Built Environment Journal

Faculty of Architecture, Planning and Surveying
Volume 14 No. 2 July 2017 ISSN 1675-5022

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Built Environment Journal is jointly published by Faculty of Architecture, Planning and Surveying and UiTM Press, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia.

The Status of Integration of BIM into the Curricula of Construction Education in Nigeria

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Received: 17 Feb 2017
Reviewed: 4 June 2017
Accepted: 21 June 2017

ABSTRACT

This research appraises the status of BIM integration in the Curricula employed for training construction professionals in the Nigerian Construction industry. Using qualitative research approach, semi-structured interviews were conducted to the sample of nine (9) Construction Engineering and Management (CEM) programs offered in four tertiary institutions in Kaduna State. The heads of department of Architecture, Building and Quantity Surveying in these institutions were invited to participate in the survey. Data collected through the interviews were subsequently analysed using content analysis. The study found that although BIM is yet to be fully integrated into the curricula of the CEM programs of the surveyed institutions, the institutions have a fair awareness of the concept of Building Information Modeling and the potential benefits of its implementation in the industry. Also, several barriers such as; lack of room in the existing curriculum for additional classes; lack of staff with the knowledge of BIM; high cost of training; lack of accreditation standards and requirements to guide the integration of BIM within a curriculum were identified to be the major obstacles hindering successful integration among others. The study concludes that the status of integration of BIM into construction education in CEM programs is unsatisfactory and requires tremendous improvement. To ensure wide and improved BIM integration in the curricula of CEM programs, it's recommended that the regulatory and professional bodies of the various disciplines in the built environment should mandate the inclusion BIM in the curricula of all CEM programs offered in the country.

Keywords: *Building Information Modelling (BIM), Construction Engineering and Management (CEM), Curricula, Construction education.*

INTRODUCTION

The rate at which the Architecture, Engineering and Construction (AEC) industry is embracing Building information modelling (BIM) in the delivery of its services is continuing to grow. Various sectors of the industry such as the construction professionals, public, and private construction clients in many parts of the world have established formal requirements for implementing BIM in their projects (Khemlani, 2012). McGraw-Hill Construction (2014) summarised the status of BIM adoption over the last three to five years around the globe and identified Canada, France, Germany, the UK and the USA as mature markets for BIM technology with new under explored market in countries such as; Australia, Brazil, Japan, New Zealand, South Korea, China and India. On a general note, the report depicts the rapid and robust BIM uptake globally, especially in the US and the Scandinavian regions where BIM acceptance and adoption is growing exponentially. Furthermore, significant successes have also been reported in the UK, Australia, Singapore and other maturing countries in the Middle East (McGraw-Hill Construction, 2014).

Despite the numerous potentials and benefits associated to the application of BIM tools in AEC's delivery process, low rate of BIM implementation has been widely reported in many parts of the world (Isa, 2015; Jung & Joo, 2011; McGraw-Hill Construction, 2014). However, 'lack of personnel with competent BIM skills' has been reported to be a major factor responsible for the low rate of implementation (Abubakar, Ibrahim, & Bala, 2013; Ashcroft & Shelden, 2008; Barison & Santos, 2010; Isa, 2015). To address this challenge, CEM programs in higher institutions of learning play a pivotal role in that in addition to producing BIM competent professionals to the industry, the burden of training professionals already in the industry is drastically reduced(Ann, Cho, & Lee, 2013). Therefore, several researchers have highlighted the importance of BIM in CEM programs. For example, Peterson et al (2011) and Sacks and Barak (2010) demonstrated the application of BIM in project management and civil engineering programs respectively.

To achieve continuous improvement and the knowledge management necessary for realising the values of BIM projected by researchers in the AEC industry(Eastman, Teicholz, & Sacks, 2011), professional education, training and development of professionals in the industry becomes imperative (Sacks & Barak, 2010). Consequently, universities around the world are developing BIM-integrated curriculums for students of construction engineering and management (CEM) programs. These curricula are based on BIM education frameworks that facilitate the establishment of comprehensive breakdown of knowledge and competency needs of the industry (Sacks & Pikas, 2013). Sacks and Pikas (2013) developed and tested a BIM framework for BIM education of graduate engineers and BIM-competent construction managers.

In Nigeria, although some level of readiness for BIM implementation has been established (Abubakar et al., 2013; Abubakar, Ibrahim, Bala, & Kado, 2014; Usman, 2015) the industry is reported to be at level 1 maturity stage(Isa, 2015). This low level of implementation has been attributed to several factors (Abubakar et al., 2013; Abubakar et al., 2014; Usman, 2015) among which includes 'lack of trained and competent BIM experts. However, despite the pivotal role and potentials of tertiary institutions to increase the rate of BIM implementation in the construction industry, the status of integration of BIM into the curricula of Nigerian Construction Professional in Nigeria is not known. Therefore, this paper examines the status of BIM integration into the curricula of CEM programs offerred in Nigerian tertiary institutions.

LITERATURE REVIEW

Definition and Application of BIM

The Acronym 'BIM' has many interpretations depending on the context in which it is used: It could be 'Building Information Modelling'; 'Building Information Model'; or 'Building Information Management'. The term BIM is considered to be ambiguous and has no universally accepted definition (Aranda-Mena et al., 2008). According to RICS (2014b), the concept of BIM has no accepted definition due to its ever-evolving nature where new areas and frontiers are creeping into the boundaries of what it could be defined as. There are definitions that present BIM as a 'Process', a 'Product', a 'technology', an 'innovation', or a 'Strategy'. However, simpler definitions consider BIM as a digital representation of the physical and functional characteristics of a facility. Whatever definition is given to BIM, the major function and goal of BIM involves the detailed and complete replication of a building in a digital environment with the sole goal of providing a collaborative platform for managing Building information throughout the lifecycle of a facility (Aouad et al., 2014). The terms '*Building Information Model'* and '*Building Information Modelling'* are often used interchangeably, basically referring to a way of creating, using, and sharing building lifecycle data.

The National Building Information Model Standard; NBIMS (2007) defines BIM as a shared informational resource, which digitally represents the physical and functional characteristics of a building and allows for reliable decision-making though out the building's life cycle (NIBS 2007). Eastman, Teicholz, and Sacks (2011) described BIM as a modelling technology and associated set of processes to produce, communicate, and analyse building models.

Several benefits have been attributed to BIM, the followings are some the benefits of BIM at the various stages of the lifecycle of a facility (Eastman et al., 2011; Pittard & Sell, 2016):

Concept, feasibility, and design benefits

Owners/clients of facilities are always interested in determining whether a building of a given size, quality level, and desired program requirements can be built within a given cost and time budget. BIM model built into and linked to a cost database can provide owners with accurate and reliable information that guides decision on whether to proceed with a project or not.

Increased building performance and quality

Schematic models developed prior to constructing detailed building model allow for a more careful evaluation of the proposed scheme to determine whether it meets the building's functional and sustainable requirements. Early evaluation of design alternatives using BIM analysis/simulation tools improves the general quality of the building.

Improved collaboration using integrated project delivery

Where Integrated Project Delivery (IPD) is the adopted project procurement approach, BIM can be used by the project team from the commencement of the design to improve their understanding of project requirements and to extract cost estimates as the design is developed (Eastman et al., 2011). This allows design and cost to be better understood and also helps in avoiding the use of paper exchange and its associated delays and other complications.

Earlier and more accurate visualisations of a design

3D models can be used to visualize the design at any stage of the process with the expectation that it will be dimensionally consistent in every view.

Automatic low-level corrections when changes are made to designs

The parametric nature of BIM makes objects used in the design to be controlled by parametric rules that ensure proper alignment, hence making the 3D model free of geometry, alignment, and spatial coordination errors which ensures automatic adjustments to changes made at later stages.

Generation of Accurate and consistent 2D drawings at any stage of the design:

Through a BIM model, 2D designs can be extracted for any set of objects or specified view of the project. This significantly reduces the amount of time and number of errors associated with generating construction drawings for all design disciplines.

Earlier collaboration of multiple design discipline:

BIM technology facilitates simultaneous work by multiple design disciplines which consequently shortens the design time; significantly reduces design errors and omissions, and ultimately gives earlier insight into design problems and presents opportunities for a design to be continuously improved

Use of design model as basis for fabricated components

BIM models are used in steel, sheet metal work, precast components, fenestration, and glass fabrication. These offsite fabrications help in drastically reducing cost and construction time. BIM also allows larger components of the design to be accurately fabricated offsite than would be done using 2D designs.

Quick reaction to design changes

Changes introduced during design can be automatically evaluated and updates made automatically based on the established parametric rules. Design changes can be resolved more quickly in a BIM system because modifications can be shared, visualized, estimated, and resolved without the use of time-consuming paper transactions. Updating in this manner is extremely error-prone in paper-based systems.

Discovery of design errors and omissions before construction

Because the virtual 3D building model is the source for all 2D and 3D drawings, design errors caused by inconsistent 2D drawings are eliminated. In addition, because models from all disciplines can be brought together and compared, multisystem interfaces are easily checked both systematically (for clash detection) and visually (for other kinds of errors).

Improved commissioning and handover of facility information

During the construction process the general contractor and MEP contractors collect information about installed materials and maintenance information for the systems in the building. This information can be linked to the object in the building model and thus be available for handover to the owner for use in their facility management systems. It also can be used to check that all the systems are working as designed before the building is accepted by the owner.

Better management and operation of facilities

BIM provides a source of information (graphics and specifications) for all systems used in a building. Previous analyses used to determine mechanical equipment, control systems, and other purchases can be provided to the owner, as a means for verifying the design decisions once the building is in use. This information can be used to check that all systems work properly after the building is completed.

Integration with Facility Operation and Management Systems

A building model that has been updated with all changes made during construction provides an accurate source of information about the as-built spaces and systems. This provides a useful starting point for managing and operating the building. A building Information Model supports monitoring of real-time control systems, provides a natural interface for sensors, and remote operating management of facilities. Many of these capabilities have not yet been developed, but BIM provides an ideal platform for their deployment.

BIM Education in Construction Engineering and Management Courses

The state-of-the-art in university-level BIM education for the broad architecture, engineering, and construction (AEC) sector, report positively, inspite of the hitches faced by institutions in terms of understanding 'what to teach' and 'how to teach' BIM components they integrate into their CEM related program(Sacks & Pikas, 2013). Studies report that BIM is being adopted gradually, and that implementation by majority of existing course is done at basic level by teaching a specific tool (Barison & Santos, 2010). For example, results of the survey of 488 U.S. CEM accredited programs show that 60% of construction management programs have some BIM component in their curriculum in only one or two courses which mostly are electives (Becerik-Gerber, D.J. Gerber, & Ku, 2011). The various components of BIM courses according to Becerik-Gerber et al. (2011) include introduction to BIM concepts (40%); BIM assignments merged into the project work in classes (67%); standalone BIM courses (67%); BIM immersed into existing courses and design projects (60%); and BIM merged into research projects (28%).

Many institutions apply BIM in the teaching of construction methods and that has fundamentally improved the understanding of the students(Kymmell, 2008). Facilities are virtually built and all necessary tasks involved in the construction process such as estimating, scheduling, constructability analysis, clash detections and several others which before are taught theoretically are now demonstrated and undertaken in BIM environment, and that to some large extent eases and fast track students understanding(Sacks & Barak, 2010; Sacks & Pikas, 2013).

To effectively produce BIM competent construction professionals, institutions of learning must align their curriculum with the current industry needs in addition to other relevant BIM skills. This is quite necessary because different maturity levels are achieved at different times by various industry sectors, and thus, training should be directed towards meeting up with the various needs at all times(Ahmad, Demian, & Price, 2012). Lee and Hollar (2013) identified and rated BIM competency areas, most of which concern BIM functionality such as clash detection, 4D modeling, etc, and concluded that effective BIM education should be adopted broadly across multiple courses, to satisfy the growing need for BIM-competent professionals. Therefore, several frameworks for BIM education have been proposed by researchers (Molavi & Shapoorian, 2012; Pikas, Sacks, & Hazzan, 2013; Solnosky, Parfitt, & Holland, 2013). These frameworks were designed to bridge the gap between industry needs and university education and emphasized that curricula development should also consider innovations such as green building and integrated project delivery(Molavi & Shapoorian, 2012).

RESEARCH METHOD

In order to ascertain the status of integration of BIM education into the curriculum of Nigerian tertiary institutions offering CEM programs, an extensive literature review was first conducted, purposely to articulate issues regarding the concept of Building Information Modelling (BIM) and BIM in Construction Education. Based on the information gathered from the review, a semi-structured interview guide was developed and administered to the heads of department of CEM programs offered in tertiary institutions in Kaduna state, Nigeria. The interview involved only tertiary institutions offering CEM courses; Architecture, Building Quantity Surveying, Civil engineering, Estate Management and Urban and Regional planning. A total number of nineteen (19) CEM programs were identified to be offered in four (4) tertiary institutions resident in Kaduna state. These institutions are; Ahmadu Bello University (5); Kaduna State University (3); Nuhu Bamalli Polytechnic (6); and Kaduna Polytechnic (6). Table 1 shows the distributions of the CEM programmes offered in all the institutions.

Table 1: Study Sample Frame: CEM Programs

Program		Frequency	Percentage
Architecture		4	21%
Building		4	21%
Quantity Surveying		4	21%
Urban and Regional Planning		2	11%
Estate management		2	11%
Civil Engineering		3	16%
	Total	**19**	**100%**

As shown in Table 2, nine (9) Heads of Department from the four (4) Institutions offering CEM programmes which represent 47% of the study sample frame were selected for the interview. Each head of department was invited to participate in the study and was issued interview guide to prepare for the discussions. The sample was considered to be adequate and representative in that most of the programs operate similar curriculum as provided by the minimum bench mark by either the Nigerian Universities commission (NUC) or National Business and Technical Education Board (NABTEB) as the case may be. The interviews conducted were audiotaped, transcribed, coded and analysed using content analysis. The interview focused on four (4) major themes; background of the respondents; BIM awareness of the respective departments involved; status of BIM integration in the institution's curriculum and finally the challenges and barriers hindering the full implementation and integration of BIM into CEM programs in these institutions.

Table 2: Respondents' Profile

Variables Discipline	Categories	Frequency	Percent
	Architecture	4	44%
	Quantity Surveying	2	22%
	Building Services	3	33%
Experience & Qualification	**Respondents**	**Qualification**	**Years of experience**
	INTVW 1	BSc. Qs, MSc. PhD, MNIQS,RQS	8 years
	INTVW 2	BSc. Qs, MSc.,PhD, MNIQS	10 years
	INTVW 3	BTech. Qs	5 years
	INTVW 4	BSc., MSc., MNIQS,RQS	18 years
	INTVW 5	BSc., Msc, MSc.	8 years
	INTVW 6	BSc., MSc.	9 years
	INTVW 7	BSc., MNIQS	10 years
	INTVW 8	BSc., MSc.	11 years
	INTVW 9	BSc., MSc.	12 years

* INTVW: Interviewee

RESULTS AND DISCUSSION

Respondents' Background, BIM awareness and Knowledge

To ensure the reliability of the data collected from the respondents, only heads of department were involved in the survey. This is based on the assumption that the heads have acquired reasonable understanding and knowledge of the entire workings of the department and have adequate and sound technical competence in their respective disciplines. As shown in Table 2, all the respondents were registered members of their respective professional bodies and have at least Bachelors and Master of Science degrees in their academic profiles which clearly suggest the reliability of information they provide.

Furthermore, the respondents BIM awareness and knowledge was also considered to be a crucial measure of the reliability of data obtained from the survey and therefore, it was explored to further ascertain the reliability of information collected. All the nine (9) respondents demonstrated satisfactory level of BIM awareness, as most of them have heard and read about the concept. Similarly, while 55.56% (5) of the respondents have knowledge and skill of BIM, 44.45% (4) are not knowledgeable in BIM. This logically confirms the low status of adoption reported locally(Abubakar et al., 2014) and globally(McGraw-Hill Construction, 2014).

The extent of BIM Integration into the Curricula of the surveyed CEM programs

With regards to the integration of BIM into the curriculum of the CEM programs surveyed, only three (3) out of the Nine (9) departments were found have incorporated some aspects BIM education into their curriculum. BIM is integrated as a Core course delivered weekly for a period of 2-hours and is taught to students in their fourth year (400 Level) when they have covered most of the technical components of the curricula. According to the interviewees, BIM is taught at lecture, practical and Computer Aided Design (CAD) sessions. This clearly corroborates the findings of Woo (2006) who reported similar results. While Building departments have integrated BIM as an independent course in their curriculum, the Quantity Surveying departments did not integrate BIM as a course but rather as a module or sub-component of other courses, e.g computer application courses. The BIM modules in their curricula are delivered in the students' third year and covered within the period of three to four consecutive weeks. The modules capture BIM concept and its application in the areas of model visualisations, quantity take-off and estimating. Design, modeling, visualisation, scheduling, simulation were the major areas captured in the curricula of the Architecture and Building departments surveyed. Emphasis is generally made on the specific skills of modeling and basic analysis in both QS and building departments. The major BIM-based applications used in demonstrating BIM concepts in these programs are Revit Autodesk QTO, and Google. These results support the findings of Woo (2006) that there is no commonly accepted approach to teaching BIM in AEC programs . Furthermore, BIM integration and implementation in these programs is done at basic level, focusing on specific tools just as the case was reported by Barison and Santos (2010) that integration is limited to a single discipline in 90% of CEM programs and that majority of the programs implement BIM at a basic level, teaching a specific tool and limiting their perspective on BIM to viewing it simply as a productivity enhancing tool for producing drawings.

Challenges facing the integration of BIM into the Curricula of the Surveyed Institutions

The interviewees identified several barriers hindering the integration of BIM in the curriculum of their programs. The barriers highlighted by the respondents are:

- Lack of room in the existing curriculum for additional classes
- Lack of staff with the knowledge of BIM
- High cost of training
- Lack of accreditation standards and requirements to guide the integration of BIM within a curriculum
- Difficulty in learning and using software
- Poor staffing capability
- Lack of BIM-specific materials and textbooks as well as other educational resources for students
- Lack of staff with the knowledge of BIM
- Training staff is expensive
- Availability of electricity supply
- Scepticism in introducing BIM
- Industry is not serious about BIM
- Lack of client readiness and demand
- Lack of government support.

Most of the challenges identified by the interviewees were similar to the challenges reported by previous researches investigating BIM integration in CEM programs in other parts of the world(Barison & Santos, 2010; Kymmell, 2008; Pikas et al., 2013; Sacks & Barak, 2010; Sacks & Pikas, 2013; Woo, 2006). For example Kymmell (2008) listed difficulty in learning and using BIM software; misunderstanding of the BIM processes; and issues related to the circumstances of the academic environment as the major issues stumbling BIM education.

CONCLUSION

This study has appraised the status of BIM integration into the curriculum of tertiary institutions in Nigeria. The study found that although BIM is yet to be fully integrated into the curricula of the CEM programs of the surveyed institutions, all the institutions are aware of BIM. Also, BIM integration was found be done differently. While some of the programs teach BIM as a course of its own others capture BIM as sub-component of other courses. Several barriers such as; lack of room in the existing curriculum for additional classes; lack of staff with the knowledge of BIM; high cost of training; lack of accreditation standards and requirements to guide the integration of BIM within a curriculum were identified to be the major obstacles hindering successful integration among others. The study concludes that the status of integration of BIM in construction education is unsatisfactory and requires serious improvement.

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