the above-mentioned statement, BIM teaching approach is recommended to be a stand-alone or single courses that may often replace and existing CAD class with BIM class [4; 35; 32; 31]. In a research by C. Clevenger et al. [36] the result shows 29% of the respondents who are students preferred BIM to be introduced as standalone or single course. The students believe that the existing courses already cover a significant amount of information, and otherwise it would make those courses over. However, Sabongi et al. [37] argued that it is less than 1% of institutions teach BIM as standalone course.

Lee et al. [31] summarized that standalone course may underlined the learning outcomes to give better understanding in term of design, construction and engineering information, and the architect's role in the design and construction process. Offering a standalone course can have its benefits of allowing for a more in-depth examination of the use of BIM [38]. This approach would able to provide a much better understanding of BIM use for QS students, for instance in taking off the quantity, and estimating.

3.2.3. Interactive teaching modules

Lee et al. [31] shortened an interactive teaching modules is an approach to integrate into numerous upper level course. It can become as one of the teaching approaches that enhance the students' ability to understand the building structure and components, complex construction systems, construction plans and specifications, and construction means and methods. Other than that, this approach can help the students in improving the accuracy of their quantity takeoffs; provides positive perceived impact on students' learning and willingness to use BIM; and also as an effective course content delivery for active learning.

3.2.4. BIM capstone course or project

In 1971, the Worcester Polytechnic Institute (WPI) Project-based education program known as the WPI Plan replaced the traditional rigidly curriculum [39]. The capstone project helps the student to identify, investigate and report on open-ended problems

synthesizing classroom experience to solve real world problems. Developing BIM implementation as capstone course will promotes the students' strong interest in learning BIM [31]. The capstone or thesis project course is applies in the final semester. However, according to Azhar et al. [40], students spent more than thirty in learning the drawing modelling, up to ten hours learning to create estimate model and another 10 hours learning to perform collision detection between the various building information models.

Thus the BIM capstone course is appropriate to be implemented for final year students since it takes time for the students to learn each level in BIM processes.

3.2.5. Collaboration

Since there is low level and lack of standardization incorporation of BIM into QS programs, Khiyon [22] were proposed three (3) types of collaboration as the strategies to enhance the incorporation. There are collaboration with another higher institutions that allow for sharing session of ideas and skill in developing a thorough pedagogy incorporating BIM into the programmes; collaboration with professional bodies in gather the idea demands and needs from construction industry; and collaboration with industry as they are the one who will employ the graduates once they graduated. This has been agreed by [26] sine there are lacking of BIM teaching material, it can be developed with the collaborative partnership between the academic world, BIM software developers and industry practitioners.

In different, Barison & Santos [4] suggested on distance collaboration in BIM teaching where there should have teamwork or partnership with students from two or more distant schools. The collaboration between distant schools may involve a collaboration with different disciplines, like one of architecture and other of architectural engineering.

3.2.6. Add BIM in existing courses

From the research done by C. Clevenger et al. [36] this approach to add BIM in existing courses is very few with only 9% responses. Every course offer for each semester will require to include BIM as the sub-topics in the course outline. There might be constraints where the educators for specific course shall have capabilities and expertise for BIM application.

3.2.7. Combination: Standalone and add BIM in existing courses

29% of the respondents who are students suggested that BIM to be introduced as standalone or single course [36]. By the approach, students would first learn the software in a standalone BIM course, understand the application of BIM and BIM software through the BIM course modules, and finally get the chance to fully utilize BIM in a capstone course that brings everything together.

4. Conclusion

BIM is a new revolution in the construction industry started in AEC and now continuously being implement by the quantity surveying field. This paper seeks to establish the BIM teaching approaches in QS education framework. From all over the world, few teaching approaches have been implemented in higher education institutions that offer AEC and quantity surveying courses. An overview of BIM teaching approached in QS education initiated that cross-disciplinary or multidisciplinary module is the most implemented approach in BIM teaching and learning. Simultaneously this approach can promotes the collaboration between disciplines. The scenario of construction industry require on collaboration of different professionals like architect, engineers, contractors and QS where each profession represent various roles within the organization. By implementing BIM education cross-disciplinary module or approach in QS education framework, it will help the QS students in understanding on their own roles and responsibilities in working environment; and BIM tools application.

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