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Barriers to effective use of CAD and BIM in architecture education in Nigeria

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ABSTRACT

This study investigated barriers to the effective use of CAD/BIM in response to the dearth of data from Nigerian schools of architecture relative to information obtained from practice. This is important to bridge the gap between skill sets required in practice and those obtained from architecture graduates. Objectives of the study were to establish barriers that influence effective use of CAD/BIM tools in Nigerian schools of architecture as well as to identify means of addressing these barriers within the curriculum from the perspective of students. A mixed methodology was employed via questionnaire responses from 64 MSc students at the department of Architecture, Ahmadu Bello University Zaria as well as suggestions for improvement. Quantitative data were analysed in SPSS v. 21 for means (M) and Relative importance Index (RII). Suggestions proffered by respondents were assessed using content analysis. Results reveal that requirements for high computer specifications (RII=0.92), expensive cost of computers (0.91), requirements for intensive training (0.81), inadequate integration within the curriculum (0.81), lack of steady power supply (0.77) and time to master skills (0.76) were the most important barriers to effective CAD/BIM use in architecture education. Overall, government and institutional related barriers recorded the highest means (M 3.68 each). The study recommends government action via policies supporting clear BIM standards, local manufacture and assembly of high-tech computers to mitigate importation costs as well as added funding to higher institutions to augment research, power supply and ICT facilities. At departmental level, CAD/BIM tutorials should be integrated within studio sessions as seminars from 200L. At 400L and MSc levels, studio should support collaboration with students from other allied professionals. Recruitment requirements in future also need to include CAD/BIM proficiency to improve quality of teaching staff and learning experience of students.

1. Introduction

In recent years, Computer Aided Design (CAD) including Building Information Modelling (BIM) have become synonymous to beautiful designs, photo-realistic rendered works, cutting edge innovations and effective project delivery in the design and construction industry. For many contemporary architects, it is impossible to commence and complete a project without using CAD and BIM software/ tools. This ideology has been transferred to students in architecture schools who feel inadequate if not highly proficient in using CAD and BIM tools because these tools have become the industry standard worldwide (Iyendo and Alibaba, 2015; Rodriguez, 2014; Senyapili and Bozdag, 2012). Abdiran and Dossick (2016) as well as Foulcher and Gu (2011) note inadequacy of graduates to meet up to increasingly demanding industry standards is partly responsible for the tension and conflict between architects in academia and those in practice. While academics in the past have generally viewed CAD related tools as likely to impede design and innovation (Alcaide-Marzal et al., 2013; Becerik-Gerber et al., 2011; Lu, 2009; Salman et al., 2008), contemporary practice demands effective and seamless delivery of high-end projects frequently requiring multiple CAD and more recently, BIM software and tools.

Despite on-going debates about the advantages and disadvantages of integrating CAD and BIM within the architecture and design curriculum, the realistic and undeniable fact remains that CAD and BIM tools have become indispensable to contemporary practice in design and construction. Several studies address the most effective strategies of ensuring students are equipped with requisite CAD/BIM related skills (Almutiri, 2016; Abdiran and Dossick, 2016; Botchway et al. 2015; Iyendo and Alibaba, 2015; Alagbe et al., 2014; Aly, 2014; Rosli, Razak, Younus, Keumala and Ismail, 2014; Hancock, 2013; Mandhar and Mandhar, 2013; Ibrahim and Rahimian, 2010; Barison and Santos, 2010; Sabongi, 2009; Juvancic and Zupancic, 2008). Few studies however assess barriers students face to effectively acquire mastery and skilful use of these software and tools. Although barriers to the effective use of CAD/ BIM software/tools have been the focus of studies in practice (Chan, 2014; Ramilo and Embi, 2014a; 2014b) and academia (Mandhar and Mandhar, 2013; Ozcan-Deniz, 2016), it is often unclear what the current barriers are within the architecture educational environment from the student perspective especially in Nigeria. Establishing these barriers is important to improve effectiveness of teaching and learning CAD/BIM by students. This ultimately influences employability and quality of graduates entering the labour market.

This paper aims to identify barriers that hamper the effective use of CAD and BIM tools in Nigerian schools of architecture. Objectives of the study are: (a) to establish barriers that influence effective use of CAD/BIM tools in Nigerian schools of architecture, (b) to identify means of addressing these barriers within the curriculum from the perspective of students.

MSc I students (2016/2017) at the department of Architecture at Ahmadu Bello University (ABU) Zaria were selected because the department is the pioneer school of architecture in the country and is currently preparing to convert into a faculty. The MSc class was employed for this study because students have undergone all variances of learning CAD/BIM as taught within the architecture curriculum as well as experienced some form of professional practice through internship programs as part of Student Industrial Work Experience Scheme (SIWES) and National Youth Service Corps (NYSC). The latter is mandatory for graduates of all first-degree programs in Nigeria. A recent study (Gidado & Abdullahi, 2018) employed a similar population as a justification for assessing BIM awareness in architecture education.

Students at the department of Architecture, ABU are exposed to CAD, specifically AutoCAD and SketchUp from the first year (100L) as part of basic computer skills separate from Basic Design Studio, which targets mastery of manual drafting techniques and skills. Consequently, CAD is largely self-taught and exploratory at this stage, as computer design does not feature in Architectural Design Studio (ADS) assessment in the first year. By the second year (200L), AutoCAD and Revit are taken as stand-alone courses in preparation for the mandatory 6 months Student Industrial Work Experience Scheme (SIWES) in the third year (300L) as AutoCAD is still the industry standard in Nigeria (Ryal-Net and Kaduma, 2015). Students are attached to firms and architectural practices in preparation for the job market and as such should have acquired sufficient mastery of the tools to fit into practice. Many learn the finer techniques of CAD at the end of this period, as local firms are yet to fully employ BIM in practice (Abubakar et al., 2013). The basic principles of CAD/BIM are then built upon in the final undergraduate year (400L), specifically 3D AutoCAD and Revit BIM. Students employ these tools for their design projects and theses during their MSc program. To supplement power supply to the department, a 200KVA generator often provides power during office hours between 8am to 4pm.

The paper is organized in five sections after the introduction. Section two reviews literature on CAD and BIM as well as barriers to the effective use of these tools. This is followed by the methodology in section three and results/discussion in section four. The paper concludes with recommendations and references in sections five and six respectively.

2. Theoretical Background

2.1 CAD and BIM

The acronyms CAD and BIM are often employed interchangeably in part because BIM is a successor and advancement of CAD (Wong et al., 2011). The fundamental difference between the two is based on the computation technology underlying their programming (Guidera and Mutai, 2008). CAD is generally conceived as an automated version of manual drafting (Grabowski, 2010). CAD programs such as Autodesk's AutoCAD, 3D Studio Max, Google's SketchUp (Ramilo and Embi, 2014b) are built on the tradition of hand drafting to mimic building components (Botchway et al., 2015). They are non-parametric tools largely employed for drafting, visualisation and documentation purposes (Ramilo and Embi, 2014b). BIM software such as Autodesk's Revit simulates intelligent 3D models using parametric building components to mimic real life (Ramilo and Embi, 2014b). "BIM is based on a virtual 3D model of the proposed facility as the sole source of all information about the project" (Czmoch and Pekala, 2014, p. 211). At its essence is collaboration where all documentation of a building such as architectural design, landscape, mechanical and electrical components/ installations, construction, bill of quantities cost estimates, sustainabilty and maintenance details are all contained within a single 3D model with a database syncronising the above documents (Czmoch and Pekala, 2014, Guidera and Mutai, 2008). BIM at its full potential is targeted to be implemented in several dimensions, the first being 3D parametric modelling accepted as a natural extension of the 2D design in the AEC industry (Czmoch and Pekala, 2014). BIM 4D denotes the extension of 3D modelling in time using schedules, division of the project into phases up to product and delivery (Almutiri, 2016). BIM 5D, 6D and 7D involve cost estimating, sustainability and facility management applications respectively. The latter is projected to effectively manage detailed specifications of all project components to aid maintainance and replacement information over the life time of the project (Czmoch and Pekala, 2014).

Due to this overview, BIM is translated either as Building Information Modelling (Rodriguez, 2014; Aly, 2014; Becerik-Gerber, Gerber and Ku, 2011) or Building Information Management (Czmoch and Pekala, 2014; Sacks and Pikas, 2013). Differences regard viewing the model as a product of documents or managing the construction and maintenance process of projects. This dual role of BIM as a technological product and managerial process is partly responsible for issues encountered with effective understanding, uptake and benchmarking within the Architecture Engineering and Construction (AEC) industry (Almutiri, 2016). As a consequence, effective teaching of BIM in AEC schools has been problematic in spite of benefits associated with its use. Almutiri (2016) notes that architects see the benefits of BIM in three basic areas- Efficiency, Presentation and Teamwork.

BIM is seen to assist in producing more efficient projects in terms of speed in information flow as well as reduced costs for producing construction documents (Halttula et al., 2015). It also aids production of photo-realsitic visualisations while fostering competence and teamwork among design professionals. This has generally meant an improved return on investment (ROI) for businesses (Almutiri, 2016) as well as improvement in project delivery (Doumboya et al., 2016). Specifically, BIM is beneficial in marketing new business to clients and construction professionals via high visualisation outputs, reduction in errors and ommisions in construction documents, offering new services, reduction in rework (Almutiri, 2016), easier modalities to share information and collaborative effort across multiple construction teams (Halttula et al., 2015). It also aids owners a better operational efficiency across the lifetime of the project (Doumboya et al., 2016).

Despite these benefits, challenges abound in the effective use of CAD/BIM software in the AEC industry. These include difficulties in adopting the software by older professionals and management (Eadie et al. 2014; Ramilo and Embi, 2014a), inadequate supply of qualified staff to meet specialised skills (Ozorhon and Karahan, 2016), high costs for software and training in line with rapid transformations (Gimenez et al., 2016; Czmoch and Pekala, 2014), scale of cultural changes required for implementation, lack of flexibility (Eadie et al., 2014), supply-chain buy-in (ibid), IT literacy and staff resistance (Bui et al., 2016), legal uncertainties (Almutiri, 2016), interoperability and compatibility issues, lack of practical and standard guidelines as well as unclear benchmarks for practice (Bui et al., 2016; Halttula et al., 2015; Becerik-Gerber et al., 2011). Ramilo and Embi (2014b) categorized most barriers to digital innovation and use of BIM by firms into six common attributes. These are technological, financial, organizational, governmental, psychological and process barriers. Findings from their study reveal that large architectural organizations coped better than small or medium sized firms because of the substantial number of projects with considerable fees that can support innovation as well as collaboration with other firms and institutions. Financial barriers were the most crucial for firms out of the barriers studied.

2.2 Barriers to the effective use of CAD/BIM software and tools in academia

Due to the on going issues of the lack of common standard benchmarks and guidelines or BIM implementation in practice, it is unclear what the content, principles and methods of education are required in AEC curricula (Botchway, Abanyie and Afram, 2015; McCuen, 2014; Sacks and Pikas, 2013; Hancock, 2013; Guidera and Mutai, 2008). Several barriers to the effective use of CAD/BIM in

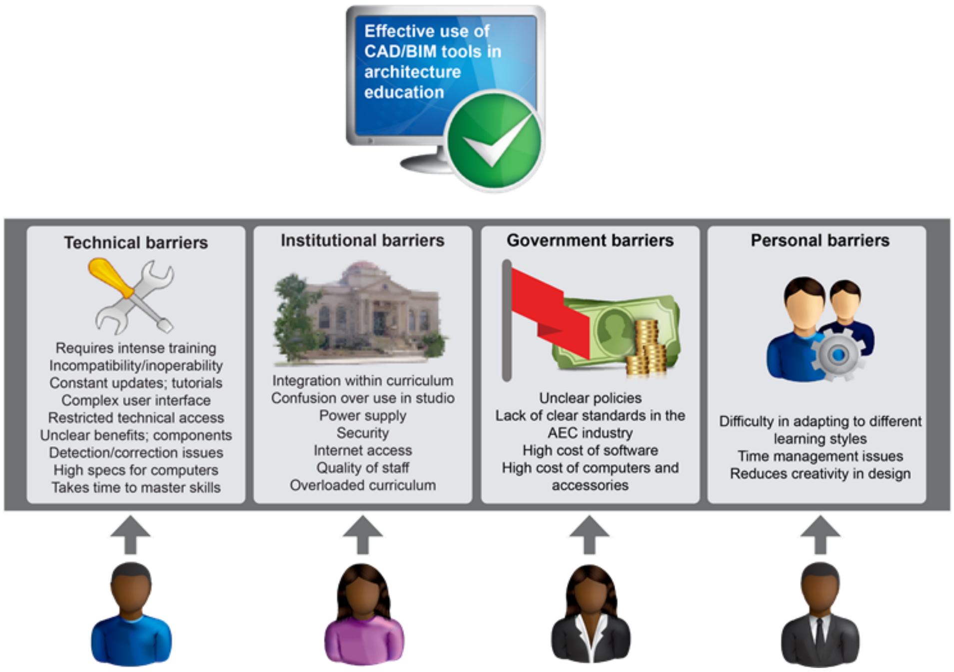

Figure 1: *Categories of barriers mitigating the effective use of CAD/BIM in architecture education*

academia have been identified in literature (Wong et al., 2011; Hancock, 2013, McCuen, 2014; Botchway et al., 2015; Al-Mutiri 2016; Al-Saati et al., 2016; Bui et al., 2016). These are categorised in this study under four themes namely Technical, Institutional, Personal and Governmental barriers (Figure 1).

Technical barriers to the effective use of CAD/BIM in AEC education involve programming and software development related issues such as error detection and correction by BIM software, limited choices for component databases (Wong et al., 2011), constant need and time to update software and skills (Hancock, 2013), complex user interface and access to training materials (Botchway et al., 2015). Others technical barriers include model development not following construction sequence (Wong et al., 2011), time required to master complex programs as well as hardware/system specifications (Al-Saati et al., 2016). Institutional barriers concern issues within institutions and organizations such as knowledge required to use BIM software as well as low quantity of teaching staff with high levels of practical experience in construction to translate AEC requirements into CAD/BIM teaching modules (Wong et al., 2011). Others are overloaded curricula (Becerik-Gerber et al., 2011), curriculum design/integration (McCuen, 2014), quality of teaching staff/incompetent trainers, unconducive learning environments, poor power supply, inadequate access to the internet and security (Kehinde, 2016). Governmental barriers largely concern issues regarding national/economic policies notably costs and expenses for software especially in developing countries (Bui et al., 2016) as well as unclear government policies and lack of clear standards in the AEC industry (Abubakar, Ibrahim and Bala, 2013). Personal barriers relate to issues within the sphere of influence of students and teaching staff. These include individual teaching and learning styles as well as personal disposition (Ozcan-Deniz, 2016; Petkowska, 2015; Botchway et al., 2015).

In view of the challenges of effectively incorpoating BIM within the architectural curriculum, Mandhar and Mandhar (2013) proposed a framework of incremental learning from beginner to advanced levels. These are complemented with learning outcomes and desired skill sets. The authors propose that teaching and learning at first year should focus on the basics of modelling and communicate different types of information and understanding of BIM concepts. In the transitional level in the second year, the focus should be building teamwork and collaboration as part of a design team. Realistic aspects of construction with advanced levels of practice and construct protocol should be the focus of learning in the third year.

3. Methodology

To address the objectives of the study, a questionnaire was designed in three sections. The first section (A) solicits information regarding demographics of the respondents. These include gender, method of presenting their design portfolios-whether manual drafting, CAD or BIM as well as the method CAD and BIM were learnt. Respondents were also required to choose between three alternatives for teaching CAD/BIM: Maintain it as is, Restructure or Remove it completely from the curriculum. Section B required respondents to rate 26 barriers identified in literature on a Likert Scale of 1-5 (1 being not important and 5, very important). These were analysed using means (M), Standard Deviation (SD) and Relative Importance Index (RII). RII is calculated as the ratio of the total actual scores (AS) for each barrier divided by a product of the number of responses and the maximum possible score[1] (Max.PAS). Mathematically, this is expressed as:

$$RII = \frac{\sum AS}{\sum Max.PAS}$$

These were then employed to rank the order of importance of factors in response to the first objective. Barriers with RII values of 0.75 and above were considered highly important for this study. These correspond to ratings in the upper quartile range (75% and above). RII values between 0.50 and 0.74 corresponding to the second quartile (50%-74%) are considered important. RII values below 0.5 (or median) are considered unimportant in this study. Mean values (M) of categories of barriers were also computed. Means of 3.0 and above (3 corresponding to the midpoint on a scale of 1 -5), were considered important for the purpose of this study.

Section C solicited modalities for improvement and suggestions on ways to overcome the challenges students face in school in response to the second objective of the study. This was presented as an open-ended question at the end of the questionnaire. The approach was utilized in place of interviews with respondents as previous experiences with a similar sample revealed that students were more forthcoming in proffering suggestions anonymously. Interviews are not anonymous. Suggestions were proffered in the form of statements, which were analysed using content analysis. Lune and Berg (2017) define content analysis as "a careful, detailed, systematic examination and interpretation of a particular body of material in an effort to identify patterns, themes, assumptions and meanings" (p. 182). Because student responses were presented as sentences, themes were adjudged the most useful unit of analyses and not words. A theme is defined as "a simple sentence, a string of words with a subject and predicate" (p. 189). The steps employed to analyse and categorise the qualitative data, adapted from Lune and Berg (2017) are as follows:

- All suggestions (qualitative data) were collated verbatim from the questionnaires into a word document. All suggestions from a single respondent were typed together in the same format the respondent wrote it. These may comprise several separate sentences representing different ideas. A total of 42 sentences were collated.
- Themes were analytically developed and inductively identified in the data. These pertain to specific suggestions, which recur within the text relating to modalities for the effective ways of teaching and learning CAD/BIM in the curriculum.
- Responses were sorted according to these categories by identifying similar phrases, patterns, ideas and commonalities.
- The data was analysed and sorted according to the number of times a theme appears. These are presented as counts (N) and percentages (%).
- Themes were considered in light of findings from section B of the questionnaire as well as from previous research to triangulate trends and disparities. Quotes are provided in italics as specific examples of suggestions from students.
- Findings from rankings and themes were employed to proffer recommendations on ways to improve the effective teaching and learning of CAD/BIM in the curriculum.

4. Results and Discussion

4.1 Results

Out of 88 questionnaires targeting the entire MSc I class, 64 (73%) were returned and employed for analyses. Demographic data obtained from the respondents reveal

[1]The maximum score for any factor per respondent is 5 (on a 5 point likert scale). For 63 respondents, maximum possible score = 315

that 53% (N34) were male while 6% (N 4) were female. The relatively high number of male respondents is characteristic of the gender skew in architecture education from previous studies. A large proportion of respondents (N 26, 41%) however did not report their gender (Table 1). CAD remains the most popular method for design presentation (N 52, 81%). Half of the respondents employ BIM and manual-drafting techniques while 70% of the sample is self-taught regarding CAD/BIM use. A third of the sample note departmental courses were the means they learnt CAD/BIM. 80% of respondents (N 51) indicated restructuring the way CAD/BIM is presently taught in the department against five students (8%) who indicated CAD/BIM courses should be maintained as they are. A single respondent (2%) wanted courses removed.

Results from section B of the questionnaire reveal that seven barriers record RII values of 0.75 and above (Table 2). These, in order of importance are high specification for laptops and equipment (0.92), cost of laptops and PCs (0.91), requirements for intensive training (0.81), inadequate integration of CAD/BIM in the curriculum (0.81), lack of steady power supply (0.77), time required to master skills (0.76) as well as lack of standards in the AEC industry (0.75). Majority of the identified barriers (69.2%) were ranked as important as RII values of these 18 barriers fell within 0.50-0.74. The issue that CAD/BIM reduces creativity recorded the lowest RII value of 0.45 below the 0.50 median cut off.

Table 1: *Attributes and Responses*

Gender of respondents	N	%
Male	34	53
Female	4	6
Missing	26	41
*Method of design presentation**	N	%
CAD	52	81
BIM	33	52
Manual drafting	32	50
*Method of learning CAD/BIM**	N	%
Self-taught	45	70
Private lessons	42	66
Departmental courses	21	33
CAD/BIM courses within the curriculum	N	%
Restructure	51	80
Maintain	5	8
Remove	1	2
Missing	7	10

Table 2: *Ranking of individual barriers to the effective use of CAD/BIM in architecture education*

Barrier	*Category*	*N*	*Sum*	*RII*	*Rank*
Requires high specs for laptops/equipment	Technical	64	293	0.92	1
Expensive cost of laptops and PCs	Government	63	286	0.91	2
Requires intensive training	Technical	64	259	0.81	3
Inadequate integration of CAD/BIM in the curriculum	Institutional	64	258	0.81	3
Lack of steady power supply	Institutional	63	242	0.77	5
Takes time to master skills	Technical	64	243	0.76	6
Lack of standards in the AEC industry	Government	64	239	0.75	7
Overloaded curriculum	Institutional	63	233	0.74	8
Poor internet access	Institutional	63	233	0.74	8
High cost of software	Government	63	233	0.74	8
Lack of training materials	Technical	64	231	0.72	11
Quality of teaching staff/ trainers	Institutional	64	231	0.72	11
Constant need to update software	Technical	64	229	0.72	11
Poor security for laptops & equipment	Institutional	64	229	0.72	11
Difficult to adapt to different learning styles	Personal	62	205	0.66	15
Confusion regarding usage in studio	Institutional	64	211	0.66	15
Complex user interface	Technical	63	206	0.65	17
Time management issues	Personal	63	198	0.63	18
Restricted access to technical information	Technical	59	178	0.60	19
Limited choice for components	Technical	63	186	0.59	20
Incompatibility/inoperability issues	Technical	61	180	0.59	20
Full range of benefits unclear	Technical	64	188	0.59	20
Overload of materials/ tutorials	Technical	63	183	0.58	23
Poor detection and correction technology	Technical	63	174	0.55	24
Unclear government policies regarding adoption	Government	64	175	0.55	25
Reduces creativity in design	Personal	64	143	0.45	26

Overall, government and institutional barriers recorded the highest mean values of 3.68 each. Technical barriers (M 3.37) follow these. Personal barriers (M 2.89) on average, recorded the lowest values and are considered the least important barriers to effective use of CAD/BIM from the sample.

In response to the second objective of the study, seven themes emerged from 42 suggestions proffered by respondents (Table 3). The suggestion to incorporate CAD/BIM at all levels within courses other than Architectural Design Studio (ADS) was the most frequently occurring theme (N 10, 24%). This is closely followed by the need to improve quality of teachers/trainers (N 9,

Table 3: *Themes from the content analysis of responses for ways to improve the effective use of CAD/BIM in architecture education*

Theme	*N*	*%*
Incorporate CAD/BIM at all levels and within	10	24%
Improve quality of teachers and training	9	21%
Encourage use by students for design	6	14%
Add CAD/BIM courses and seminars in the	5	12%
Availability of software/systems/internet con-	5	12%
Create avenues for exposure to more diverse	4	10%
Create awareness of the importance of CAD/	3	7%

21%), encourage CAD/BIM use by students in ADS (N 6, 14%), add CAD/BIM courses/seminars in the present curriculum as well as improve availability of software, systems and internet connectivity (N 5, 12% each). It is worthy to note that all themes suggested by students relate to institutional and technical barriers specifically issues of training, inadequate integration of CAD/BIM courses within the curriculum as well as provision of support infrastructure notably internet connectivity and system components. These barriers were ranked third, eighth and eleventh in Table 2.

4.2 Discussion

4.2.1 Institution and government-based barriers most affect effective use of CAD/BIM tools in architecture education

Results from the study reveal that seven barriers most affect the effective use of CAD/BIM in architecture education with RII equal to or above 0.75 (Table 2). The first two barriers from the results relate to the high specifications for computers required for CAD/BIM use (a technical barrier) as well as costs and expenses in purchasing these computers (a government influenced barrier). Typically, CAD/BIM software operate best on computers with high computational power and graphic card specifications. These are generally expensive for the average student in a public university such as ABU. A recent study identified high cost of equipment and materials as the number one factor influencing the overall academic performance of students of architecture in two public universities (Maina et al., 2017), supporting these results. Unfortunately, most of these computers are imported from foreign countries, often using foreign currencies. With the recent economic recession in Nigeria, students struggle to purchase these high-end computers, implying that a number of students maybe disadvantaged in acquiring the skills expected to be adequately CAD/BIM literate. While these barriers exist in the AEC industry (Gimenez et al., 2016; Czmoch and Pekala, 2014), firms maybe less sensitive to these barriers compared to individual student needs while in school.

Closely related to this point is the intensive training required to master CAD/BIM software ranked third in Table 2. Although a technical issue, the requirement for intensive training also relates to the availability of qualified professionals to within institutions (ranked eleventh). This is most pertinent in a climate of rapid technical improvements and upgrades required in becoming a current and proficient professional (Czmoch and Pekala, 2014). Students encounter difficulties in keeping up costs and time required for learning CAD/BIM. Not surprisingly, students ranked the inadequate incorporation of learning CAD/BIM third alongside intensive training required. This is compounded by epileptic power supply in the institution (ranked fifth), which generally reflects the scale of the problem nationwide. Although supplemented during official school hours, students are often left without adequate power supply in the evenings when they most need it for personal study and learning. Consequently, government and institutional barriers, often out of the sphere of influence of students, present the greatest barriers to the effective use of CAD/BIM in architecture education in three areas: inadequate/high cost of infrastructure (hard/software, power supply, internet connectivity), inadequate integration of CAD/BIM courses within the curriculum and quality of training.

Contrary to earlier debates that CAD/BIM may hamper and negatively influence creativity (Ibrahim and Rahimian, 2010), students ranked this barrier the lowest (Table 2), supporting findings in literature (Ahmad et al., 2013) that the use of CAD/BIM tools does not affect creativity.

4.2.2 Suggestions for improvement target Institutional barriers

Perhaps arising from awareness that some important barriers are out of direct influence of students, suggestions largely targeted institutional adjustments to the curriculum that can be implemented at departmental and institutional level (Table 3). First is the suggestion to incorporate CAD/BIM at all levels and courses. This was the most frequently occurring theme from the data. This is linked to the suggestion to allow its use from inception of ADS at 200L for design related courses, in line with the framework proposed by Mandhar and Mandhar (2013). Students noted the follpowings:

"CAD/BIM should be incorporated into the architecture curriculum and students should be taught well and instructed to do their designs from 200 level using CAD/ BIM software as that is what is being used in the building industry outside school. This will also increase the students chances of employment after school".

"I strongly suggest that CAD/BIM courses be integrated into all levels to familiarize students with the use of the software".

"The effectiveness of CAD/BIM in architecture education can be improved by making CAD/BIM default programs for design and analysis of all design oriented courses at all levels of the architecture program. The effectiveness of this should be checked by timely researches that obtains students' feedback".

"CAD/BIM should be improved in architecture education by incorporating them into the curriculum at an early stage say from 100 level so students understand how the software work. Manual drafting and CAD/BIM should go hand in hand to get better results".

Suggestions also focused on quality of teachers, teaching and training. While this suggestion looks straight forward, solutions may not be as simple as students envision largely because of the general lack of available experts in the use of BIM in the NCI (Abubakar et al., 2013). Awareness of the full capabilities is low even among construction professionals (Ryal-Net and Kaduma, 2015). Comprehensive training in the use of such tools also involves knowledge of teamwork and construction management, which in architecture education at ABU is largely completed in the final year. Consequently, implementing the framework proposed by Mandhar and Mandhar (2013) may only be possible at the last stage of undergraduate studies or at Masters level in collaboration with teams from allied programs in the faculty notably Quantity Surveying, Building, Urban and Regional Planning as well as Geomatics. Notwithstanding, students advised that the department should do the followings:

"Allow only truly qualified lecturers who are passionate about CAD/BIM to lecture students on the subject. Impartation is much easier, fluid and fun to teach and learn."

"Improve method of teaching".

"Provide adequate training materials along with competent trainers".

Interestingly, while previous feedback suggests that the architecture curriculum is overloaded (ranked eighth, Table 2), students suggest incorporating and adding more CAD/BIM related courses to the curriculum, inferring that students may not view learning CAD/BIM as being burdensome.

"The department should provide more courses to help students learn CAD/BIM"

"Workshops and seminars should be carried out to provide more awareness into the collaborative and integrative capabilities of BIM"

"CAD/BIM courses should be added to the curriculum".

"Extra classes should be organized for intensive training".

This theme was closely followed by suggestions for a wider variety of CAD/BIM tools and provision for software installations, better computers and improved internet connectivity.

"Students should be taught advanced tools like 3dmax, Maya etc not just the basic tools like AutoCAD, Sketchup or Revit."

"Software installation could be done for students/users on first contact"

"At least two different CAD/BIM software e.g. Revit/ Sketchup should be taught to undergraduate students plus an additional rendering software e.g. Lumion, Vray e.t.c."

5. Conclusions and Recommendations

This paper aimed to establish current barriers and challenges students face in the effective implementation of CAD/BIM in architecture education at a Nigerian university. The study also sought the opinion of the students regarding modalities to overcome challenges identified. Results revealed that the most pressing barriers were largely due to government and institutional related factors. Specifically, students rated high systems specification, high cost of computers, requirement for intensive training, inadequate incorporation within the curriculum, poor power supply, time to master skills as well as the lack of clear standards in the AEC industry as important challenges facing effective adoption of BIM. Similar challenges have been proffered in practice from literature, as most of these are government and institution dependent and heavily influenced by policies at national level or within individual institutions. Suggestions from students target institutionally based modifications notably incorporation of CAD/BIM for all courses and design, improvement of the quality of trainers as well as availability of updated software and better internet connectivity.

Recommendations target both government and institutional barriers. For government barriers specifically effective integration into the curriculum high cost of computers and provision of support infrastructure:

First, it is important that a BIM national policy be made clear in the country as this influences how it is taught in various schools of architecture in Nigeria. This has been advocated in literature and well overdue for implementation (Abubakar, Ibrahim and Bala, 2013). This is better projected through various professional bodies in the NCI as CAD/BIM use is directly within the spheres of influence of government agencies that regulate activities, policies and licensing of built environment professionals. Additionally, agencies such as Architects' Registration Council of Nigeria (ARCON), Quantity Surveyors Registration Board of Nigeria (QSRBN), Council of Registered Builders in Nigeria (CORBON), Town Planners Registration Council of Nigeria (TOPREC) as well as Council for the Regulation of Engineering in Nigeria (COREN) link academia and professional practice to government legislations and are thus better positioned to champion such a cause. Further research on how CAD/BIM is currently employed across academia and professional practice within the Nigerian built environment should be sponsored by such agencies.

Secondly, research and grants targeting local fabrication and assembling of computer systems that support CAD/BIM should be encouraged by government policies in Nigeria. This will not only provide employment for many aspiring entrepreneurs but reduce importation and cut down the cost of hardware and systems requirements. These barriers were ranked first and second from findings of this study.

Thirdly, the issue of funding to universities to augment power and ICT connectivity is paramount in Nigerian public universities as these were ranked fifth and eighth respectively. Power supply has been a recurrent factor mitigating the growth of the educational sector in the country. This finding supports recent revelations by the Vice Chancellor of Ahmadu Bello University that funding, especially to augment power supply was inadequate for the institution (Alabelewe, 2017).

Specific recommendations targeting CAD/BIM courses in the study area to improve integration within the curriculum and quality of training include the following:

- CAD/BIM use should be encouraged from undergraduate level design projects with a proviso after detailed manually produced presentation drawings have been completed and approved by the academic staff and studio mentors. Basic modelling of simple forms need be integrated with design studio sessions as students find it easier to link specific tutorials to design tasks at hand. CAD software such as SketchUp should be introduced at the beginning of ADS in 200L relating to studio exercises for the week.

- The department needs to consider the use of taking up studio sessions for an entire day instead of breaking it up into four-hour daily sessions, as is currently the practice. Such an arrangement is likely to afford time for specific CAD/BIM seminars relating to the studio exercise for that day to be presented at the beginning of the class, in line with suggestions from students.

- CAD/BIM need to be incorporated within lectures for design related courses notably Building Construction, Environmental Science/Building Climatology, Site Planning, Interior design, Building Services and Maintenance offered from 200-400L. Integrating the use of CAD/BIM tools for presentations, assignments and assessment will create avenues for students to be proactive and proficient in learning the tools in preparation for the world of professional practice.

- Teamwork and collaboration through competitions involving allied professionals in the built environment should be encouraged. A few of such design competitions have been successfully hosted in the last sessions, mostly at the request of professional bodies notably the Nigerian Institute of Structural Engineers. This can be incorporated into the final year (400L) design studio and will go a long way into creating proactive CAD/BIM proficiency among graduates, produce better qualified future professionals who can train others effectively as well as to reverse the fragmented trend of BIM use in the NCI (Odeyale, Olalekan, Kayode, & Abraham, 2016).

- ADS at Master's level should incorporate input from other allied disciplines using BIM such as cost/estimation as well as sustainability and energy studies in future. This will encourage students to explore the other neglected aspects of BIM within the curricula.

- The department needs to pursue a CAD/BIM proficiency policy in future recruitment exercises as practiced by some institutions (Joannides, Olbina and Issa, 2012) to address the issue of quality of training staff.

6. Areas for further research

A limitation of this study was the use of one department of architecture in Nigeria. Further study on modalities on how best to contextualize the framework is required for Nigerian schools offering architecture. It is also important that more studies regarding the integration of BIM into the curriculum be conducted in various Nigerian schools of architecture with the aim of capturing contextual peculiarities of local curricula, as what is advocated globally may not be properly implementable in every context.

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