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Barriers to the incorporation of BIM into quantity surveying undergraduate curriculum in the Nigerian universities

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Abstract

Purpose –In developing countries, adoption of Building Information Modelling (BIM) concept within the Architecture, Engineering, and Construction (AEC) curricula in universities is a relatively new effort and subsequently, studies on the status of BIM implementation in universities are rare. This study, therefore, becomes imperative with a view to identifying and examining the barriers to the incorporation of BIM into quantity surveying (QS) undergraduate curriculum in the Nigerian Universities.

Design/methodology/approach – The study adopted a questionnaire survey, which was targeted at the academia and students from two selected universities offering QS honours degree programme. Data collected were analyzed using mean score, Mann-Whitney test and factor analysis.

Findings – The study identified 30 barriers and the analysis of the ranking revealed that 17 (out of 30) identified barriers were considered as the most serious barriers. The study, through factor analysis, grouped the 30 identified barriers into six major factors.

Practical implication –The findings provide greater insights and empirical evidence on the major barriers to implementation of BIM education in developing countries.

Originality/value – The identified barriers are relevant not only to QS education but also to other related disciplines within the AEC context. These findings would be of great value to academic staff and university management board to develop strategies for incorporating BIM into AEC disciplines curricula in developing countries at large.

Keywords: BIM, barriers, curriculum, higher education, developing countries

Research Paper

Introduction

Building Information Modelling (BIM) has been widely acknowledged as an emerging technological and procedural shift within the Architecture, Engineering, and Construction (AEC) industry (Panuwatwanich *et al*., 2013). There is a growing demand for Higher Education Institutions (HEIs) to incorporate BIM into their construction education degrees curricula, in this case for quantity surveying honours degree programmes to equip new graduates with such knowledge and preparing quantity surveying graduates for more employment in the industry. This is aligns with the observation by Keraminiyage and Lill (2013) that studying at HEIs is a primary mode of knowledge and skills enhancement for construction professionals. This is affirmed by Perera *et al*. (2017) that updating of knowledge and skills for construction graduates becomes imperative and it is a clarion call for those responsible for programme development in HEIs to be on the lookout for appropriate areas of expansion, innovation and adjust where possible to changing professional needs. It is on this premise that a number of universities around the world are offering courses for various BIM applications.

Existing studies have reported the adoption of BIM technologies in many developed countries such as USA, UK, Australia, Netherlands, Singapore, Hong Kong, New Zealand among others (Isikdag and Underwood, 2010; Wong *et al*., 2011) with impressive outcomes, despite some challenges to the adoption of BIM. Olatunji *et al*. (2010) advocated for the full adoption of BIM technologies across all disciplines. This is supported by Han and Bedrick (2015) that BIM adoption will suffer without its incorporation into education. Therefore, it is important for HEIs to incorporate BIM into their programmes with the support from government and industry (NATSPEC, 2013). This will ensure a continuous production of BIM-ready graduates and prepared the graduates for more employment in the industry. It is against this backdrop that the UK government mandated that all public building projects are required to use BIM from the year 2016 (McGough *et al*., 2013; Eadie *et al*., 2015). Due to this reason and to satisfy the AEC industry requirements, many of the UK universities have started integrating BIM concept into AEC education (Abbas *et al*., 2016). For instance, Adamu and Thorpe (2015) identified some UK universities such as Westminster University, Middlesex, Salford, Liverpool (in London), the University of West of England, Northumbria University, and the University of South Wales are already offering several BIM-related courses in their AEC programmes.

In the United States, Sacks and Pikas (2013) indicated that very few of the universities have incorporated BIM content into their AEC curricula. Some of these universities include Auburn University, Philadelphia University, University of Washington, University of Arkansas at Little, University of Southern California, Montana State University, and Purdue University. Other countries like Australia, New Zealand, and Hong Kong have also dealt with the integration process of BIM into AEC curricula in some of their universities. Therefore, it is evident that a number of universities worldwide are offering courses for various BIM applications within AEC programmes, while several others are under the process of integrating BIM into their curricula. In Nigeria, however, adoption of BIM concept in universities AEC curricula is a relatively new effort and studies on the status of BIM implementation in universities are not very common. For instance, similar previous studies include Babatunde *et al*. (2018) that focused on the drivers and benefits of BIM incorporation into quantity surveying profession in Nigeria. The study found that understanding the BIM is compulsory for quantity surveying and incorporation of BIM into the quantity surveying profession would make the quantity surveyors perform their practices better in a sustainable manner. However, the study does not pay attention to the factors preventing the Nigerian universities from incorporating BIM into their AEC curricula unlike some universities in the developed countries. It is on this premise that this study becomes imperative with a view to identifying and examining the barriers to the incorporation of BIM into AEC curricula, in this case for quantity surveying undergraduate curriculum in the Nigerian Universities. The findings of this study would be of great value to academic staff and university management boards to develop practices for incorporating BIM concept into the QS curriculum in Nigeria and developing countries at large.

Literature review

BIM in quantity surveying profession

Quantity Surveying (QS) is a profession that is well established in the British Commonwealth as being responsible for the management of cost and contracts in the construction industry (Pheng and Ming, 1997; Bowen *et al*., 2008; Ling and Chan, 2008). The profession is also known as construction economics in Europe and cost engineering in the USA and parts of Asia (Pathirage and Amaratunga, 2006; Smith, 2009). Traditionally, the role of quantity surveyors is primarily associated with estimating and cost planning, procurement advice, measurement, preparation of bills of quantities, tender documentation, construction cost control, and preparation of valuations, contractual claims and final accounts (Ashworth and Hogg, 2007). Following the emergence of BIM, some of the aforementioned quantity surveyor roles could be achieved through BIM more efficiently (Ashworth and Hogg, 2007; Wu *et al*., 2014). Therefore, it is important for quantity surveyors to appreciate BIM, understand its potential, and develop effective processes to integrate BIM into their current practices (Cartlidge, 2011).

Existing studies in this area have highlighted the reasons of integrating BIM into the QS profession (Sabol, 2008; Eastman, Teicholz, Sacks and Liston, 2011). For instance, Thomas (2010) identified some reasons such as: 30% of the projects do not meet original programme or budget; 37% of materials used in construction become waste; 10% of the cost of a project is typically due to change orders; and 38% of carbon emissions are from buildings not cars. Sabol (2008) described that during conventional (e.g. manual) project development, accurate, actionable costing information has been difficult to define during preliminary project phases. This process is prone to human error and tends to propagate inaccuracies. The quantification is time intensive, and it requires 50% to 80% of a cost estimator's time on a project. However, the development of early cost estimates is widely facilitated by BIM (Sabol, 2008). This is supported by Nagalingam *et al*. (2013) who avers that BIM reduces the resources needed for a construction project and costs are saved on the reduction of resources. This is affirmed by Gier (2015) that BIM is a helpful teaching tool for construction estimation, quantity take-off and highly contribute to design comprehension skills and understanding of construction materials, methods, and processes.

State of BIM in the Nigerian construction Industry

There is very little evidence that BIM is widespread in the Nigerian construction industry and this is evident in the lack of literature precisely on the subject. Conversely, a number of studies have examined the uptake of information and communications technology (ICT) by construction professionals in Nigeria as well as the challenges to its implementation in practice. However, the review of extant literature revealed that some improvements are required to construction education as regards BIM implementation. According to Oladapo (2006 and 2007), the main uses of ICT in the industry are word processing, internet communications, costing and work scheduling. Ibironke *et al*. (2011) examined the current state and use of ICT by quantity surveyors in Nigeria. The research revealed that despite the awareness of the importance of ICT in improving service delivery and productivity, the level of adoption by quantity surveyors in Nigeria is still very low and BIM tools such as Auto Cad, Revit, Master Bill, QS Cad, Win QS, CATO are yet to be fully exploited.

Musa *et al*. (2010) concluded that harnessing appropriate ICT tools would improve the quality of quantity surveying services in the country. In addition, several other studies have buttressed this assertion (Ibironke *et al*., 2011; Olanrewaju, 2016; Dada and Musa, 2016; Dada, 2017). There is a clear-cut evidence that ICT has numerous benefits but the implementation in practice is one of a different story in the Nigerian construction sector (Oladapo, 2006; Waziri *et al*., 2015). Perhaps we should look to the providers of construction-related education in Nigeria to instil students with increasing awareness of BIM. Conversely, it may be that there are genuine and important barriers to the incorporation of ICT, especially BIM, into HEI curricula. In the current era, the need for value-added services, complexity of modern construction infrastructure, and on-time delivery of projects are few of the factors necessitating the use of modern ICT as a viable tool to improve the quality of QS services. Although a limited number of construction firms in Nigeria have been adopting and using basic ICT for their services since late 1980s (Musa *et al*., 2010), the use and benefits of BIM has not been fully realized in the sector as a whole (Ikediashi and Ogwueleka, 2016). It becomes pertinent therefore to explore the minimal uptake of BIM in the Nigerian AEC sector. This is the focus of this study. It established empirical barriers to implementation of BIM education in Nigerian higher education programs.

Barriers to BIM incorporation into curricula in HEIs

There is no known conclusive empirical study on barriers to the incorporation of BIM into QS education in Nigeria. Therefore, the research offers a fresh understanding around what is happening in the Nigerian AEC sector as regards BIM implementation as well as the challenges of its integration into construction curriculum not only in Nigeria but also elsewhere. While some of the barriers to BIM implementation are common; others are peculiar to Nigeria as a developing nation. Despite the fact that progress has been made in incorporating BIM into AEC curricula, particularly in developed countries such as USA, UK, Australia, New Zealand, Hong Kong, and Singapore among others. The extant literature revealed the challenges of integrating BIM into the undergraduate curriculum, which are presented in Table I as follows:

>>>>>>>>> Insert Table I>>>>>>>>>>>

While reports abound on BIM education in the construction industry of developed countries, very little exists for developing countries such as Nigeria. This study therefore seeks to examine the barriers to the implementation of BIM education in Nigeria in the context of a developing economy. The constraints to the use of modern ICT in Nigeria, which this study focuses on include insufficient/irregular power supply, high cost of ICT hardware and software, low job order for firms, fear of virus attacks, and high rate of obsolescence of ICT hardware and software amongst others (Oladapo, 2007). Musa *et al*. (2010) identified the lack of ICT infrastructural facilities, power supply in the country, education and training as some of the reasons limiting the uptake of BIM tools in practice. Other proponents in the field (Waziri *et al*., 2015; Dada, 2017) agreed that education and training are paramount to developing quantity surveyors ICT skills and knowledge and continuous professional development. Dada and Musa (2016) argued that educational training can be considered an integral part of organisation learning, change and skill development. In general, a review of the existing literature of ICT adoption in Nigeria revealed shortcomings in BIM implementation and education in comparison with what is obtained globally. In the light of the above, Dada (2017) opined that there is need to understand the identified gap in construction education provided by relevant stakeholders, especially the academic institutions offering QS programmes in Nigeria.

In developing countries such as Nigeria, adoption of BIM concept in universities AEC curricula is relatively a new effort and studies on the status of BIM implementation in academia are not very common (Alkalbani *et al*., 2012; Olanrewaju, 2016). While the above studies have provided useful insights into the current state of ICT in the Nigerian construction industry and barriers to its implementation in practice, none has investigated the barriers to the implementation of BIM education in Nigerian HEIs. It is on this premise that this study becomes imperative with a view to identifying and examining the barriers to the incorporation of BIM into AEC curricula, in this case for quantity surveying undergraduate curriculum in the Nigerian Universities. This was not done in previous studies. For the Nigerian quantity surveyors to attain the required competence standard in BIM practice, BIM education is crucial (Dada and Musa, 2016), and the barriers to its implementation in QS programs need to be explored.

Research methodology

Previous studies conducted on the integration of BIM within the Architecture, Engineering and Construction (AEC) curricula surveyed between one and three key stakeholders to include the academic staff, students, and professionals within AEC industry. For example, Clevenger *et al.* (2010) administered questionnaires to students when exploring the incorporation of BIM into the construction management curriculum. Hedayati *et al.* (2015) surveyed both the students and lecturers when exploring the obstacles to implementing BIM in educational system. Abbas *et al.* (2016) sampled only academic staff (i.e. faculty members) when assessing the current state of BIM into the construction management programme within the engineering universities in Pakistan. Also, few studies adopted literature review (see Lee and Dossick, 2012; Elinwa and Agboola, 2013). Therefore, this study adopted a literature review, a desk review, and two questionnaire surveys of academia and students within the case studies of two selected public federal universities in Southwestern Nigeria to include: Obafemi Awolowo University, Ile-Ife; and the Federal University of Technology Akure offering quantity surveying honours degree programmes in Nigeria. The rationales for selecting these two universities are as follows: (1) they are the leading universities offering quantity surveying honours degree programmes for over three decades in Southwestern Nigeria; (2) their QS programmes are fully accredited by both the National Universities Commission and the Quantity Surveyors Registration Board of Nigeria; (3) they have the highest number of quantity surveying students' enrollment at undergraduate study; and (4) they already have a dedicated QS software packages laboratory for teaching students measurement and estimating.

The methodology adopted for this study comprised a literature review, desk review, and two surveys of academia and students, which are detailed as follows.

Literature review

An extensive literature review was carried out to identify the various barriers to the incorporation of BIM into the Architecture, Engineering and Construction (AEC) programmes in HEIs. These were identified from the significant literature. Thus, the outcome of literature review produced 30 barriers (see Table I for details).

Desk review

The identified 30 barriers from the literature review were subjected to a desk review which comprised three academia in the Quantity Surveying department at Obafemi Awolowo University, Ile-Ife, Nigeria. These three selected academia are actively involved in teaching students dedicated QS software for measurement and estimating (e.g. QS CAD, Masterbill Elite, Ripac etc) at undergraduate study. The three selected academia have vast experience of QS softwares and their applications. Thus, the feedback obtained from these three academia informed the development of the academia and student questionnaire surveys. This, therefore forms the basis of inquiry for the data collection and analysis.

Survey of the academia

The identified barriers from the literature and desk review formed the basis of the survey questionnaire. The academic survey is one of the two surveys conducted in the case studies comprised two selected universities to include QS department at Obafemi Awolowo University (OAU), Ile-Ife, and QS department at the Federal University of Technology Akure (FUTA). The total number of academic staff in the QS department from the two universities is 39 academic staff comprised 13 academic staff at OAU and 26 academic staff at FUTA. Due to the small sample size of the academic staff from both universities, the entire 39 academic staff were sampled. The survey received 10 and 17 responses from OAU and FUTA, respectively.

This is resulting into a total of 27 completed responses representing 69%, which were found suitable for the analysis

Survey of the students
The student survey is the second survey conducted among the final year undergraduate students in the QS department from both universities- OAU and FUTA. The QS programme is 5 years (i.e. part/level 1 to part/level 5). The reasons for choosing final year undergraduate students are: they have undergone several courses/modules relating to software applications for measurement and estimating (e.g. QS CAD, Masterbill Elite, Ripac etc); and they are mature and already exposed to the industry during their industrial attachement/intership. In 2016/2017 academic session, the total number of final year undergraduate students in the QS department from the two universities is 161 students comprised 62 students at OAU and 99 students at FUTA. Therefore, for objectivity, half of final year undergraduate students in each university were randomly selected. Hence, 81 QS students comprised 31 QS students at OAU, and 50 QS students at FUTA were randomly sampled. The survey received 27 and 45 fully completed responses from OAU and FUTA, respectively. This resulting into a total of 72 fully completed responses.

The questionnaire designed for this study was structured and multiple-choice type. The questionnaire was divided into two sections. Section "A" comprised demographic information of the respondents, while section "B" was designed in relation to the purpose of this study. The questions were asked on a five-point Likert scale rating with 5 being the highest of the rating. A reliability test was conducted on the five point Likert scale in the questionnaire using Cronbach's alpha test through Statistical Package for Social Science (SPSS). The reliability coefficients value of Cronbach's alpha 0.872 was obtained, signifying that the questionnaire used for the study is reliable and indicates evidence of good internal consistency. This is supported by George and Mallery (2003) that Cronbach's alpha value of greater than 0.6 is considered acceptable. This is affirmed by Pallant (2007) that the value for Cronbach's alpha should be higher than 0.7 for the scale to be reliable. The data collected were analysed using SPSS through the use of descriptive statistics, mean score, Kruskal-Wallis test, and factor analysis. The mean score was used for ranking of identified 30 barriers to the integration of BIM into quantity surveying undergraduate curriculum. Mann-Whitney test was carried out to determine whether there is statistically significant difference in perceptions of the respondents comprised academic staff and students on the ranking of 30 identified barriers. Also, factor analysis was used in data reduction to identify a small number of factors that explain most of the variance (Pallant, 2010; Hair *et al.*, 2010).

Results and discussion

Demographic information of respondents
Table II indicates the demographic information of the academic staff in quantity surveying department from the two selected universities comprised OAU and FUTA. It can be seen from Table II that the background information of academic staff only was indicated. It is because the other category of respondent was final year undergraduate students in the QS department from aforementioned two universities. In the context of this study, there is no need for any further background information regarding the students. Thus, Table II reveals the demographic information of the academic staff in terms of academic qualification, designation of academic staff and year of service as an academic staff undertaken by the respondents in the two selected universities. The academic qualifications of respondents revealed that the majority of the respondents had PhD, followed Master's Degree. It can also be seen from Table III that the

designation of the respondents cuts across the academic staff cadre in university (see Table III for details).

>>>>>>>>> Insert Table II>>>>>>>>>>>

Ranking of the barriers to the incorporation of BIM into quantity surveying undergraduate curriculum

Table III shows the analysis of the ranking for the 30 identified barriers to the incorporation of BIM into quantity surveying undergraduate curriculum as indicated by the respondents, which comprised academic staff and students in the two selected universities. Based on the five-point Likert rating scale, an attribute was deemed critical if it had a mean value of 3.5 or more (Badu *et al*., 2012; Babatunde *et al*., 2016). Given two or more identified barriers (see Table III) with the same mean values, the one with the lowest standard deviation was assigned highest importance ranking (Field, 2005). The analysis of the ranking in terms of the total mean score values for the 30 identified barriers ranging from 2.96 to 4.01, this indicates that not all the identified barriers are considered by respondents as critical barriers influencing the incorporation of BIM into quantity surveying undergraduate curriculum. It can be seen further from Table IV that 17 (out of 30) identified barriers scored mean values between 3.58 and 4.01, which are considered as important barriers (Badu *et al*., 2012; Babatunde *et al*., 2016).

Therefore, the highest total ranked 17 barriers that displayed mean score values ranging from 3.58 to 4.01 are as follows: lack of IT infrastructure or poor internet connectivity; BIM is resource intensive; lack of government lead/direction; cost of training the staff/lecturers; availability of qualified staff to take BIM course; need to continually upgrade the BIM software; lack of accreditation standards and requirements to guide the implementation of BIM within a curriculum; inadequate/erratic power supply; lack of collaboration with industry expert; BIM is problematic for people with weak general IT skills; resistance to change-difficulty in introducing BIM in an already well-established curriculum; need for industry involvement i.e. the need to engage expert industry practitioners in the development and delivery of a BIM curriculum; lack of university management support; ICT literacy of staff or lack of technical expertise; integrating different areas of the curriculum to realise the multidisciplinary aspect of BIM is problematic; BIM demands new teaching methods; and lack of BIM-specific materials and textbooks as well as other educational resources for students, respectively. The similar barriers were identified by several previous studies. For instance, Sabongi and Arch (2009), and Panuwatwanich *et al.* (2013) found that lack of time and resources to prepare a new curriculum, lack of space in established curriculum to include new courses and lack of suitable materials for BIM related training are the main obstacles to integrating BIM into universities engineering undergraduate curriculum in developed countries. Abbas *et al.* (2016) identified lack of trained BIM faculty members, structure of existing education curriculum, need for the industry involvement, inadequate funding, and unwillingness to change existing curriculum are top ranked barriers to integrating BIM into construction management programmes in Pakistani universities. In addition, it can be deduced from this study finding that there are more important barriers influencing the integration of BIM into undergraduate curriculum in the Nigerian universities.

In order to determine whether there is statistically significant difference in perceptions of the respondents comprised academic staff and students from the two selected universities on the ranking of 30 identified barriers. The Mann-Whitney test was conducted at a significance level of 5%. The results of Mann-Whitney test indicated a very slight statistically significant difference on four and five (out of 30) identified barriers in perceptions of the respondents at OAU and FUTA, respectively (see Table III). This little significant difference is not surprising because it could be connected with their lived experience of the respondents about the existing infrastructure in their respective university and their familiarity with quantity surveying practices in the industry.

>>>>>>>>>> **Insert Table III**>>>>>>>>>>>

Factor analysis of the barriers to the incorporation of BIM into quantity surveying undergraduate curriculum

In an attempt to achieve more interpretable results and thereby determine the underlying relationships among the identified 30 barriers to BIM incorporation into quantity surveying undergraduate curriculum (see Table III), factor analysis was conducted. In assessing the suitability of data obtained for factor analysis, Kaiser-Meyer-Olkin (KMO) and Bartlett's tests of Sphericity was conducted using Statistical Package for the Social Sciences (SPSS).This approach was supported by Pallant (2010) who asserted that before embarking on factor analysis, the data must be assessed for suitability for factor analysis using KMO and Bartlett's tests of Sphericity. Table IV revealed the results of KMO and Bartlett's tests of Sphericity. The KMO value indicated the sampling adequacy to be 0.872 (see Table IV). This shows a satisfactory for accurate completion of factor analysis. This was supported by Tabachnick and Fidell (2007) that the KMO index ranges from 0 to 1, with 0.6 suggested as the minimum value for a good factor analysis. Similarly, the result of Bartlett's test of Sphericity showed a recorded value of 0.000 (see Table IV), which is considered appropriate for the factor analysis. This is corroborated by Pallant (2007) that the significance value should be 0.05 or less. It is evident that the data obtained were suitable for conducting factor analysis.

>>>>>>>>>> **Insert Table IV**>>>>>>>>>>>

Therefore, factor analysis was conducted and the factors with an eigenvalue greater than 1.0 were considered for further investigation. This is corroborated by a number of earlier researchers that the default position in making a decision about the number of factors to be considered in factor analysis is the "eigenvalue greater than 1.0 rule" (Pallant, 2010). It can be seen from Table V that six components were retained for further investigation after satisfying the eigenvalues greater than 1. Table V contains the six factors with their eigenvalues, the percentage of the variance, and the cumulative percentage of the variance in each factor. It can be seen from Table V that the eigenvalues for the six factors retained were ranging from 1.205 to 5.227. The total variance explained by extracted six factors accounted for 66.077%.

>>>>>>>>>> **Insert Table V**>>>>>>>>>>>

Table VI revealed the principal factor extraction with a varimax rotation conducted on the identified 30 barriers to the incorporation of BIM into quantity surveying undergraduate curriculum in Nigeria. The result of analysis grouped the 30 identified barriers into six principal interpretable factors with their components (see Table VI for details).

>>>>>>>>>> **Insert Table VI**>>>>>>>>>>>

The six principal factors derived are interpreted as follows:

1. Factor 1: Scale of culture change
2. Factor 2: Lack of enabling environment
3. Factor 3: Staff resistance and non-availability of industry expert

4. Factor 4: Lack of accreditation standards and requirements
5. Factor 5: High cost of implementation
6. Factor 6: High security risk (see Table VI for details).

The six interpretable principal factors are explained as follows:

Factor 1: Scale of culture change: This factor accounts for 17.42% (see Table V) of the total variance of barriers to the incorporation of BIM into quantity surveying undergraduate curriculum. The main components of scale of culture change as a factor include: it is difficult to educate the lecturers due to rapidly evolving technology; disagreement over BIM concept is concerned whether BIM is a methodological process or a software tool; BIM demands new teaching methods; modelling requires expert construction knowledge that is not easily understood by students, especially when they lack work experience; BIM is problematic for people with weak general IT skills; What to include in BIM course among others (see Table VII). These six components have a factor loading: 0.800; 0.731; 0.699; 0.695; 0.667; and 0.655, respectively. This study finding confirms the previous studies that alluded to the fact that the introduction of new processes into an organisation involves the shifting of the culture of the organisation, which involves people, finances, systems and physical resources (Ahmad *et al*., 2010). Therefore, it is evident from this study finding that the incorporation of BIM into quantity surveying curriculum will necessitate dramatic changes among the academic staff and students in the department, and the university at large.

Factor 2: Lack of enabling environment: This factor amounts to 16.46% of the total variance of barriers to the incorporation of BIM into quantity surveying undergraduate curriculum. The main components are lack of government lead/direction, lack of university management support, lack of IT infrastructure or poor internet connectivity, need to continually upgrade the BIM software, and inadequate/erratic power supply among others (see Table VI for details). These components have a loading: 0.809, 0.789, 0.788, 0.628, and 0.601, respectively. Lack of enabling environment as a factor encompasses the policies and legislations of government and university management towards the incorporation of BIM into the built environment discipline's curricula in higher education. This study confirms the finding by Oladapo (2007) that identified lack of IT infrastructure or poor internet connectivity and inadequate/erratic power supply as constraints to the use of ICT in the Nigerian construction industry. This is not surprising that inadequate/erratic power supply is among the barriers as power supply in Nigeria has been unreliable, which forced all the higher education institutions in Nigeria to run their own power generating facilities. Currently, these are still a serious challenging issues in Nigeria.

Factor 3: Staff resistance and non-availability of industry expert: This factor accounts for 15.98% (see Table V) of the total variance of barriers to the incorporation of BIM into quantity surveying undergraduate curriculum. The main components include staff resistance/reluctance to initiate new workflow, which BIM software should be taught to the students, ICT literacy of staff or lack of technical expertise, traditional (and current) program structures, and difficulty to appoint industry expert among others (see Table VI for details). These components have a loading: 0.793, 0.760, 0.759, 0.679, and 0.606, respectively. This finding is similar to previous studies. For instance, Ruikar *et al*. (2005) asserted that it is very common to experience resistance to the adoption of new technologies and processes from staff. This can be connected with the staff insufficient IT skills among others. This assertion is corroborated by Aouad *et al*. (2006) that identified lack of skilled BIM operatives in the industry as a significant barrier to BIM adoption now in the developing countries.

Factor 4: Lack of accreditation standards and requirements: This factor accounts for 7.65% (see Table V) of the total variance of barriers to the incorporation of BIM into quantity surveying undergraduate curriculum. The factor has two main components, this includes lack of accreditation standards and requirements to guide the implementation of BIM within a curriculum, and integrating different areas of the curriculum to realise the multidisciplinary aspect of BIM is problematic. These two components have a factor loading 0.775 and 0.667, respectively. This study affirmed few of the previous studies that identified inconsistency in the integration of BIM into AEC curricula in higher education (Sabongi, 2009; Becerik-Gerber *et al*., 2011; Sacks and Pikas, 2013). However, properly structured BIM courses would provide industry-required knowledge to prepare students for successful careers in the industry.

Factor 5: High cost of implementation: This factor amounts to 4.55% of the total variance of barriers to the incorporation of BIM into quantity surveying undergraduate curriculum. The factor has two main components comprised BIM is resource intensive, and cost of training the staff/lecturers. These two components have a factor loading 0.594 and 0.562, respectively. This finding is similar to previous studies. For instance, Eadie *et al*. (2015) asserted that implementing BIM necessitates organisations to purchase the pertinent software and hardware and train their staff in the use of that software. It is on this premise that Ayarici *et al*. (2011) found that cost of training and high cost of software are the barriers to BIM adoption in the industry. This is affirmed by Lee *et al*. (2012) that software packages need updates and it is necessary to consider the fact that BIM software packages will periodically need to be updated, which is an added cost.

Factor 6: High security risk: This factor amounts to 4.02% of the total variance of barriers to the incorporation of BIM into quantity surveying undergraduate curriculum. This factor has only one component, which is fear of virus attacks/high security risk with a factor loading of 0.570 (see Table VII for details). This finding is similar to the ones by previous studies, especially Oladapo (2007) that identified fear of virus attacks as fourth top ranked constraints to the use of ICT in the Nigerian construction industry. In developing countries, this is not surprising as the maintenance of BIM softwares becomes a serious challenge, which makes BIM softwares susceptible to virus attacks and other various security risks.

Conclusions

This study provided empirical evidence on the barriers militating against the integration of BIM into AEC curricula, in this case for quantity surveying (QS) undergraduate curriculum in the Nigerian Universities. The study identified 30 barriers to the incorporation of BIM into QS undergraduate curriculum. The analysis of the ranking in terms of the total mean score values for the 30 identified barriers revealed that 17 (out of 30) identified barriers scored mean values between 3.58 and 4.01, which are considered as serious barriers. It can be deduced from this study that there are more serious barriers influencing the integration of BIM into QS undergraduate programme in the Nigerian universities.

In addition, the top 10 ranked barriers are as follows: lack of IT infrastructure or poor internet connectivity, BIM is resource intensive, lack of government lead/direction, cost of training the staff/lecturers, and availability of qualified staff to take BIM course, respectively. Others include the need to continually upgrade the BIM software, lack of accreditation standards and requirements to guide the implementation of BIM within a curriculum, inadequate/erratic power supply, lack of collaboration with industry expert, and BIM is problematic for people with weak general IT skills, respectively. The results of Mann-Whitney test indicated a very slight statistically significant difference on four and five (out of 30) identified barriers on perceptions of the respondents at OAU and FUTA, respectively. This little significant difference is not surprising because it could be connected with their lived experience of the respondents about the BIM concepts in relation to the existing infrastructure in their respective university and their familiarity with quantity surveying practices in the industry.

The study, through factor analysis, grouped the 30 identified barriers to BIM incorporation into QS programme into six major factors to include: scale of culture change; lack of enabling environment; staff resistance and non-availability of industry expert; lack of accreditation standards and requirements; high cost of implementation; and high security risk. This study is not without limitations. For instance, the respondents considered in this study were from two universities fully accredited by both the National Universities Commission and the Quantity Surveyors Registration Board of Nigeria in Southwestern, Nigeria. Considering other accredited universities offering QS programme in Nigeria would have enhanced the credibility of the findings. Also, the use of questionnaire survey allows a large sample to be captured, having other methods together such as interviews may enrich the findings. Despite the limitations, the findings of this study provides greater insights and empirical evidence on the major barriers that both academia and students need to overcome to successfully incorporate BIM into a curriculum. The findings would be of great value to academic staff and university management to develop strategies for incorporating BIM into AEC disciplines curricula in developing countries at large. Further, the barriers identified in this study are relevant not only to QS profession, but also to other related disciplines within the AEC industry.

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Table I: Barriers to incorporation of BIM into curriculum in HEIs

S/n	Barriers	References
1	There is a lack of accreditation standards and requirements to guide the implementation of BIM within a curriculum	Sabongi, 2009; Wong *et al*., 2011; Sacks and Pikas, 2013
2	Integrating different areas of the curriculum to realise the multidisciplinary aspect of BIM is problematic	Sabongi, 2009; Wong *et al*., 2011; Sacks and Pikas, 2013
3	There is no room in the existing curriculum for additional classes/courses	Sabongi, 2009; Clevenger *et al*., 2010
4	BIM demands new teaching methods	Gordon, Azambuja and Werner 2009; Clevenger *et al*., 2010
5	There is a lack of BIM-specific materials and textbooks as well as other educational resources for students	Sabongi, 2009; Gier, 2015
6	Modelling requires expert construction knowledge that is not easily understood by students, especially when they lack work experience	Sabongi, 2009; Guo and London, 2010; Sylvester and Dietrich, 2010
7	It is difficult to educate the lecturers due to rapidly evolving technology	Becerik-Gerber *et al*., 2011; Alabdulqader, Panuwatwanich and Doh, 2013
8	BIM is resource intensive	Gordon *et al*. 2009; Sacks and Pikas, 2013; Puolitaival and Forsythe, 2016;
9	BIM is problematic for people with weak general IT skills	Taylor *et al*., 2008; Gordon *et al*. 2009
10	What to include in BIM course	Panuwatwanich *et al*.,2013; Sacks and Pikas,2013
11	Disagreement over BIM concept is concerned whether BIM is a methodological process or a software tool	Clevenger *et al*., 2010; Becerik-Gerber *et al*., 2011; Panuwatwanich *et al*.,2013
12	Need for strong fundamental knowledge for the students before being able to undertake BIM	Panuwatwanich *et al*.,2013; Gier, 2015
13	Need for industry involvement i.e. the need to engage expert industry practitioners in the development and delivery of a BIM curriculum	Lee and Dossick, 2012; Panuwatwanich *et al*.,2013
14	Resistance to change- difficulty in introducing BIM in an already well-established curriculum	Becerik-Gerber *et al*., 2011; Panuwatwanich *et al*.,2013
15	Which BIM software should be taught to the students	Panuwatwanich *et al*.,2013
16	Traditional (and current) program structures-refers to the typical isolated, discipline-specific program structure that exists in most universities	Gordon *et al*. 2009; Panuwatwanich *et al*.,2013
17	Inadequate/erratic power supply	Oladapo, 2007
18	Fear of virus attacks/high security risk	Oladapo, 2007
19	Availability of qualified staff to take BIM course	Oladapo, 2007; Lee and Dossick, 2012
20	Need to continually upgrade the BIM software	Oladapo, 2007
21	Cost of training the staff/lecturers	Efficiency and Reform Group, 2011; Eadie *et al*., 2015
22	Staff resistance/reluctance to initiate new workflow	Arayici *et al*, 2009; Becerik-Gerber *et al*., 2011; Eadie *et al*., 2015
23	ICT literacy of staff or lack of technical expertise	Arayici *et al*.,2009; Eadie *et al*., 2015
24	Lack of vision of BIM tangible benefits	Arayici *et al*., 2011; Lee *et al*., 2012
25	Lack of university management support	Arayici *et al*., 2011; Jung and Joo, 2011
26	Lack of IT infrastructure or poor internet connectivity	Oladapo, 2007
27	Lack of government lead/direction	Australian Institute of Architects(AIA), 2010
28	Lack of space and facilities to accommodate BIM	Sabongi, 2009; Sacks and Pikas, 2013
29	Difficulty to appoint industry expert	Becerik-Gerber *et al*., 2011; Macdonald, 2012
30	Lack of collaboration with industry expert	Becerik-Gerber *et al*.,2011; Lee and Dossick, 2012

Table II: Demographic information of academic staff

Academic staff profile	Academic staff (OAU) (Frequency (%))	Academic staff (FUTA) (Frequency (%))
Highest educational qualification		
BSc	-	5(29.41)
MSc	2(20.00)	8(47.06)
PhD	8(80.00)	4(23.53)
Total	10(100.00)	17(100.00)
Designation of academic staff		
Graduate assistant	-	5(29.41)
Assistant lecturer	1(10.00)	5(29.41)
Lecturer II	2(20.00)	1(5.88)
Lecturer I	5(50.00)	5(29.41)
Senior Lecturer	1(10.00)	1(5.88)
Associate Professor	-	-
Professor	1(10.00)	-
Total	10(100.00)	17(100.00)
Year of service as an academic staff		
<5years	1(10.00)	9(52.94)
6- 10years	5(50.00)	3(17.65)
11-15years	-	1(5.88)
16- 20years	2(20.00)	4(23.53)
>20years	2(20.00)	-
Total	10(100.00)	17(100.00)

Table III: Ranking of the barriers to incorporation of BIM into QS undergraduate curriculum

Barriers	Obafemi Awolowo University, Ile-Ife								Federal University of Technology, Akure									
	Academic staff			Students			Mann-Whitney		Academic staff			Students			Mann-Whitney		Total	Total
	Mean	SD	Rank	Mean	SD	Rank	Z-Value	Sig.	Mean	SD	Rank	Mean	SD	Rank	Z-Value	Sig.	Mean	Rank
B 01. There is a lack of accreditation standards and requirements to guide the implementation of BIM within a curriculum	3.70	1.89	7	3.74	0.09	8	0.983	0.326	4.06	1.03	8	3.86	1.18	9	0.555	0.579	3.84	7
B 02. Integrating different areas of the curriculum to realise the multidisciplinary aspect of BIM is problematic	3.30	1.64	15	3.56	0.70	17	0.073	0.942	3.94	0.83	12	3.82	0.87	11	0.483	0.629	3.66	15
B 03. There is no room in the existing curriculum for additional classes/courses	2.40	1.35	28	3.07	1.11	30	-1.305	0.192	3.29	1.10	24	3.66	1.08	26	-1.199	0.231	3.11	26
B 04. BIM demands new teaching methods	3.30	1.16	14	3.52	0.89	21	-0.519	0.604	3.71	1.10	17	3.84	1.08	10	-0.366	0.714	3.59	16
B 05. There is a lack of BIM-specific materials and textbooks as well as other educational resources for students	3.00	1.25	20	3.56	1.05	19	-1.260	0.208	4.06	1.25	10	3.72	1.13	22	1.422	0.155	3.58	17
B 06. Modelling requires expert construction knowledge that is not easily understood by students, especially when they lack work experience	3.10	1.20	16	3.37	1.01	27	-0.517	0.605	3.41	0.94	22	3.76	1.08	18	-1.429	0.153	3.41	22
B 07. It is difficult to educate the lecturers due to rapidly evolving technology	2.60	1.47	26	3.19	1.04	29	-1.239	0.215	2.53	0.72	30	3.50	1.11	30	-3.393	0.001*	2.96	30
B 08. BIM is resource intensive	3.90	1.37	4	3.78	1.03	7	0.659	0.510	4.41	0.62	1	3.92	1.12	7	1.432	0.152	4.00	2
B 09. BIM is problematic for people with weak general IT skills	3.60	1.37	8	3.67	1.18	14	-0.143	0.886	4.00	0.87	11	3.92	1.07	6	0.076	0.940	3.80	10
B 10. What to include in BIM course	2.20	1.23	30	3.56	1.22	20	-2.627	0.009*	3.00	1.00	27	3.64	0.98	27	-2.471	0.014*	3.10	27
B 11. Disagreement over BIM concept is concerned whether BIM is a methodological process or a software tool	2.50	1.27	27	3.26	0.86	28	-2.000	0.046	3.06	0.97	26	3.54	0.97	29	-1.711	0.087	3.09	28
B 12. Need for strong fundamental knowledge for the students before being able to undertake BIM	3.10	1.29	17	3.52	0.98	22	-0.788	0.431	3.41	0.62	21	3.82	1.04	13	-1.740	0.082	3.46	20
B 13. Need for industry involvement i.e. the need to engage expert industry practitioners in the development and delivery of a BIM curriculum	3.50	1.08	9	3.67	0.88	13	-0.163	0.870	4.12	0.70	6	3.76	0.96	17	1.315	0.188	3.76	12
B 14. Resistance to change- difficulty in introducing BIM in an already well-established curriculum	3.50	1.35	12	3.48	0.85	25	0.216	0.829	3.94	0.97	13	4.14	0.95	1	-0.837	0.403	3.77	11

Barriers	Obafemi Awolowo University, Ile-Ife								Federal University of Technology, Akure									
	Academic staff			Students			Mann-Whitney		Academic staff			Students			Mann-Whitney		Total	Total
	Mean	SD	Rank	Mean	SD	Rank	Z-Value	Sig.	Mean	SD	Rank	Mean	SD	Rank	Z-Value	Sig.	Mean	Rank
B15. Which BIM software should be taught to the students	2.30	1.06	29	3.37	0.93	26	-2.916	0.004*	2.88	1.11	29	3.74	0.94	20	-2.680	0.007*	3.07	29
B 16. Traditional (and current) program structures-refers to the typical isolated, discipline-specific program structure that exists in most universities	2.60	1.43	25	3.52	1.05	24	-1.843	0.065	3.41	1.12	23	3.92	0.90	5	-1.701	0.089	3.36	24
B 17. Inadequate/erratic power supply	3.90	1.29	3	3.78	1.01	6	0.555	0.579	3.88	1.17	14	3.74	1.10	21	0.499	0.618	3.83	8
B 18. Fear of virus attacks/high security risk	3.10	1.60	18	3.59	0.97	15	-0.935	0.350	3.59	1.06	19	3.66	1.06	25	-0.320	0.749	3.49	18
B 19. Availability of qualified staff to take BIM course	4.00	1.33	2	3.70	0.99	11	1.070	0.285	4.06	1.14	9	3.76	1.20	19	1.010	0.313	3.88	5
B 20. Need to continually upgrade the BIM software	3.80	1.32	6	4.04	0.90	3	-0.306	0.759	3.82	1.13	15	3.80	1.01	14	0.174	0.862	3.87	6
B 21. Cost of training the staff/lecturers	3.50	1.10	11	4.11	0.89	2	-1.588	0.112	4.18	1.01	5	4.02	0.96	2	0.827	0.408	3.95	4
B 22. Staff resistance/reluctance to initiate new workflow	2.60	1.17	24	3.81	1.00	5	-2.713	0.007*	3.00	1.11	28	3.88	0.98	8	-2.808	0.005*	3.32	25
B 23. ICT literacy of staff or lack of technical expertise	3.00	1.33	21	4.15	0.86	1	-2.488	0.013*	3.59	1.28	20	4.02	1.04	3	-1.227	0.220	3.69	14
B 24. Lack of vision of BIM tangible benefits	2.90	1.52	22	3.56	0.93	18	-1.279	0.201	3.18	1.07	25	3.82	1.00	12	-2.168	0.030*	3.37	23
B 25. Lack of university management support	3.50	1.09	10	3.59	1.05	16	-0.054	0.957	4.06	0.75	7	3.68	1.15	24	1.007	0.314	3.71	13
B 26. Lack of IT infrastructure or poor internet connectivity	3.90	1.40	5	3.93	0.78	4	0.416	0.677	4.41	0.71	2	3.78	1.22	16	1.860	0.063	4.01	1
B 27. Lack of government lead/direction	4.10	1.45	1	3.74	0.86	9	1.614	0.107	4.24	0.83	4	3.78	1.13	15	1.376	0.169	3.97	3
B 28. Lack of space and facilities to accommodate BIM	3.00	1.22	19	3.52	1.01	23	-1.246	0.213	3.71	0.92	16	3.68	1.08	23	-0.189	0.850	3.48	19
B 29. Difficulty to appoint industry expert	2.70	1.42	23	3.74	0.94	10	-2.043	0.041	3.59	0.87	18	3.64	1.03	28	-0.335	0.738	3.42	21
B 30. Lack of collaboration with industry expert	3.40	1.26	13	3.70	1.20	12	-0.623	0.534	4.24	0.66	3	3.96	1.05	4	0.740	0.459	3.82	9

* Significant at 0.05 (i.e.5%)

Table IV: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.872
Bartlett's Test of Sphericity	Approx. Chi-Square	1.817E3
	df	435
	Sig.	.000

Table V: Total variance explained

	Initial Eigenvalues			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	10.372	34.574	34.574	5.227	17.423	17.423
2	3.975	13.250	47.825	4.937	16.456	33.879
3	1.996	6.654	54.479	4.793	15.977	49.856
4	1.338	4.459	58.937	2.296	7.653	57.508
5	1.099	3.664	62.602	1.365	4.551	62.059
6	1.043	3.475	66.077	1.205	4.018	66.077
7	.971	3.236	69.313			
8	.857	2.858	72.171			
9	.812	2.708	74.879			
10	.678	2.261	77.140			
11	.644	2.146	79.286			
12	.582	1.940	81.226			
13	.544	1.812	83.038			
14	.538	1.792	84.830			
15	.529	1.762	86.592			
16	.454	1.512	88.104			
17	.449	1.498	89.602			
18	.417	1.391	90.993			
19	.360	1.200	92.193			
20	.307	1.024	93.217			
21	.293	.977	94.194			
22	.268	.893	95.087			
23	.253	.843	95.930			
24	.219	.729	96.658			
25	.201	.671	97.329			
26	.196	.655	97.984			
27	.179	.598	98.582			
28	.157	.525	99.107			
29	.140	.467	99.573			
30	.128	.427	100.000			

Extraction Method: Principal Component Analysis

Table VI: Rotated component matrix[a]

Barriers	Component 1	2	3	4	5	6
B07. It is difficult to educate the lecturers due to rapidly evolving technology	0.800					
B11. Disagreement over BIM concept is concerned whether BIM is a methodological process or a software tool	0.731					
B 04. BIM demands new teaching methods	0.699					
B 06. Modelling requires expert construction knowledge that is not easily understood by students, especially when they lack work experience	0.695					
B 09. BIM is problematic for people with weak general IT skills	0.667					
B 10. What to include in BIM course	0.655					
B 05. There is a lack of BIM-specific materials and textbooks as well as other educational resources for students	0.634					
B 12. Need for strong fundamental knowledge for the students before being able to undertake BIM	0.615					
B 03. There is no room in the existing curriculum for additional classes/courses	0.602					
B 13. Need for industry involvement i.e. the need to engage expert industry practitioners in the development and delivery of a BIM curriculum	0.527					
B 27. Lack of government lead/direction		0.809				
B 25. Lack of university management support		0.789				
B 26. Lack of IT infrastructure or poor internet connectivity		0.788				
B 20. Need to continually upgrade the BIM software		0.628				
B 17. Inadequate/erratic power supply		0.601				
B 19. Availability of qualified staff to take BIM course		0.581				
B 28. Lack of space and facilities to accommodate BIM		0.536				
B 22. Staff resistance/reluctance to initiate new workflow			0.793			
B15. Which BIM software should be taught to the students			0.760			
B 23. ICT literacy of staff or lack of technical expertise			0.759			
B 16. Traditional (and current) program structures-refers to the typical isolated, discipline-specific program structure that exists in most universities			0.679			
B 29. Difficulty to appoint industry expert			0.606			
B 24. Lack of vision of BIM tangible benefits			0.545			
B 30. Lack of collaboration with industry expert			0.512			
B 14. Resistance to change- difficulty in introducing BIM in an already well-established curriculum			0.443			
B 01. There is a lack of accreditation standards and requirements to guide the implementation of BIM within a curriculum				0.775		
B 02. Integrating different areas of the curriculum to realise the multidisciplinary aspect of BIM is problematic				0.667		
B 08. BIM is resource intensive					0.594	
B 21. Cost of training the staff/lecturers					0.562	
B 18. Fear of virus attacks/high security risk						0.570