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Procedia Engineering 145 (2016) 151 – 157

Procedia Engineering

www.elsevier.com/locate/procedia

International Conference on Sustainable Design, Engineering and Construction

Integration of BIM in construction management education: an overview of Pakistani Engineering universities

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Abstract

Didactical methods are changing in construction education in contemporary times. The advent of information technology (IT) such as Building Information Modelling (BIM) and modern tools such as Unmanned Aerial Vehicles and Laser Scanners are influencing construction education. It is critical for the universities to introduce new IT tools in the construction management (CM) education, and BIM is a promising tool for this purpose. Currently, several universities worldwide offer BIM courses in CM programs, while many others are under the process of integrating BIM into their curricula. As a matter of fact, the most of the universities lack realization of the importance of BIM application, BIM teaching strategy, and plans to overcome the barriers to integration of BIM into CM curriculum. This study analyzed the current state of BIM education in the CM program in universities of Pakistan and developed countries offering architectural, engineering, and construction education. A detailed literature review and questionnaire survey was performed for this purpose. The research presented the status of BIM education in Pakistani universities and formulated a framework that will provide guidelines for those universities which are not currently implementing BIM or just started developing BIM curriculum. As a result, universities will be able to produce graduates who are equipped with the necessary knowledge and skills of the modern tools such as BIM before they enter into their professional career.

Peer-review under responsibility of the organizing committee of ICSDEC 2016

Keywords: Building information modeling (BIM); Information Technology (IT); Curriculum Development; Construction Management (CM); Construction Education

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Peer-review under responsibility of the organizing committee of ICSDEC 2016
doi:10.1016/j.proeng.2016.04.034

1. Introduction

One of the essentials of construction education like the other technical education is to remain up to date and current. It is quite important for universities to teach new technologies in construction education curriculum. Building Information Modeling (BIM) as a new technology and tool is one of the latest developments in construction industry [1]. BIM is an emerging technology in which digital information models are prepared [2].To satisfy the industry demand for engineers with BIM skills, many universities around the world have started to integrate BIM into their academic programs of architecture, engineering, and construction (AEC) [3].

Adoption of BIM in educational programs is relatively a new effort. BIM teaching programs are being offered in many universities; however, they are usually narrowed to software training. There is growing interest and demand to implement BIM in academic programs and to offer entire courses or programs focused on BIM at all levels (undergraduate, post-graduate) of the AEC specialties [4].

Researchers [5] have identified the need to incorporate BIM into university teaching to equip engineering graduates with an adequate understanding of BIM concepts and they identified engineers' BIM skills as a means to help achieve the successful uptake of BIM within the AEC industry. BIM can be incorporated into university education in four different ways. The options are as follows: (1) introducing a BIM elective or organizing a workshop, (2) introducing an advanced BIM focused degree program, (3) restructuring the existing curriculum to include BIM, and (4) integrating BIM into the existing construction management (CM) curriculum [6].

Some researchers have highlighted the strong points of introducing and integrating BIM into the CM curriculum in the engineering universities. Researchers [7] have concluded that BIM is a helpful teaching tool for construction estimation and quantity take-off skills and highly contribute to design comprehension skills and understanding of construction materials, methods, and processes.

The National Building Specification report 2015 has established that BIM education is at different levels of implementation around the globe. Some countries have successfully implemented this integration while the others are in the process of integration. In Australia, many Technical and Further Education (TAFE) institutions are providing BIM courses within AEC programs. However, this education is inclined towards the use of particular BIM software packages with little consideration to BIM management topic or the procedures for working in a collaborative environment [8].

In the UK, the government has mandated that all public building projects will be required to use BIM design processes—a fully combined 3D BIM, or higher—from the year 2016 [9]. Due to this reason and to satisfy the AEC industry requirements, many of the UK universities have started integrating BIM concept into AEC education. Researcher [10] have highlighted that a few UK universities like Westminster University, Middlesex, Salford, Liverpool (in London), the University of West of England, Northumbria University, and the University of South Wales are offering several BIM-related courses in their AEC programs.

In the US, there are several degree programs at various levels to support AEC industry which include Civil Engineering, Architecture, Architectural Engineering, Construction Engineering, and Construction Management, and a research study [11] highlighted that very few of them have incorporated BIM content into their curricula. The challenge is that most of the universities lack understandings of what skills are needed in the industry. Moreover, little research has been done on BIM-teaching methods, course contents, and BIM-teaching objectives and outcomes.

Panuwatwanich K., et al. [12] carried out research in which majority of the respondents were from the US, the UK, and Australia. The respondents agreed that the main obstacles to integrating BIM into higher education are the lack of time and resources to prepare a new curriculum, lack of space in established curriculum to include new courses and a lack of suitable materials for BIM related training.

The identification of problems about the integration of BIM in AEC education has helped some institutes, and that is why, many institutes in the USA are interested in resolving these issues. The findings of the [13, 14] study from the members of Associated Schools of Construction (ASC) in the US indicates that 54% of the programs had dedicated and fully developed BIM classes in their curriculum. To learn more, the authors studied BIM education status in the US, i.e. BIM courses in Construction Engineering and Management programs (CE&M). Table. 1 shows an overview of some of the US universities that are offering BIM courses in their AEC curriculum.

Table 1. Typical BIM courses offered in CM programs in the US universities

Course names	Institutions	Credit Hours	Descriptions/Purpose of course
Construction Information system	Auburn University	3	To explore, create and implement BIM that exists in mobile and/or cloud application forms
CNMG 2318, BIM	The University of Arkansas at Little	3	To focus on utilizing basic functions of BIM for residential and commercial construction and examine geometry, spatial relationships, geographic information, quantities and properties of building components. To ease quantity takes off by virtual models of buildings.
MCM-602, Construction Information Modeling	Philadelphia University	3	Integrated practice and BIM are given comprehensive coverage, about the application of the software to the actualization of the built form
CM 414, Virtual Construction	University of Washington	3	To examines the use of BIM for managing the construction process and facilitating collaboration among project participants.
CE 570, BIM Collaborative CM	University of Southern California	3	To provide some hands-on experience with advanced BIM solution and to provide some knowledge about how to work in BIM teams and learn to different aspects of BIM-based scheduling, estimating and collaborative modeling.
ECIV 309, BIM in Construction	Montana State university	2	To develop working knowledge of BIM and its software applications and to understand BIM role in AEC industry.
CGT 46000, BIM for commercial construction	Purdue University	3	Study of commercial job site planning and coordination. Trade coordination, visualization, and communication are also emphasized.

This review of the best practices in AEC universities supported the foundation for integration of BIM into construction education. Research study [15] also highlighted that some countries have already prepared to deal with the integration while others have yet to start this integration process into CM programs. However, in Pakistan, studies on the status of BIM implementation in academia and in the construction industry are not very common [16]. BIM education is lacking in formal and informal settings. Universities across Pakistan are facing a serious lack of focus on overall construction engineering and management skills and education. It believed that 60-70% of Civil Engineering graduates join construction firms and rest to the other domains such as design and consulting firms. Therefore, there is a need to introduce BIM education at university level so that when the students join professional organizations, it will be easy for them to apply BIM on projects [17].

2. Objectives

The aim of this research was to capture the current state of CM curriculum regarding BIM in the engineering universities of Pakistan, and the following objectives were formulated for this study:

1. To study the current state of CM curriculum with regard to BIM
2. To identify the barriers to integrating BIM into CM curriculum.

3. Research Methodology

After the preliminary study, a detailed literature review was carried out. Based on the gathered knowledge, online questionnaire was developed and distributed online for collecting the data regarding the current state of BIM

education and the barriers to integration of BIM into AEC programs. The link to the questionnaire was sent to architectural and civil engineering faculty members of Pakistani universities. The email addresses of the potential respondents were acquired from the websites of the universities.

The questionnaire consists of the following subsection: 1) Personal Information, 2) University Information, 3) Evaluation of current state of BIM integration in the CM curriculum, and 4) the barriers to integrating BIM into CM curriculum. The combined sample size for this study is summarized in Table 2.

Table 2. Summary of Sample Size and Response Rate

Number of Universities targeted	35
Number of Universities responded	29
Total number of response collected	62

4. Analysis and Discussion

The respondents were faculty members who possessed varying level of teaching experience. The majority of respondents, 45.2% (28 respondents), had more than five years, 14.5% (9 respondents) had 3 to 5 years, and 22.6% (14 respondents) had 1 to 3 years of teaching experience; whereas, 17.7% (11 respondents) had less than one year of teaching experience. Furthermore, 59.7% (37 respondents) had no experience of using BIM application, but they had some knowledge of BIM, 16.1% (10 respondents) had less than two years, 14.5 % (9 respondents) had 2 to 5 years, and 9.7% (6 respondents) had more than 5 years of experience of using BIM application both in professional and amateur settings as shown in Fig. 1.

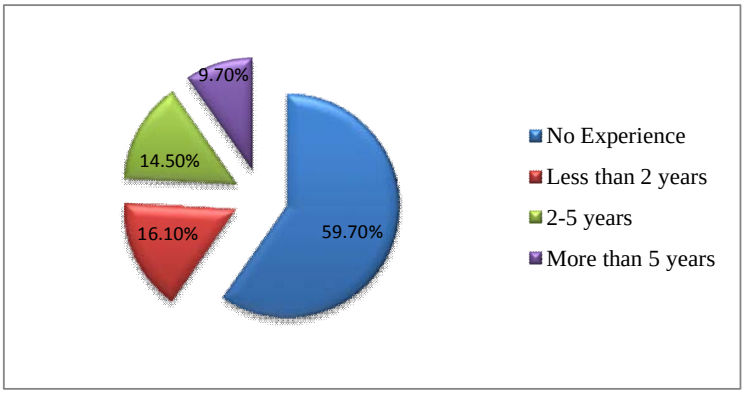

Fig.1. BIM user experience (Professional/Amateur)

The geographical distribution of the engineering universities contacted for collecting the data is as follows: 50% in Punjab, 24.2% in Sindh, 17.7% in KPK, 3.2% in Azad Kashmir, and 4.8% in Baluchistan–the four provinces and one affiliated territory of Pakistan. The results obtained after the analysis of the responses have been summarized in Table 3 and Table 4 respectively.

Table 3. Summary of Responses

Sr. No	BIM and University curriculum	%Yes	% No
1.	Do you teach or discuss BIM in AEC (Architecture, Engineering and Construction) curriculum program?	41.37	58.62
2.	Faculty member(s) at their institution researching on BIM?	40.90	59.09

As the Table 3 shows, 41.37% of the universities teach BIM, out of 41.37%, the majority of the universities 89.25% teach BIM at an undergraduate level, 39.28% teach BIM at a graduate level, and 7.14% teach BIM at a Ph.D. level in AEC programs. Among these universities majority of the universities use Autodesk Revit Architecture, Structure, and MEP, Autodesk Navisworks, and TEKLA Structures, as BIM software in the AEC curricula at the university level.

In response to a multiple choice question of what strategy should be used to integrate BIM into CM program. It was found that 62.90% of the respondent suggested teaching standalone BIM course, 59.67% responded to incorporate BIM topics/contents into conventional AEC courses, 69.35% suggested organizing BIM workshops in CM program, 46.77% opined to restructure the existing CM curriculum to include BIM and 12.9% expected that student will learn BIM skills by themselves. In response to the question that when respondents were asked how long time the BIM will take to get integrated into the AEC program of the universities, 16.2% said they already use BIM, 14.5% estimated that it will take one year, 25.8% said in three year time, and 43.5% of the respondents said it might take five years to integrate the BIM completely into AEC programs at their schools respectively.

Also, in response to the question on the current status of BIM education within the AEC curricula in their universities, 27.4% believed that it was at very low level. Furthermore, 45.2 % considered high level that use of BIM will increase in coming five years in Pakistani construction industry. The summary of these responses is shown in Table 4 and the scale 1 to 5 was used, where scale 1 shows very low, and scale 5 shows the highest level of importance.

Table 4. Summary of Responses

Sr. No	BIM and University curriculum	Very Low	Low	Medium	High	Very High
1.	Current status of BIM education within the AEC curricula in your university	27.4%	37.1%	24.2%	9.7%	1.6%
2.	Use of BIM in the Pakistani construction industry will increase in coming five years	3.2%	12.9%	29%	45.2%	9.7%

4.1. Barriers to integrating BIM into CM curriculum

There were some factors that affect the successful integration of BIM into CM programs in Pakistani engineering universities as shown in Fig. 2. The majority of the respondent, 91.93% consider the lack of trained BIM faculty and 52.90% consider conventional CM education structure the main barriers to integrating BIM in CM Programs. The similar barrier has witnessed by [18] in their study which was based on 101 Architecture, Civil Engineering, and CM programs in the US. The absence of BIM faculty and traditional CM education structure make it difficult for the AEC universities to have successful BIM integration. Therefore, there is a possibility that important BIM topics will be overlooked. However, AEC universities can overcome these barriers through BIM training of the CM faculty members and by the improvement in the conventional AEC curriculum structures. The third most significant barrier as indicated by 47.10% of the respondents was the need for industry involvement—designers, constructors, and owners. The need for industry collaboration is due the fact that the traditional Design-Bid-Build (DBB) delivery system is common in Pakistani construction industry that hinders the use of BIM in AEC industry. Therefore, the industry involvement is required to work on other delivery methods. Though BIM has not necessarily been developed in tandem with some specific project delivery system, but most of the benefits can only be reaped using Integrated Project Delivery (IPD). Therefore, globally, the emphasis is on developing the collaborative work environment rather than adversarial in the construction industry, and use of the traditional DBB system is considered outdated due to its various disadvantages. But Pakistan still seems to embrace DBB due to the lack of understanding of alternative delivery methods by the bureaucracy, and owners that only care about low bidding price [19]. The others significant barriers were indicated by respondents that inadequate funding to the engineering universities, 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. In order fully integrate of BIM into CM programs and to overcome barriers mentioned above, a policy-level change at national and global scale is needed. The policy change

will pave the way for the integration of the latest ICT tools into CM education and research. It is important to note that only 20.60% consider the unavailability of BIM Handbook and other training material and 7.40% believe other factors, e.g. lack of advanced computer lab, are the main barriers in the integrating of BIM in Pakistani engineering universities. It is obvious that AEC students are willing to learn this latest ICT tool, and sufficient training materials is also available, but the lack of trained BIM faculty, conventional CM structures, and lack of industry involvement are the top three significant barriers to integrating BIM into CM programs in Pakistani universities.

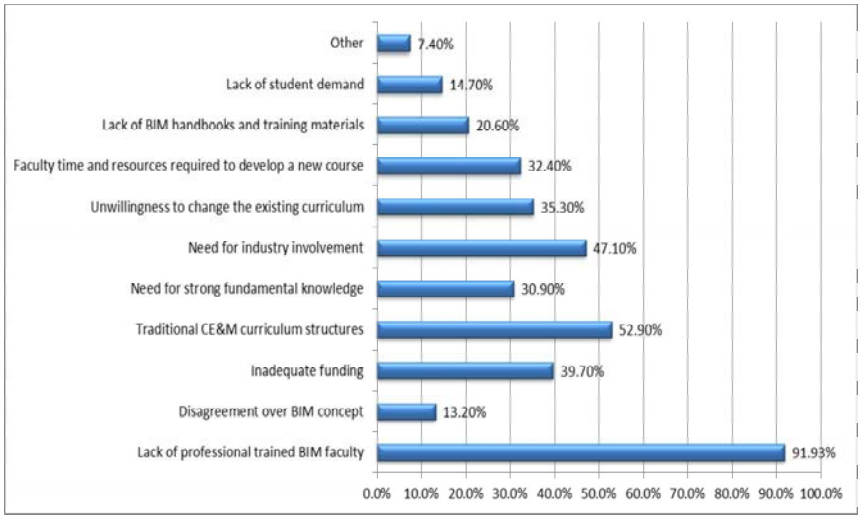

Fig. 2. Barriers to integrating BIM in CM curriculum

5. Conclusions

The requirement of BIM education in AEC programs has been aptly stressed globally and cannot be ignored in Pakistan, too. It is clear from this study that the awareness of BIM education is increasing at a blinding pace, and many of the AEC universities are at different levels of implementation across the US, the UK, and Australia. However, in Pakistan, some of the AEC universities have started to teach or discuss BIM in their AEC programs, but the current status of BIM education in AEC program is not satisfactory. Only 41.37% universities teach or discuss BIM in their AEC programs at the undergraduate, or graduate, or Ph.D. level. According to the 43.5% respondents, universities might take five years for complete BIM integration into AEC programs. There are some factors that affect the successful integration of BIM into CM program, but the lack of trained BIM faculty is the most significant barrier to integrating BIM into CM programs in Pakistani engineering universities.

6. Recommendations

At the national level, there should be a plan to create awareness on BIM integration into AEC curricula. The main barrier to integrating BIM is the shortage of BIM skilled personnel. Therefore, workshops and conferences should be arranged which will not only impart knowledge to CM students but will also provide knowledge to the faculty members. Also, traditional CM curriculum structure needs to be revised, and it is extremely important for AEC universities to develop new BIM course or to develop the other best strategy for integrating BIM into CM programs that are based on current local and international construction industry needs.

Acknowledgements

Special thanks to Dr. Salman Azhar for the guidance. Participation of architectural, civil engineering and construction management faculty members of universities in the survey is highly appreciated and acknowledged.

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