# BIM Practice: Training and Education of Nigerian Quantity Surveyors in Preparation for BIM Adoption [1]

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## ABSTRACT

The disruptive nature of newly evolving innovations in the construction industry is largely unstoppable and would become inevitable with time. Though developed economies have taken proactive measures to ensure their industry is not relegated in the face of emerging technologies, there does not seem to be anything short of a reactive measure from the stakeholders of the Nigerian construction industry. Previous authors had proposed diverse solutions which include training and Education. However, there has been no in-depth analysis of the curriculum requirements of recent graduates from our institutions to provide the needed BIM technical know-how. The course contents of academic curricula of higher institutions offering quantity surveying at undergraduate level was examined to gauge the availability of training on BIM usage and practice. The study revealed that BIM training is non-existent in all the institutions of learning in Nigeria with just a University offering an introductory course. It is recommended that Nigerian AEC professional bodies and the academia actively engage in providing the basic training for BIM learning in the face of reluctant government support. This could be achieved through an introductory BIM course and stand-alone teaching modules for integration into a variety of core courses in the Nigerian built environment curricula.

**Keyword**: Adoption BIM, Education, Quantity Surveyors, Training,

## INTRODUCTION

BIM has been described as a set of policies and processes which are being enhanced by emerging technologies in producing newly improved construction methods and processes (Hamma-Adama & Kouider, 2018). While Nigerian stakeholders, are yet to fully grasp, adopt and utilize the innovations attributed to BIM, Hamma-Adama and Kouider (2018) opine that BIM has gone beyond a concept for building design and construction in advanced economies

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and has fully being integrated into large scale infrastructural design and construction processes. According to Opoko, Sholanke, Joel, Ciafas, Fakorede and Oyeyemi (2019) BIM started in the 1970s in Georgia Institute of Technology where the idea was developed and became generally accepted in design and construction management. With the introduction of "Building Information Modelling (Autodesk, 2013), BIM gained in popularity and global awareness and has since moved to achieving significant output in construction processes (Opoko et al, 2019).

BIM is highly imperative to the construction industry by contributing integrated project delivery (see Opoko et al 2019), collaborative work and good teamwork (Rokooei, 2017); proper and enhanced process scheduling (Malacarne, Giovanni, Carmen, Michael & Dominik, 2018). As stated by Hamma-Adama, and Kouider (2018), Education and research are the bedrock of innovation and to achieve skills transfer, training is inevitable. This puts education and training at the forefront in developing policies, processes and technical know-how for BIM impplementation and adoption.

## LITERATURE REVIEW

BIM, Building Information Modeling has been regarded as ever evolving in meaning and interpretations due to its inherent nature of reinventing processes and workflows (RICS, 2014). However, some attempts to define BIM states that it involves the "digital representation of physical and functional characteristics of a facility creating a shared knowledge resource for information about it forming a reliable basis for decisions during its life cycle, from earliest conception to demolition" (BIM Hub, 2014). While there have been mis-matched comparisons of BIM with software such as Revit, it is much more than a software but a concept that has been embedded in the development of BIM-based applications (Bashir, 2018; Makarfi & Abdullahi, 2016). Karen (2014) described "BIM as an integrated, structured digital database, informed by the architecture, engineering, and construction operations industry that consist of 3D parametric objects and allow for interoperability". While Azhar, Khalfan and Maqsood, (2012) opines that "BIM is an improved process and tool, which contains a set of virtual aspects, concepts and systems of a facility within one environment". BIM provides myriads of solution to the industry's problems of integrating construction processes and methods, addressing construction project development challenges achieving maximum productivity (Mohammed & Ahmad, 2017). BIM is not limited to just BIM-based softwares but has various layers of dimensions from 3D to nD – which involves dimensions such as 3D-visualization, 4D-scheduling, 5Destimation, 6D-facility management applications, and 7D-sustainability (Badrinath, Chang, & Hsieh, 2016).

## BIM in the Nigerian Construction Industry

The construction industry is a pivotal part of the economy of any Nation; therefore, it requires urgent attention when plagued by issues such as low productivity, lack of timely communication and coordination (Bashir, 2018). In sub-Saharan Africa, South Africa has been said to be the BIM leader of the continent even as it still battles procurement route in BIM adoption (Hamma-adama, Salman & Kouider, 2017; Kekana, Aigbavboa & Thwala, 2014). While the usage of existing software technology such as AutoCAd and Microsoft tools is largely rampant, it is primitive in comparison to the interoperability and centralized communication enhancement capabilities of BIM. Previous studies such as Fazli Fathi, Enferadi, Fazli and Fathi(2014); Al-btoush & Haroun (2017) have highlighted the needed edge BIM provides as involving functions such as enhancing construction output, improving the flow and centralization of communication processes on projects, reduced errors in design and conceptualization of ideas.

Discourse on BIM in Nigeria commenced lately in 2013 and focused on readiness of first line adopters (Consultants and designers); the study evaluated the lack of readiness as due to technological reasons or an absence of policy and process (Hamma-Adama & Kouider, 2018; Succar & Kassem, 2015). Furthermore, the slow pace of adoption has been attributed to the uniqueness of the industry in resisting changes, lack of training (Walasek & Barszcz, 2017), resistant of contractors to innovating and reinventing processes and methods (Hamma-Adama & Kouider, 2018; Succar & Kassem, 2015). While previous studies such as Abdullahi, Ibrahim, and Mohammed (2011); Abubakar et al. (2013); Abubakar, Ibrahim, Bala, and Kado (2014);Usman (2015); Isa (2015) and Bashir (2018) dwelt in examining the readiness and level of implementation on BIM in Nigeria, there has been no study of the existing curricula of institutions on BIM taught programmes. IF BIM is to be implemented and largely adopted, the academia is the bedrock of providing training and the required competencies and skills in this emerging technology.

## BIM Education and Training in the Nigerian Construction Industry

As stated by Hamma-Adama (2018), current education and training in institutions of learning is farfetched from the knowledge proficiency required to participate in BIM. Though Universities and Polytechnics mention 3D packages in their syllabus, the practical industry-based knowledge is not comprehensive and systematic. The use of computers is fairly inevitable in construction firms and consulting firms in current practice, it will not therefore be a totally strange and unfamiliar move if firms were to adopt BIM as it is just a reinvented process. While Ogunsote, Prucnal-Ogunsote and Umaru (2007) noted that the training modules offered to undergraduate in

Nigerian universities falls in between an introduction to computer science I and II, computer programming I and I, introduction to CAD, computer in architecture and AutoCAD (2007). To change the narrative of an education program unable to cater for emerging technologies, Oladele (2009) recommended a curriculum review with additional modules and which takes socio-cultural backgrounds into cognizance, however Dankwort, Weidlich, Guenther, and Blaurock (2004) recommended a practical course with physical interactions between the instructor/lecturer and student. Furthermore, Dankwort et al (2004) argued this would be more beneficial by availing a direct and immediate feedback system, one –on-one interaction and the opportunity to answer the student's questions.

Also, Clevenger, Ozbek, Glick, Porter, (2010); Hamma-Adama, et al (2018) argued that basic construction principles and concepts should be introduced and taught with new teaching modules in accordance with industry best practices. Barriers to a more BIM inclusive curriculum has been highlighted as cost of investment in new technologies (Migilinskas 2013), unavailability of resources on BIM for student's use, overloaded curricula and lack of resources for the institution to develop a new curriculum (Sabongi & Arch, 2009, Hamma-Adama et al, 2018). However these barriers have been overcome by institutions in developed economies; in the US, BIM tools education has been incorporated alongside the Universities curriculum (Clevengr et al, 2010), Hamma-Adama et al, 2018). These barriers are therefore not insurmountable by developing economies, strategizing on solutions to overcome the barriers is essential in building a bedrock of education and training on BIM. This is by extension imperative in developing a pool of technical expertise necessary for BIM practice in the construction industry (Froise & Shakantu, 2014).

Kymell (2008) identified factors that might hinder the adoption of BIM Education into curriculum as usage problems with the BIM software, inadequate understanding of the BIM process and inadequate curriculum development on BIM education. Though understanding is imperative to the right usage of BIM, it is impossible without the development of an instructive curriculum to train professionals on BIM usage.

**BIM Education Curriculum Framework**

Previous studies had divided BIM curriculum for quantity surveyors into four sections to incorporate; visualization, quantification, planning/scheduling, and management (Ali, Mustaffa, Keat, Enegbuma, 2015). While in South Korea, BIM adherents have created "eduBIM", the first self-learning private BIM education tool with an open BIM library embedded (Badrinath, et al, 2016). Also, Educationists in Singapore have developed a BIM education program which assesses and teaches BIM on three levels:

1. BIM modeling: This provides introductory lessons, modeling, processes and methods and data management.
2. BIM Coordination: This is carried out by educating students about collaboration, calculation, estimation and scheduling, sustainability and coordination
3. BIM Management: This is done by educating students about advanced modeling, technologies, management, and training (Hoang & Bedrick 2015).

## RESEARCH METHODOLOGY

In achieving the aims and objectives of this research study, the academic curricula of Universities offering quantity surveying was obtained and examined based on the knowledge and competencies areas as required by the Royal Institution of Chartered surveyors (RICS) pathway guide. Census sampling was used in gathering secondary data.

### Institutions Training Quantity Surveyors in Nigeria

Quantity surveying education and training is offered at both the undergraduate level and postgraduate degree level in Nigeria while the first degree is a requirement to practice; the advanced degree is not a requirement. According to Oke et al (2017), the Joint Admission board (JAMB) regulates entry of students in institutions in Nigeria and is responsible for providing guidelines and information regarding higher institutions in the country. Albeit, the Nigerian Universities Commission (NUC) conducts regulatory checks to approve and verify if universities have necessary intellectual facilities, equipment's and staff to offer the required competencies. Also, the Quantity surveyors registration board of Nigeria (QSRBN) performs similar function of approving the conduct or teaching of quantity surveying in Nigeria universities.

**Table 1: Institutions Training Quantity Surveyors in Nigeria.**

| Institutions | No. in Nigeria | No. training Qs | Sample frame |
|---|---|---|---|
| **Universities** | 146 | 22 | 22 |
| **Polytechnics** | 112 | 43 | 1 |
| **Total** | 258 | 65 | 23 |

**Source**: JAMB (2018)

As presented in table 1, Population for this study was gotten from the e-brochure of the Joint Admission and Matriculation Board (JAMB) for the 2017/2018 admission guidelines. There are 146 universities and 112 polytechnics in Nigeria. Only 22 universities offer quantity surveying while 43 polytechnics offer quantity surveying courses.

The National Board for Technical Education (NBTE) gives guidelines on the syllabus of polytechnics in Nigeria and therefore endears all polytechnics to use the same syllabus (Oke et al, 2019). Consequently, the number of curriculum sampled for the polytechnics was brought down from the 43 polytechnics offering quantity surveying to the syllabus of one polytechnic since they all use the same syllabus.
In carrying out the study, census sampling was adopted. Data gathering through direct observation and visit to classrooms in the universities was difficult to achieve, therefore the academic curriculum of quantity surveying departments of the institution were assessed with focus on their course contents. The data collected was collated and compared with the standard guideline of competencies provided by RICS (2018).

## FINDINGS AND DISCUSSION

### Quantity surveying curriculum and BIM Knowledge Areas

Table 2 indicates that in BIM introductory courses, most of the institutions examined had a partial availability of courses on Evolution of computer Aided Design in the Architecture and Engineering Constriction curriculum. In definition and concept of BIM in Nigerian institutions, it was discovered that out of higher institutions of learning examined, only one has commenced an active course study on the concept of BIM while the course outline is Non-available in other institutions of learning. The review of the curriculum of higher institutions of learning also revealed that there is unavailability of a study on emerging trends in BIM practice across higher institutions of learning in Nigeria except for one. The concept of BIM and theoretical knowledge is important and not just the practical knowledge (Shanbari, Blinn & Issa, 2016). An understanding of the concept is imperative in furthering more innovations in BIM technology and expanding the frontiers of what BIM could be used for or could become in the construction sector. The principles and concept of BIM is important as the BIM process expands more daily with recent addition to software and innovations in the BIM process. As further stated by Shanbari et al (2016), the introduction to BIM needs to commence with a conceptual understanding of BIM and its associated technologies and how these technologies can optimize, improve and enhance the construction workflow. An incomplete understanding of the concept would hinder students or professionals from innovating and improving the existing BIM workflow system.

### Table 2: Introduction to BIM

Note: U. = Universities, P = Polytechnics AA= Adequately Available; NA= Not Available; PA= Partially Available N = 23

| Introduction to BIM | U1 | U2 | U3 | U4 | U5 | U6 | U7 | U8 | U9 | U10 | U11 | U12 | U13 | U14 | U15 | U16 | U17 | U18 | U19 | U20 | U21 | U22 | P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Evolution of AEC CAD** | PA | AA | PA | PA | PA | PA | PA | PA | PA | PA | PA | PA | PA | PA | PA | PA | PA | PA | PA | PA | PA | PA | NA |
| **Definition, Principles & Concept of BIM** | NA | AA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **Emerging Trends in BIM Practice** | NA | AA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

From Table 2, it is observed that BIM Modelling and Virtual construction is greatly understudied in the Nigerian built environment education curriculum. It is seen below that while there is a partial availability of practical on computer visualization across higher institutions of learning. Also, it was discovered that no institution offers course study on standard BIM Visualization workflow and only one institution among the twenty-three institutions examined offers BIM enhanced tools such as Revit, Navisworks, & lumion. There is also no available institution offering Virtual Reality/Virtual Programming. Though BIM models are still relatively uncommon in the Nigerian construction industry, it is vital to train graduates to have the requisite knowledge on navigating BIM models, and working with employees who have the knowledge (Shanbari et al, 2016). Students can then leverage such basic skills to rise to intermediate and proficiency levels through personal development initiatives or firm's reskilling programmes. If students are able to have the needed minimum skills, it will better position them in the construction job market and give them a chance to compete favourably globally. It also favours the implementation drive as increased awareness and knowledge means professionals are better able to convince clients on the need to adopt the BIM concept. Therefore, the Education is not only the responsibility of the institutions of higher learning but that of the professional bodies and firm's active in the construction sector.

### Table 3: BIM Modeling & Virtual Construction

| BIM Modeling & Virtual Construction | U1 | U2 | U3 | U4 | U5 | U6 | U7 | U8 | U9 | U10 | U11 | U12 | U13 | U14 | U15 | U16 | U17 | U18 | U19 | U20 | U21 | U22 | P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Computer visualization** | PA | AA | PA | PA | PA | PA | PA | PA | PA | PA | PA | PA | PA | PA | PA | PA | PA | PA | PA | PA | PA | PA | NA |
| **Standard BIM Visualization Workflow** | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **BIM Enhanced Tools: Revit,** | NA | AA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

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| **Navisworks & Lumion** | | | | | | | | | | | | | | | | | | | | | | | |
| **BIM Enhanced Tools: Vico Office, Synchro Professional** | NA | AA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **Virtual Reality/Virtual Programming** | NA | PA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

Note: U. = Universities, P = Polytechnics AA= Adequately Available; NA= Not Available; PA= Partially Available N = 23

In Table 3, strategic BIM implementation through the study of Employer's information requirements, choosing the right team and BIM sustainable design is unavailable with the exception of studies on the environmental impact of buildings which is partial available across higher institutions of learning offering AEC education.

**Table 4: Strategic BIM implementation**

**Note:** U. = Universities, P = Polytechnics AA= Adequately Available; NA= Not Available; PA=

| Strategic BIM implementation | U1 | U2 | U3 | U4 | U5 | U6 | U7 | U8 | U9 | U10 | U11 | U12 | U13 | U14 | U15 | U16 | U17 | U18 | U19 | U20 | U21 | U22 | P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **The Employer's Information Requirements** | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **Choosing the right team** | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **BIM sustainable design** | NA | PA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **Environmental Impact of Buildings** | PA | PA | PA | PA | PA | PA | PA | PA | PA | PA | PA | PA | PA | PA | PA | PA | PA | PA | PA | PA | PA | PA | NA |

Partially Available N = 23

BIM coordination and collaboration examines the needed internal and external support system vital to the success of BIM implementation on a proposed project. Other factors vital to effective coordination and collaboration are Team mobilization and Evaluation, construction planning, selection of design process, virtual construction model and 5d workflow and model. While there is no available course study on BIM collaboration, Team mobilization, virtual construction model and 5D workflow and model. There is adequate training on selection of design process which could be traditional or new design process. There is also a partial availability of courses on construction planning for BIM implementation. As affirmed by Ali et al, (2016), the quantity surveying profession follows the 5D BIM which operates in the context of construction costing, generation of quantity take offs and measurement from a model.

### Table 5: BIM Coordination & Collaboration

**Note:** U. = Universities, P = Polytechnics AA= Adequately Available; NA= Not Available; PA=

| BIM Coordination & Collaboration | U1 | U2 | U3 | U4 | U5 | U6 | U7 | U8 | U9 | U10 | U11 | U12 | U13 | U14 | U15 | U16 | U17 | U18 | U19 | U20 | U21 | U22 | P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Collaboration &Interoperability issues | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Team mobilization & Evaluation | NA | PA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Construction Planning | NA | AA | PA | PA | PA | PA | PA | NA | NA | NA | PA | PA | PA | PA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Selection of Design Process: Traditional& New Design | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | PA |
| The Virtual Construction Model | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 5D Work Flow & Model | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

Partially Available N = 23

In Table 5, a critical examination is carried out to examine QuickTime VR techniques, sharing of model data and computer rendering techniques which were found unavailable for study in Nigerian higher institutions; this is not surprising as it is a result of an absence of adequate BIM learning platforms in the Nigerian AEC curriculum. Immersive VR has been used in education domains when there are physical barriers to participation in an event. QuickTime VR therefore offers not just enhanced BIM learning but practical stimulation of construction site events to aid students learning. Emerging innovations in this area with regards to BIM also includes Laser scanning technology which is an important tool in evaluating the existing conditions of historical buildings to assist in the preparation of as-built drawings and for renovation or reconstruction purposes. Laser technology has therefore been introduced in BIM courses on other developed countries (Shanbari, et al, 2016). It is therefore inevitable that BIM would be the standard in the construction industry in not too distant future, the readiness of the Nigerian construction industry is therefore imperative not to be caught unguarded.

**Table 6: BIM Construction/project management**

**Note:** U. = Universities, P = Polytechnics AA= Adequately Available; NA= Not Available; PA=

| BIM Construction/project management | U1 | U2 | U3 | U4 | U5 | U6 | U7 | U8 | U9 | U10 | U11 | U12 | U13 | U14 | U15 | U16 | U17 | U18 | U19 | U20 | U21 | U22 | P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Computer Rendering Techniques | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| QuickTime VR | NA | PA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Sharing model data: XML | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

Partially Available N = 23

BIM has embedded quantity surveying functions that improves the traditional quantity surveying process and workflow. While there is adequate raining on traditional system of cost variances, variance estimating, element identification, quantity take-off and schedule inventories there is an absence of course study on cost estimation with BIM and interactive schedule workflow. Though the available training on the traditional quantity surveying process is vital to involvement of quantity surveyors in BIM implementation, other vital processes is imperative for quantity surveyors to compete globally with their peers from advanced countries. The absence of these knowledge areas in the curriculum would therefore only limit the performance and competitiveness of Nigerian quantity surveyors globally. BIM enabled estimation involves different approaches such as IFC Export Approach, Model as-is costing approach, Model Moderation cost approach and process simulation costing approach (Olatunji & Sher, 2014). None of this approach is however being undertaken in Nigerian institutions of learning.

**Table 7: BIM Quantity surveying**

| BIM Quantity surveying | U1 | U2 | U3 | U4 | U5 | U6 | U7 | U8 | U9 | U10 | U11 | U12 | U13 | U14 | U15 | U16 | U17 | U18 | U19 | U20 | U21 | U22 | P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cost Variances | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA |
| Variance Estimating | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA |
| Element Identification | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA |
| Quantity take-offs | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA |

| | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Schedules Inventories** | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | AA | PA |
| **Cost Estimation with BIM** | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **Interactive Schedule Workflow** | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

**Note**: U. = Universities, P = Polytechnics AA= Adequately Available; NA= Not Available; PA= Partially Available N = 23

Table 7 analyses the BIM technology and processes vis a vis the curriculum course content of higher institutions of learning in Nigeria and discovered that important emerging technologies to the BIM process such as creating a BIM execution workflow, BIM computer aided manufacturing workflow, BIM and prefabrication, object technologies in CAD and parametric object technology are all unavailable in all Nigerian higher institutions of learning with no exceptions. This indicates an unappreciable lack of progress in BIM adoption and implementation especially in higher institutions of learning where it is most vital. What this suggests is an unenthusiastic drive of BIM implementation in Nigeria as the academic is vital in driving overall policy development and intellectual reskilling. This also shows that the future graduates of AEC in the Nigerian academic environment would have a basis to compete globally in regards to BIM work environment.

This therefore paints an uninspiring image of the AEC academic environment and its capacity to innovate and adopt emerging technology in resolving issues germane to the Nigerian construction industry. While BIM is changing the workflow and processes in the construction industry, it is also influencing AEC curricula and course development (Puolitaival & Kestle, 2018). Therefore, the current curricula need to show the improvisations and innovations in the industry so as to adequately prepare graduates for industry-based skills proficiency. In advanced economies, BIM has not been isolated but incorporated into curriculum (Puolitaival & Forsythe, 2016). Other approaches used are; vertical integration (Puolitaival & Kestle, 2018; Forsythe, Jupp & Sawhney, 2013, Ghosh, Chasey & Root, 2015). While Macdonald and Mills, (2011) opined on the integrated project delivery approach and Demirdroven, (2015) suggested varied interdisciplinary models. Though the models and method of training could influence the learning outcome, an effective and efficient process is vital in ensuring students get the basic understanding. To achieve this, it is imperative that teaching staff stay in touch with emerging industry practice (Lee & Dossick 2012, Clevenger et al, 2010). Other vital solutions are the provision of educational resource (Becerik-Gerber et al., 2011; Gier, 2015; Puolitaival &

Forsythe, 2016; Sabongi, 2009; Woo, 2007), decongesting the existing curricula to make space for emerging processes and innovations (Becerik-Gerber et al. 2011)

**Table 8: BIM technology and processes**

**Note:** U. = Universities, P = Polytechnics AA= Adequately Available; NA= Not Available; PA=

| BIM technology and processes | U1 | U2 | U3 | U4 | U5 | U6 | U7 | U8 | U9 | U10 | U11 | U12 | U13 | U14 | U15 | U16 | U17 | U18 | U19 | U20 | U21 | U22 | P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Creating a BIM execution plan outlining its process, workflow, and production | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| BIM Computer Aided Manufacturing Workflow | NA | PA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| BIM and Prefabrication | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Object Technologies in CAD | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Parametric Object Technology | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

Partially Available N = 23

This is affirmed by Barrison and Santos (2010) who opined that institutions who should serve as leaders in BIM education and training have not commenced the process of BIM implementation or teach few tools. However, the situation in the Nigerian construction industry is much worse as only one intuition out of the institution examined as commenced a semblance of training on BIM competencies.

## CONCLUSION AND RECOMMENDATION

BIM is undoubtedly a disruptive innovation whose impact on the workflow and processes of the AEC sector is here to stay. For the paradigm shift to BIM to be fully implemented, an improvement on existing skills and knowledge available in higher institutions of learning is imperative. The study revealed that there is a large gap in the Nigerian AEC curricula in training and educating graduates for BIM participation and implementation. It was discovered that just one out of twenty-three examined higher institutions of learning in Nigeria has an introductory course on BIM practice and limits it at that due to lack of educational resources while there has been no attempt to commence BIM introductory learning in all other institutions.

This indicates that other vital component of BIM understanding such as collaboration, Prefabrication, Virtual Reality, Cost estimation using BIM, BIM sustainable design, and BIM Enhanced Tools such as Revit, Navisworks, Lumion, Vico Office and Synchro are unavailable for students learning. It is highly recommended that higher institutions in Nigeria first see a need to take the bull by the horn in championing the introduction of BIM into the Nigerian AEC curriculum. To start with, an introductory BIM course and stand-alone teaching modules for integration into a variety of core courses as carried out successfully in Colorado State University (Clevenger, Ozbek, Glick, & Porter, 2010).

However, with or without the urgently needed government policy to drive BIM implementation, industry demand is ever- growing and it rests on the shoulders of professional bodies such as the Nigerian Institute of Quantity Surveyors to take on the challenge by co-opting its BIM trainings and seminars into higher institution of learning as a form of intellectual support and initiative to drive the BIM process in the Nigerian AEC sector. It cannot be overstated that great effort is needed by professional bodies in the Nigerian AEC sector to push for the adoption of BIM in the industry. Ali et al (2016) stated that promotion of BIM framework is always professional body led in advanced economies for instance the Royal institution of Surveyors in Malaysia which has promoted redevelopment of the curriculum in Malaysia to adopt BIM learning outcomes.

As affirmed by Adamu &Thorpe, (2016) there are inconsistencies globally on the agreed programmes needed in BIM curricula which mean the Nigerian institutions of learning alongside the National Universities Commission must put heads together to formulate a workable and practical programme to urgently up-skill graduates of the AEC sector. As stated by Shnabari et al (2016), an effective and efficient curriculum would ensure adequate conceptual understanding of the technologies and principles of BIM in enhancing construction workflow, proficiency in technical skills necessary to navigate the BIM technologies and process, and simulation of the technologies in practical class settings to give an adequate knowledge of what is taught.

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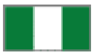

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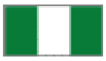

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