A QUEST NEEDS FOR BUILDING INFORMATION MODELLING TOOLS TRAINING IN A DEVELOPING NATION

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Abstract. Computer Aided Design software and their kind are generally considered as Building Information Modelling (BIM) tools; moreover, the sophistication level of one in use may determine the BIM maturity level. Education and research are the backgrounds to innovation while training is a window to continuity in skills transfer. The experts are evolving from the industry professionals who are first trained in the Universities. This study determined how ready Nigerian Universities are to providing trained (on BIM tools) graduates for BIM adoption. A questionnaire survey was used; 59 structured questionnaires were distributed out of which 39 were successfully retrieved and analysed by descriptive statistics. The study revealed a significant correlation between the output (BIM skilled graduates) and the required software as well as trained tutors. The institutions are found to be physically ready with relatively sufficient hardware, however technically not ready! Due to lack of training software and skilled BIM tutors. More than three-quarter of the students are graduating on 'file-based collaboration' – 2D and 3D CAD knowledge with proficiency level between limited and practical application. However, the collaborative software training received proficiency level from basic to practical application with just 13% receiving training on the collaboration software, therefore contributing very little to the industry. Thus, this reveals a setback in the BIM tools training to carter for BIM uptake.

Keywords: BIM adoption, BIM tools, CAD training, Nigerian universities, proficiency level.

1. Background

Since the beginning of Computer Aided Design (CAD) in the 1960s, technologies continued to evolve, changing from Computer Assisted Drawing to Computer Aided Design. CAD technologies development is driven by the industries' applications (particularly, manufacturing) but research still remains the basis. Major manufacturing companies solemnly backed the development of CAD systems at its early stage (Ye et al. 2004). Regardless of how the CAD technology and the industry evolve, students in universities want to acquire technologies that can best aid their career; also improve their employability (Eadie et al 2014).

Its apparently difficult to providing necessary needs to include Building Information Modelling (BIM) training in university education, at the same time it is the right step to preparing the future employees (built professionals) for the industry (Construction, 2008). Educational institutions – their training, played a key role in BIM transition (Javaja and Salin, 2014). This may be seen as one of the reasons for US's high rate of BIM adoption; they are ahead of every order country (Construction 2014).

The 2007 BIMForum survey of eight US academic institutions on their level of BIM training reveals that more than 80% of them teaches BIM in their courses, and even the minority (<20%) had introduced BIM in their teaching curricula since 2002 (Barison and Santos, 2010). This may have helped the US Architecture Engineering and Construction (AEC) industry to be at the forefront of BIM adoption and also the widespread of BIM concept even before the government legislated on it (Construction, 2014).

However, developing nations are lagging behind in BIM awareness, adoption and BIM experts (Eadie et al., 2013; Froise and Shakantu, 2014); could that be due to a shortage of knowledge? Thus, lack of BIM tools training poses a great challenge to adopting BIM in developing countries. It is generally accepted that institutions offered a wide range of professional knowledge, while students are expected to enhance their knowledge in some or specific areas (Dankwort et al, 2004).

Universities in Nigeria are regulated by an agency "National University Commission (NUC)" under a body of Federal Ministry of Education (FME). The NUC was established in 1962 as an advisory agency in the Cabinet Office. However, in 1974, it became a statutory body under the FME. The commission has four main functions as follows:

- Granting approval for all academic programmes run in Nigerian universities;
- Granting approval for the establishment of all higher educational institutions offering degree programmes in Nigerian universities;
- Ensure quality assurance of all academic programmes offered in Nigerian universities; and

- Channel for all external support to the Nigerian universities

In 2017, there were no more than forty-one approved (accredited) engineering schools in the country where civil, electrical and mechanical engineering courses are taught, and not more than twenty-nine accredited architectural schools out of which only six of the universities do not offer the above engineering courses (NUC, 2017). NUC also benchmarked the student capacity for every course based on the accreditation result (based on manpower and infrastructural capacity).

Although NUC accredits universities and the respective courses; but courses curricula modifications generally come or initiated by departments/institutions. Curricula in Nigerian universities are generally dated, many of which were since the development of the courses, Architecture is one of those that follow this trend "…teaching of architecture as a course of study in a Nigerian university dates back to the 1960s'. Although slight changes were being effected in the ensuing years, the curriculum on architectural education has largely remained the same" (Ogunrayewa 2013, pp.8).

BIM is the latest development in the AEC industry, a paradigm that is changing the industry very fast. This concept would be fully understood and realised while integrated into the AEC courses in preparing the future employees of the industry.

This study aims to investigate the ability of Nigerian universities in providing BIM tools training against BIM adoption in the AEC industry through an assessment of institutions infrastructure (hardware and software); skilled/manpower capacity; as well as level and proficiency of CAD(s) training offer to graduates of the built environment and engineering schools.

2. Literature Review

2.1. GENERAL CAD KNOWLEDGE AND IMPACT

The survey carried out by Ye et al. (2004) shows that all CAD users have some knowledge of computer hardware; however it is necessary for them to be hardware experts, therefore it could be helpful to acquire the fundamentals. Moreover, CAD users do not need to have any programming skill and knowledge. CAD knowledge is more of practical and application altogether, but many times taught in a conventional way of teaching computer science. A survey carried out by Ye et al (2004) reveals that over 70% of the participants think that CAD should have been taught more especially in terms of physical training and application development.

In the US, the population of their practising engineers was more than one million thirteen years ago; over the years, computers have played a significant role in their day to day jobs, their CAD usage varies from lowest of “not at all” to being “highly dependent” (Field 2004). Moreover, CAD innovation found its way not only into industries but also into higher institutions in different ways and taught in different disciplines for different applicability and focus (Ye et al. 2004). CAD technologies may be taught explicitly as a tool for design, drawing and drafting in architecture and engineering disciplines; and this is now becoming very obvious in the US (Abbas et al, 2016).

It was revealed that the BIM training or modules offered to undergraduate students in Nigerian universities generally rotates within the introduction to computer science I and II, computer programming I and II, introduction to CAD, computer in architecture and AutoCAD (Ogunsote et al 2007). Hence, the study proposes additional modules (see Table 1) across the years of studies for architectural schools. However, Oladele (2009) recommends curriculum review but focusing on preservation of socio-cultural backgrounds, to respond to societal needs while adopting the global principles (i.e. innovations) where necessary. This recommendation is very near to Wu and Issa (2014) study where integrating BIM into the conventional modules is recommended.

TABLE 1. The proposed curriculum for Nigerian Schools of Architecture (Ogunsote et al 2007).

Level	1st Semester	2nd Semester
100	Introduction to Basic Computing	Computer Graphics in Architecture
200	Introduction to CAD	Integration into 200L Studio Project Elective
300	Introduction to 2D CAD for Architecture	Integration into 300L Studio Project Elective
400	Introduction to 3D CAD for Architecture	Integration into 400L Studio Project/ITF Elective
500	Visualisation and Animation in Architecture	Integration into final year project

Moreover, electives modules were also recommended to enhance proficiency in specific software, these include:
- Mastering CorelDraw
- Mastering Microsoft Publisher
- Introduction to AutoCAD
- Advanced AutoCAD
- Introduction to ArchiCAD
- Advanced ArchiCAD
- Mastering 3D Studio Max

On the other hand, engineering students suffered the most. The curricular of engineering programmes in Nigerian universities consist mainly of the fundamental knowledge of mathematics, natural sciences and technology. This fundamental knowledge is good and very necessary to acquire the basics for understanding engineering problem, but it does not end at the fundamentals (Onwuka 2009). The signals/feedbacks (i.e. not fit and confident to work in the industry) received from employers of engineering graduates is an evidence of lack or inadequate engineering applications in their educational curriculum. Very little trace of that can be noticed in the engineering courses curriculum; such as structured programming, elements of architecture as well as computer methods in civil engineering (computer application in the design of structures) for the civil engineering discipline.

There is very limited literature to establish a BIM training in the engineering schools of Nigerian universities, "Accreditation of Engineering and Architectural Education in Nigeria: the way forward" by Agboola and Elinwa (2013) is a clear evidence. Moreover, Onungwa and Uduma-Olugu (2017) study reveal lack of incorporating BIM education in Nigerian universities amongst major barriers to adopting BIM in the country.

2.2. BIM TOOLS TRAINING AND WHY

A better but expensive way of CAD training is a practical course (face-to-face) with guidance by an instructor (Dankwort et al. 2004). Subsequently, several advantages can be deriving from a practical course, such as direct feedback, direct interaction and curiosity by students to learn more. However, graduates with little knowledge of application packages are typically facing challenges in trying to get absorbed into the industry. Although, the challenges are determined by the size of a company: generally it can be said that the bigger or the more specialised a company is, the more tailored CAD training is.

Design methods and procedures are generally taught in universities, and the fundamentals are also included; however, the CAD technological aspect is missing and needs to be included (Dankwort et al. 2004). Moreover, "design knowledge" is generally taught completely in universities and because in the future practice companies' special necessities are diverse.

The procedure and methods used for design in the industry are never adopted as a formal method as being taught in universities. Companies consider it highly beneficial if students were taught possibly in more than one of the standard systems; it is also important that students would have worked with sequences of a CAD systems (for modelling, designing and data exchange) from university (Dankwort et al. 2004).

From the inception of CAD, manufacturing industries have been the heavy users of the CAD; it was initially known as “Design Augmented by Computers” at General Motors to stress the design being done by human and computation by computers (Field 2004). Construction (2008) associated slow adoption of BIM in the industry with lack of proper training. However, there is significant progress by architectural technology schools who are leading the inclusion of BIM to their educational curriculum. Although, the engineering and construction schools are now following the suit considering the number of universities (especially in the US) integrating BIM into construction management courses.

The United States (US) and Europe are actively implementing BIM education (Tang et al, 2015). In 2006, the US mandated BIM in public building service at design stage (Zeiss G., 2013); UK mandated level 2 BIM by 2016 in the year 2011; Norway 2007-2010; Finland 2007; Hong Kong 2014; South Korea 2016 and Netherlands 2012. Therefore, the AEC industry has huge market demand for a trained graduate in BIM. Two years after the UK’s BIM level 2 mandate was released, Eadie et al (2013) reported that lack of BIM experts ranked as the top reason for slow adoption of BIM in the UK. Tang et al (2015) equally reported an insufficiently trained staff on BIM with a growing demand of the BIM experts in the Chinese AEC industry.

The 2015 survey on Beijing and London MEP international firms reveal very low training from institutions (with only 19% learned BIM from college) while those that were not trained from institutions find it difficult and very difficult to acquire the BIM tools skills.

It can be realised that amongst those that played a key role in BIM transition is the educational institutions (Javaja and Salin, 2014) - training. This may be seen as one of the reasons for the US’s high rate of BIM adoption; they are ahead of every order country (Construction 2014). There is a good start of BIM education implementation across institution around the world and this can be noticed mostly from the US. To mention but a few with: Penn State University (PSU), Montana State University (MSU), Kent State University (KSU), California State University, University of Florida, Metropolia University of Applied Sciences Finland, Dublin School of Architecture Ireland and University of Nottingham Ningbo China (Tang et al 2015). And here are some few case study universities: Auburn University, the University of Arkansas at Little, Philadelphia University, University of Washington, University of Southern California and Purdue University (Abbas et al, 2016). Abdirad and Dossick (2016) review on integrating BIM education in higher institutions established that most investigations in this area comes from the US and typically as conference papers; forty-four out of fifty-nine reviewed papers published between 2007 and 2014 happened to be from the US and mostly case study bases. This indicated a significant commitment to integrating BIM education in the country's higher institutions and also vindicates the country of having the highest BIM adopters in the industry.

Considering investment cost associated with adopting BIM in AEC industry (Migilinska et al, 2013), educational institutions may also find it costly to integrate BIM training in the AEC courses. Developing training on BIM stage 1 and stage 2 could be a bit easier and cheaper compared to the stage 3 (integration); as the stage 1 and 2 are achievable using the basic BIM tools whose "educational versions" are within reach and are capable of modelling and collaborating (Autodesk, 2018). But inadequate awareness and lack of experienced BIM educators remained critical challenges (Hon et al 2015).

On a bit of leap, the developing nations are lagging behind in BIM awareness, adoption, and also lacking BIM experts (Froise and Shakantu 2014; Onungwa and Uduma-Olugu 2017); could that be knowledge shortfall? Lack of BIM software skills posed a great challenge to students that are graduating for over a decade. Several survey findings demonstrated discontent with curriculum development regarding BIM (in relation to technical advancement) by students and educators (Sabongi and Arch 2009; Sylvester and Dietrich 2010).

Introducing BIM module is also inspiring students regarding their career in the AEC industry, especially those interested in the industry practice (Tang et al 2015). Moreover, the BIM module should be taught more with encouragement to collaborate with other team members than the emphasis on the software skill (as it is in 2D CAD training).

There are two popular approaches to integrating BIM education in the higher institutions' curricula these are: introducing standalone courses/modules and integrating the BIM into the conventional study courses/modules (Wu and Issa 2014). But one of the essentials of adopting the BIM is "the collaborative working" therefore Pikas et al (2013) suggest the implementation of BIM education to be at programme level rather than isolated module or training. On the other hand, Eadie et al (2014) preferred "standalone module (combining theory and software) taught in multidisciplinary class" as the most appropriate delivery method. Although lecturers response reveal that BIM component in each course/module is an important opportunity to meeting the industry's needs.

Most of the findings regarding non-inclusion of BIM into the universities' curriculum (Sabongi and Arch 2009) are related to the following:

- No room in the current curriculum for additional classes
- Lack of time or resources for the faculty to develop a new curriculum
- Constraint to additional required or elective module and still graduate in eight semesters

- Unavailability of resources specifically on BIM for students' use.

The curriculum of architectural schools need to be reviewed to produce CAD proficient graduates; while lack of facilities and their maintenance for CAD training as well as funding were considered a major setback to CAD training in Nigerian universities (Ogunsote et al 2007; Ogunrayewa 2013). National Universities Commission (NUC) and the Architects Registration Council of Nigeria (ARCON) have guidelines for accreditation of architectural programmes, the prerequisites include having adequate physical infrastructure such as laboratory and studio, equipment of the laboratories and studios, classrooms and lecture theatres, equipment of the classrooms and lecture theatres, office accommodation as well as manpower of different qualifications and experiences (Ogunrayewa 2013). However, attention has not focused on the availability of software/CAD training connecting that to the industry's emerging or current challenges.

The students' inputs to the best way of incorporating BIM into their courses suggest the combination of both creations of standalone BIM that discusses varieties of BIM uses with emphases on the use of software; and additional modules to the existing ones to deliberate how the BIM is relevant to the subject/area of study (Clevenger et al 2010).

Rezgui et al (2010) concluded that the perspective of knowledge management adoption in AEC sector is creating adding value which is done through knowledge sharing. On the other hand, training and educational systems must also evolve in parallel with CAD development (Field 2004).

SUMMARY

To promote BIM-enable learning and to balance the student and the industry desires, integrating approaches could be the most effective way of delivering BIM education. Few disadvantages can be foreseen with any of the two popular approaches alone. The standalone BIM courses is a good idea to integrate the other disciplines (as team members), however creating a slot for additional courses might prove difficult as the curricula are filled up to accommodate additional courses (Sabongi and Arch, 2009). On the other hand, the BIM-embedded into the conventional courses may be considered easier; but may not necessarily achieve the intended collaboration and perhaps integration because multi-disciplinary training (with other departments as team members) may not be possible. Moreover, not all schools offer all the courses in context (i.e. Architecture and the Engineering courses).

3. Research Methodology

The purpose of the survey was to determine the level of BIM software/tools training received by students (from engineering and built environment schools) in Nigerian higher institutions of learning for BIM adoption in the Nigerian construction industry. The research is quantitative in nature and its approach is interpretative. The primary data for the investigation were obtained from tutors/lecturers in the Nigerian universities through a questionnaire survey. To avoid been bias, the respondents were chosen randomly from amongst higher institutions of learning in the country where civil, mechanical and electrical engineering as well as environmental courses are taught. A structured questionnaire was used to extract information based on the research question.

The multiple choice, close-ended questions were drafted and sent directly to individual's (lecturers) emails. The respondents were mainly from the following zones of the country: North-west, North-central and South-west in sliding order of quantity than with very few from North-east and South-east; therefore the result may not reflect the true picture of the entire country but most of its parts.

The surveys were prepared and sent electronically. A total of 54 emails were sent, out of which a total of 39 responses were collated which represents 72.2% response rate; very adequate for this study according to Ballantyne (2003). The responses were distributed based on professions considered in the industry; the responses received from building departments were 2 which represents 5.1%, architectural departments returned 10 (25.7%), land/quantity surveying departments returned 2 (5.1%) and engineering departments returned 25 (64.1%).

The questionnaires were randomly distributed across forty-one (41) universities where engineering courses (civil, electrical and mechanical) are taught inclusive of thirty-three (23) where architectural technology plus additional six (6) universities where only Architectural technology is taught. The questionnaire targeting tutors in those departments was prepared in 'google docs' where the link is distributed via emails obtained from various universities' websites.

The number of the targeted audience (considering at least a representative from each department) can be deduced as:

There are 41 no. of institutions accredited for the engineering courses (in context);

3 no. of engineering departments were considered (civil, electrical and mechanical);

29 no. school of Architectural technology

- (41x3) + 29 = 152 (departments) as an estimated sample size.

- 39/152 = 25.6% response, beyond 12% (liberal condition) according to Nulty (2008).

Out of the fifty-four (54) distributed questionnaires, thirty-nine (39) responses were received; this represents 72.2% response rate, hence considered adequate for validity and reliability (Rubin and Babbie, 2009, p117). And, satisfied both the 55% and 47% paper-based and online-based response rates respectively (Ballantyne, 2003).

The respondents were engaged to assess the institutions' hardware and software capacities; after which a proficiency level of training received by undergraduate students was also assessed. Basic and simple questions were asked considering the very low level of BIM awareness and knowledge within the institutions (Onungwa and Uduma-Olugu 2017) and the industry (Hamma-adama et al 2017) in general. The limited literature in this context can be noticed from the only citation (Agboola, and Elinwa 2013) reported in "a review of tertiary BIM education for advanced engineering communication with visualization" by Badrinath et al (2016).

4. ANALYSIS AND DISCUSSION

The analysis and findings from the generated data (via questionnaire) of this study are presented in this section.

The survey outcome reveals that 82.1% of the respondents are lecturers; while 17.9% are technicians and technologist (see Table 2). Over 70% of the lecturers are having qualifications ranging from M.Sc. to Ph.D., and fewer than 30% are first degree holders. More than 50% of the respondents are experienced tutors ranging from 5years to over 15years in the academia. The below chart (Figure 1) is representing respondents' academic qualifications.

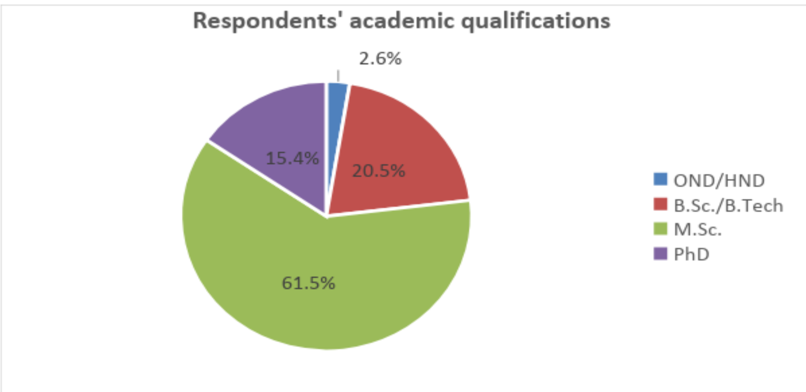

Figure 1. The respondents' academic qualifications

The below Table 3 illustrates the rates and the distribution of respondents: Architectural technology has recorded higher response rate at individual career level; this can be seen to be associated with a keen interest on the subject matter. Engineering departments constitute over 60% of the responses, perhaps because of the number of disciplines involved in the engineering profession (civil, electrical and mechanical), followed by architectural technology (25.7%) and the remaining contributed 10.2%. However, when individual courses (splitting engineering to the three branches) are considered, architectural technology can be measured as first in the succession.

TABLE 2. Demographic Profile of Respondents (N=39)

		n	*%*
Respondent affiliation	Architecture	10	25.60
	Building	2	5.10
	Engineering	25	64.10
	Land Surveying	1	2.60
	Quantity Surveyor	1	2.60
Cadre	Lecturer	32	82.10
	Technologist	7	17.90

4.1 SURVEY FINDINGS

A reliability analysis was carried on the data with the aid of SPSS V21. This is done to determine whether the instrument do measure the same construct. The Table 3 below presents the reliability analysis of the hardware and software capabilities as well as the level training offered with the available resources.

TABLE 3. Instrument Reliability Test

Instrument	Scale Statistics					Reliability Statistics	Validity Statistics	
Source	No. of Items	No. of Samples	Mean	SD	CV	Cronbach's Alpha	F-value	P-value
Impact of Hardware and Software on BIM Tools Training	3	39	10.5	4.74	0.156	.910	20.453	0.000
Input-Output Training on BIM Tools	2	39	5.150	2.581	0.012	.949	41.632	0.000

The response reliability test was carried out by means of a standardised Cronbach's Alpha which .910 and .949 were obtained regarding hardware and software impact, and input-output on BIM tools training respectively. These suggest that the evaluating instrument is very reliable as they (.910 and .949) are more than the threshold value (.500 for items <10 or .700 for items >9). Moreover, the 0.156 and 0.012 coefficient of variation (CV) justified the homogeneity in the response rating by the respondents.

It is also revealed that the test is significant at F-values equal to 20.453 and 41.632, and P-values <0.05. Therefore, the instrument is adequate since there no significant variation on the items' rating.

TABLE 4. Correlations

		Proficiency at graduation	**Number of computers**	**Highest software for training**	**Training proficiency**
Pearson Correlation	Proficiency at graduation	1.000	.556	.649	.903
	Number of computers	.556	1.000	.742	.659
	Highest software for training	.649	.742	1.000	.804
	Training proficiency	.903	.659	.804	1.000
Sig. (1-tailed)	Proficiency at graduation	.	.000	.000	.000
	Number of computers	.000	.	.000	.000
	Highest software for training	.000	.000	.	.000
	Training proficiency	.000	.000	.000	.
N	Proficiency at graduation	39	39	39	39
	Number of computers	39	39	39	39
	Highest software for training	39	39	39	39
	Training proficiency	39	39	39	39

Table 4 above presents the correlations between the final outcome as a dependent variable (proficiency of training at graduation) and three independent variables (no. of computers, training software and training proficiency – input). The result indicated a significant correction between each independent variable with the dependent variable. The significance appeared in ascending order; no. of computers, available software for training and training proficiency with corresponding values of .556, .649 and .903 respectively. The significance level of each indicates its level of influence to achieving higher level of proficiency. To quantify the level of influence by these independent variables, a regression analysis is then carried out.

Table 5 below presents the model summary of the analysis. The regression is <0.001 which is very significance; and the R Square is 0.833 which is greater the lower limit of 0.300. This indicated that there is 83.3% variance in the dependent variable with respect to independent variable.

TABLE 5. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.913[a]	.833	.818	.576	.833	58.082	3	35	.000

a. Predictors: (Constant), Training proficiency, Number of computers, Highest software for training
b. Dependent Variable: Proficiency at graduation

Subsequently Analysis of Variance was carried out; the result summary is also presented in Table 6 below. With Sig.<0.05, null hypothesis is rejected and this confirmed that it's statistically significance that the independent variables influenced the dependent variable. Therefore, the regression expression comes to F (3, 35) = 58.082.

TABLE 6. Analysis of Variance (ANOVA)

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	57.822	3	19.274	58.082	.000[b]
	Residual	11.614	35	.332		
	Total	69.436	38			

a. Dependent Variable: Proficiency at graduation
b. Predictors: (Constant), Training proficiency, Number of computers, Highest software for training

To establish the training capacity, it was discovered that 76.9% of the institutions are having relatively adequate computer laboratories as represented in the pie chart (Figure 2) below. And 56.7% of the schools have more than thirty (30) PCs in their respective laboratories (Figure 3) but only 20% happened to have collaboration software in their PCs (Figure 5); while only 13.3% of the students are enrolled for such software training.

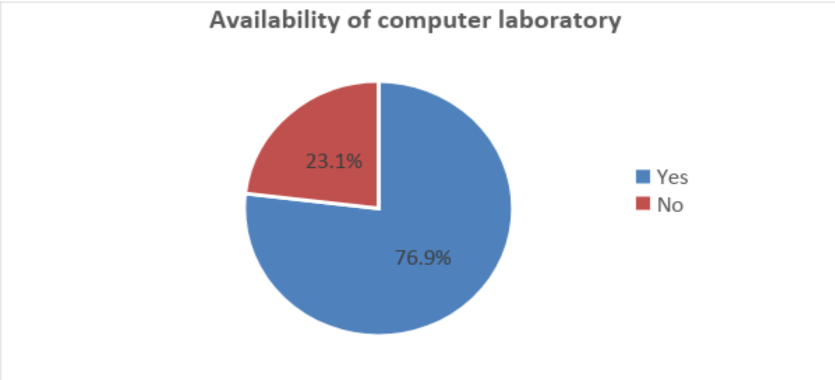

Figure 2. Availability of computer laboratory in the subject department

With over 50% of departments of architectures/ surveying and engineering having more than 30 computers for students training, a considerable number of schools can be considered to have relatively enough computers for the training as indicated in the bar chart (figure 3) below.

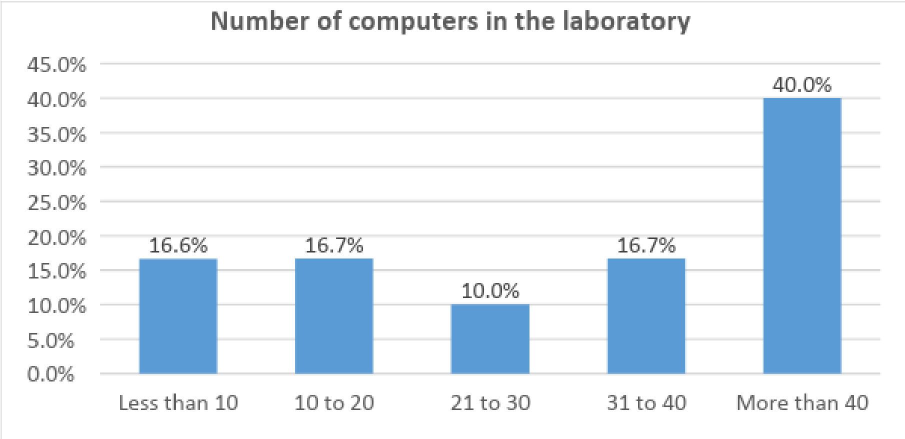

Figure 3. The quantitative capacity of the computer laboratories

4.2 PROFICIENCY OF APPLICATION SOFTWARE TRAINING

From Figure 4 below, it can be observed that the intermediate, fundamental awareness, as well as the novice are toping the proficiency level of training offered to students; however, higher percentages of a deficit can be noticed at fundamental and intermediate levels (the yield is lower than the efforts). Hence students receiving intermediate and fundamental awareness level of training are having output challenge where the outputs are less than the inputs (43.3% to 33.3% and 36.7% to 30% consecutively). However, the novice, advanced and expert got outputs greater than inputs (16.7% to 23.3%, 3.3% to 6.7% and 0% to 3.3%); hence these indicated the possibility of some trained students advancing their proficiency level; these positivity has been noticed to be associated with the type of software available (advanced software) and the student computer ratio.

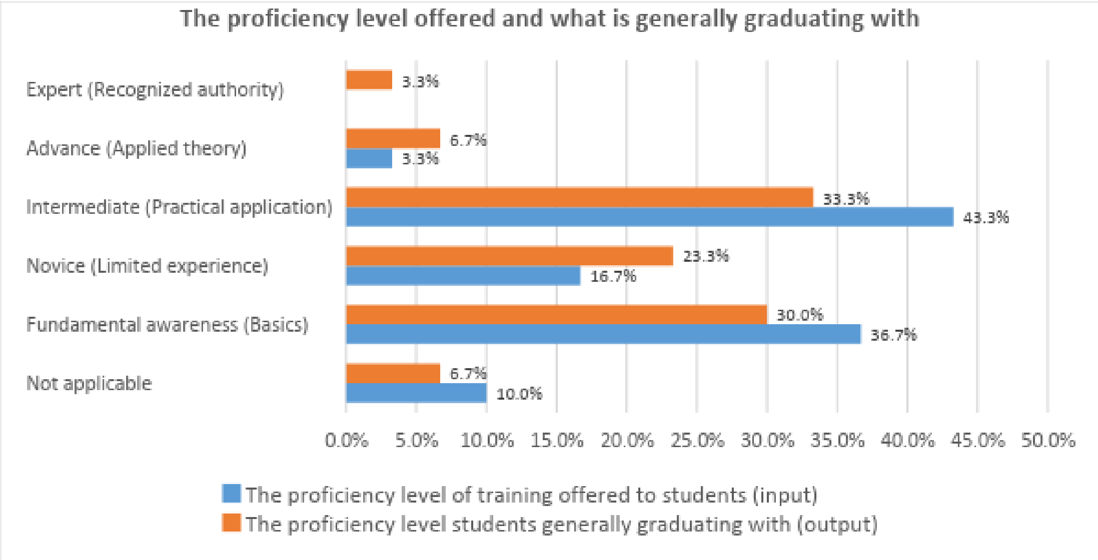

Figure 4. Proficiency level offered and what is generally graduating with

The 2D CAD can be seen to be a basic tool to all the institutions offering application software packages training to students. Not more than 73.3% are receiving training on 2D CAD basics up to the application level. For the 3D CAD training, everyone trained on 3D CAD is equally trained on 2D CAD as well; means those trained on 3D CAD are a subset of those trained on 2D CAD.

Succinctly, most students are graduating on 2D CAD knowledge acquiring limited and basic knowledge. Although, over half of the schools (53.3%) have 3D CAD software which is normally incorporated with the 2D CAD, but only 36.7% uses the 3D CAD – quite below average compared to the 2D CAD. On the other hand, 20% of the institutions were observed to having the collaboration software (Revit Arch, Struct, MEP) however, only 13.3% enrol students for the software training; perhaps due to skill shortage. Find below a chart (Figure 5) presenting variations in the software availability and usage.

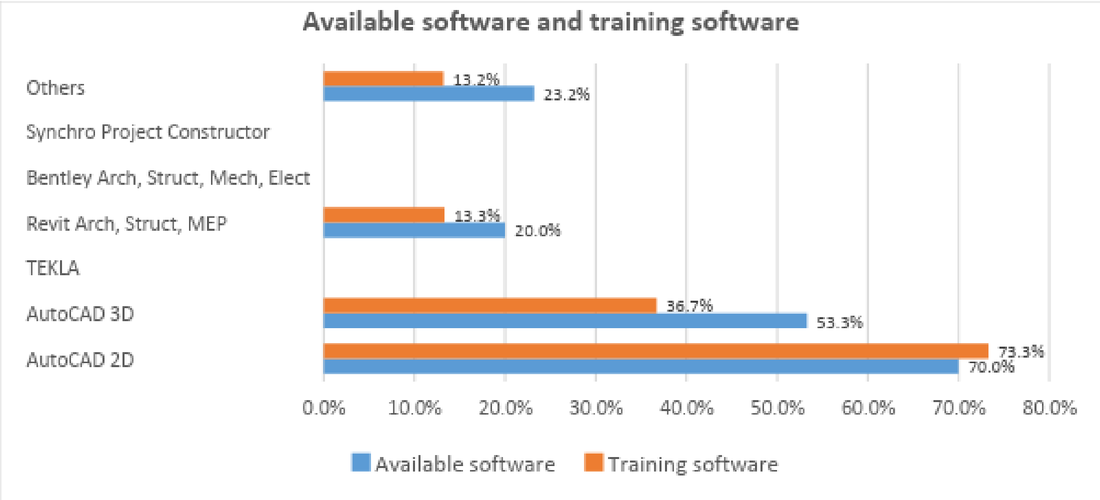

Figure 5. The available software packages and the training software

5. Conclusion

This piece of work aimed to: investigate the ability of Nigerian universities in providing BIM tools training against BIM adoption in the AEC industry through an assessment of institutions infrastructure (hardware and software); skilled/manpower capacity; as well as level and proficiency of CAD(s) training offer to graduates of the built environment and engineering schools. Architectural technology has a keen interest in the subject matter. In the same vein, more than 50% of the collaboration software is acquired by architectural technology schools. Hence, architectural technology schools are at the forefront of CAD training. Considering most institutions having relatively sufficient hardware (personal computers), the institutions can be considered physically ready to offer BIM tools training, however technically not ready, because collaboration software are virtually unavailable as well as intensive training in that regard. Moreover, there is an indication of a serious shortage of skilled tutors in BIM, because those having the collaboration software are not effectively utilising them. And this vindicated the literature (Onungwa and Uduma-Olugu 2017). There is significant connection between the availability of hardware and software, level of training provided and the skills acquired at graduation in BIM tools. The more hardware and software are supplied, provided that there are trained tutors, the more and higher skilled graduates are produced.

Most of the graduates are generally trained on ‘file-based collaboration’ – 2D and 3D CAD. A clear setback can be noticed at institutional level regarding training on collaborative working because there is no indication of collaborative design (with some of the team members). Although the proficiency level received at graduation mainly ranges from basic to practical application. On the other hand, the higher the software sophistication, the higher the proficiency level of training received and acquired by students. With 13.3% collaboration software training across the institutions mostly architectural schools, then the institution has very little to contribute to the industry. Succinctly, the level and type of training received by the students in the subject have indicated a high possibility of a shortage in BIM skilled graduate ahead of BIM adoption or collaborative working in the Nigerian construction industry. Therefore, the adoption rate is likely to be low due to a continuous shortage of trained graduates on BIM tools.

Acknowledgements

Considering this as a component of a PhD work, the authors of this paper would like to thank the Petroleum Technology Development Fund (PTDF) for sponsorship of the main research.

References

ABBAS, A., DIN, Z.U. and FAROOQUI, R., 2016. Integration of BIM in construction management education: an overview of Pakistani Engineering universities. Procedia Engineering, 145, pp. 151-157

ABDIRAD, H. and DOSSICK, C.S., 2016. BIM curriculum design in architecture, engineering, and construction education: a systematic review. Journal of Information Technology in Construction (ITcon), 21(17), pp. 250-271

AZHAR, S., 2011. Building information modeling (BIM): Trends, benefits, risks, and challenges for the AEC industry. Leadership and management in engineering, 11(3), pp. 241-252

BALLANTYNE, C., 2003. Measuring quality units: considerations in choosing mandatory questions. Evaluations and Assessment Conference: A Commitment to Quality, University of South Australia, Adelaide. pp. 24-25

BARISON, M.B. and SANTOS, E.T., 2010. BIM teaching strategies: an overview of the current approaches. Proc., ICCCBE 2010 international conference on computing in civil and building engineering.

CONSTRUCTION, M.H., 2014. The Business Value of BIM for Construction in Major Global Markets: How contractors around the world are driving innovations with Building Information Modelling. Smart MarketReport,

CONSTRUCTION, M., 2008. Smart Market Report: Building Information Modeling (BIM)—Transforming Design and Construction to Achieve Greater Industry Productivity. The McGraw-Hill Companies, New York.ISBN,

DANKWORT, C.W. et al., 2004. Engineers' CAx education—it's not only CAD. Computer-Aided Design, 36(14), pp. 1439-1450

EADIE, R. et al., 2013. BIM implementation throughout the UK construction project lifecycle: An analysis. Automation in Construction, 36, pp. 145-151

EADIE, R., COMISKEY, D. and MCKANE, M., 2014. Teaching BIM in a multidisciplinary department. Proceeding of Education, Science and Innovations,

ELINWA, U.K. and AGBOOLA, O.P., 2013. Beyond BIM–A Classroom Approach To Virtual Design Education. Procedia-Social and Behavioral Sciences, 83, pp. 393-397

FIELD, D.A., 2004. Education and training for CAD in the auto industry. Computer-Aided Design, 36(14), pp. 1431-1437

FROISE, T. and SHAKANTU, W., 2014. Diffusion of innovations: an assessment of building information modelling uptake trends in South Africa. Journal of Construction Project Management and Innovation, 4(2), pp. 895-911

HAMMA-ADAMA, M., SALMAN, H.S. and KOUIDER, T., 2018. Diffusion of innovations: the status of building information modelling uptake in Nigeria. Journal of Scientific Research & Reports, 17(4), pp. 1-12

HON, C.K., UTIOME, E., DROGEMULLER, R., OWEN, R.L., NEPAL, M.P., GRAY, J. and COFFEY, V., 2015. Gearing up academics for collaborative Building Information Modelling (BIM) education. Proceedings International Conference on Innovative Production and Construction 2015 (IPC 2015). IPC2015 Organizing Committee. pp. 23-26

MIGILINSKAS, D. et al., 2013. The benefits, obstacles and problems of practical BIM implementation. Procedia Engineering, 57, pp. 767-774

NUC, National university commission. [Online] Abuja, Nigeria: NUC. Available from: http://nuc.edu.ng/about-us/ [Accessed 03/23 2018]

NULTY, D.D., 2008. The adequacy of response rates to online and paper surveys: what can be done? Assessment & evaluation in higher education, 33(3), pp. 301-314

OGUNRAYEWA, M.O., 2013. New Trends in Architectural Curriculum Development–A Panacea for Sustainable Architectural Education in Nigeria. Journal of the Association of Architectural Educators (AARCHES-J), 1, pp. 3-8

OGUNSOTE, O.O., PRUCNAL-OGUNSOTE, B. and UMARU, N.A., 2007. Curricular Anatomy of the CAD Proficient Architecture Graduate in Nigeria. Journal of the Association of Architectural Educators in Nigeria (AARCHESJ), 6 (1), 99, 109

OLADELE, M., 2009. The Socio-Cultural Relevance of Architectural Education in Nigeria in a Global Age. AARCHES Journal, 8(1), pp. 14-22

ONUNGWA, I.O. and UDUMA-OLUGU, N., 2017. Building Information Modelling and Collaboration in the Nigerian Construction Industry. Journal of Construction Business and Management, 1(2), pp. 1-10

ONWUKA, E., 2009. Reshaping engineering education curriculum to accommodate the current needs of Nigeria. Educational Research and Reviews, 4(7), pp. 334-339

PIKAS, E., SACKS, R. and HAZZAN, O., 2013. Building information modeling education for construction engineering and management. II: Procedures and implementation case study. Journal of Construction Engineering and Management, 139(11), pp. 05013002

REZGUI, Y., HOPFE, C.J. and VORAKULPIPAT, C., 2010. Generations of knowledge management in the architecture, engineering and construction industry: An evolutionary perspective. Advanced Engineering Informatics, 24(2), pp. 219-228

SABONGI, F.J. and ARCH, M., 2009. The Integration of BIM in the Undergraduate Curriculum: an analysis of undergraduate courses. Proceedings of the 45th ASC Annual Conference. The Associated Schools of Construction. pp. 1-4

SUWAL, S., JÄVÄJÄ, P. and SALIN, J., 2014. BIM Education: Implementing and Reviewing" OpeBIM"—BIM for Teachers. Computing in Civil and Building Engineering (2014). pp. 2151-2158

SYLVESTER, K.E. and DIETRICH, C., 2010. Evaluation of building information modeling (BIM) estimating methods in construction education. Proceedings of 46th ASC Annual International Conference, April. pp. 7-10

TANG, L., JIN, R. and FANG, K., 2015. Launching the innovative BIM module for the architecture and built environment programme in China. Building information modelling (BIM) in design, construction and operations, 149, pp. 145

WU, W. and ISSA, R.R., 2013. BIM education and recruiting: Survey-based comparative analysis of issues, perceptions, and collaboration opportunities. Journal of Professional Issues in Engineering Education and Practice, 140(2), pp. 04013014

YE, X. et al., 2004. Today's students, tomorrow's engineers: an industrial perspective on CAD education. Computer-Aided Design, 36(14), pp. 1451-1460

ZEISS, G., 2013. Widespread adoption of BIM by national governments. Accessed February, 28