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BIM implementation for Nigeria's polytechnic built environment undergraduates: challenges and possible measures from stakeholders

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Abstract

Purpose – Studies show that building information modelling (BIM) technology can improve construction productivity regarding the design, construction and maintenance of a project life cycle in the 21st century. Revit has been identified as a frequently used tool for delivering BIM in the built environment. Studies about BIM technology via Revit are scarce in training middle-level workforce higher education institutions. Thus, this study aims to investigate the relevance of BIM technology and offer measures to promote digitalisation in Nigeria's built environment polytechnic undergraduates via Revit.

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Design/methodology/approach – Given the unexplored nature of training the middle-level workforce in Nigeria, 37 semi-structured virtual interviews were conducted across Nigeria, and saturation was achieved. The participants were knowledgeable about construction-related BIM. The researchers used a thematic analysis for the collected data and honed them with secondary sources.

Findings – Improved visualisation of design, effective and efficient work productivity, automatic design and quantification, improved database management and collaboration and data storage in the centrally coordinated model, among others, emerged as BIM's benefits. BIM technology via Revit is challenging, especially in Nigeria's polytechnic education curriculum. The 24 perceived issues were grouped into government/regulatory agencies-related, polytechnic management-related and polytechnic undergraduate students-related hindrances in Nigeria's built environment.

Research limitations/implications – This study is limited to BIM implications for Nigeria's built environment polytechnic undergraduates.

Originality/value – This study contributes to the literature paucity in attempting to uncover perceived issues hindering the implementation of BIM technology via Revit in training Nigeria's built environment polytechnic undergraduates via a qualitative approach.

Keywords BIM, Built environment undergraduates, Construction industry, Nigeria, Revit, Communication technologies, Data collection, Building, Higher education, Education

Paper type Research paper

1. Introduction

In the 21st century, the construction industry is fast shifting from conventional labour-intensive construction activities (pre- to post-construction) to construction digitalisation through emerging technological innovation (Aluko *et al.*, 2018; Aliu and Aigbavboa, 2020; Manzoor *et al.*, 2021). Panuwatwanich *et al.* (2013) and Babatunde and Ekundayo (2019) opined that building information modelling (BIM) has been recognised as an emerging technological innovation within the built environment industry. BIM has existed for over two decades within the built environment (Babatunde *et al.*, 2018). Thus, it is a much-desired skill for the built environment students in higher education institutions (HEIs), especially for those preparing for their careers in innovation (skilled in many arts through learning to accomplish every task) (Liu and Hatipkarasulu, 2014; Babatunde *et al.*, 2018). For this study, the built environment programmes are architecture, urban and regional planning, geo-informatics (land surveying), quantity surveying (QS), construction management, building and engineering. This aligns with Ebekozien *et al.* (2021), who adopted the same major disciplines in the Nigerian-built environment. It slightly differs from Manthe and Smallwood (2007) and Ebekozien and Aigbavboa (2022). They adopted the built environment disciplines of QS, project management, construction management, civil engineering and architecture. These core disciplines' curricula contain construction digitalisation-related courses, but implementation may be challenging. The study focuses on polytechnics because it develops and trains middle-level workforce. The polytechnic focuses on training in technical and practical sciences for the middle-level workforce by combining teaching and learning regarding economic production with the practical work experience of the instructor/moderator/mentor/teacher. BIM inclusion in higher education pedagogy is vital in preparing skilled manpower graduates for employment in the built environment industry (McGraw Hill, 2010; Han and Bedrick, 2015). Han and Bedrick (2015) emphasised that the sustainability of BIM practices will be threatened without incorporating it into the education curriculum. This may be lacking in developing countries' technical HEIs like the Nigerian Polytechnics. In Nigeria, the government focuses more on universities than the polytechnic system. This is reflected in some professional bodies' employment and examinations, including some built environment programmes. Nwabughiogu (2021) affirmed that the government's inability to sign the bill to end the disparity between university and polytechnic graduates calls for concern.

A BIM technology environment is a mechanism or platform that allows an organisation or project to integrate software tools to offer BIM services (Eastman *et al.*, 2011). Delivering a BIM-based project requires a BIM environment integrated within an organisation or on a project. The BIM environment in this context includes software, hardware, protocol and coordination workspace (Building and Construction Authority of Singapore, 2013). The BIM processes call for a collaborative and integrative environment with tools. The tools will create the platform to develop, share and exchange construction project information electronically during the project life span (Olugboyega, 2017). BIM is developing a brainy virtual framework that integrates the project information from pre- to post-construction, including the project life cycle (Babatunde *et al.*, 2018). Hence, BIM can accelerate construction project documentation, quantification and estimation. Technology is vital during a construction project's pre- and post-design phases and focuses on operations and maintenance (Lee and Dossick, 2012). Kim (2012) opined that BIM technology had become a trending issue in the built environment because of the associated benefits. Many scholars are exploring BIM's potential as a new information technology to enhance efficiency. These, among others, motivated the study to explore the relevance of BIM technology via Revit in training Nigeria's built environment polytechnic undergraduates in the 21st century. The software is multi-expert friendly and could be used by construction professionals. Revit is a common BIM software for built environment practitioners, including engineers, quantity surveyors, architects, landscape experts, planners, clients and contractors. Graves (2012) described Revit as a 4D BIM application capable of tools and can be used within the building's lifecycle, from conceptualisation to development and later maintenance and demolition. It is a significant player in the BIM market, especially regarding the built environment professionals' services. It is encompassing and can be used for multi-task activities. This includes designing, project planning, estimating and bill preparation, materials scheduling, valuation, certificate verification, etc.

The benefits associated with BIM create the need for built environment undergraduates to know BIM because of its increasing relevance to the built environment industry (Babatunde *et al.*, 2018). Thus, incorporating BIM into the higher education curriculum may not only serve the request of BIM professionals. It will generate innovative opportunities for built environment undergraduates in their professional professions to deal with new occupational hindrances with high competence (Wong *et al.*, 2011). BIM is not a single software but a technology/platform that allows the fusion of various software to achieve a 3D model that serves as a digital representation of a facility's physical and functional characteristics. There is much software that can be used to achieve BIM technology. This includes Revit, ArchCAD, AECOsim, Naviswork, Planswift, MS Project, etc. The most frequently used is the Revit. It is one of the many tools that can be used to achieve BIM. There are various forms of Revit. This includes Revit Architecture (for architectural model), Revit MEP (for mechanical, electrical and plumbing model) and Revit cost (for resources and cost model) (Olugboyega, 2016). It is one of the study's motivations to explore BIM via Revit software technology. Studies about applying BIM via Revit in training Nigeria's built environment polytechnic undergraduates are scarce. Thus, infrastructural development through training middle-level manpower in HEIs such as the polytechnic is pertinent to enhancing the economy.

There are studies on BIM in Nigeria's context, such as Maina (2018), Babatunde *et al.* (2018), Babatunde and Ekundayo (2019), Olatunji (2019), Olanrewaju *et al.* (2020; 2021), Aka *et al.* (2021), Babatunde *et al.* (2021) and Okwe *et al.* (2022). However, Babatunde *et al.* (2018), Maina (2018), Babatunde and Ekundayo (2019) and Olatunji (2019) are among the few studies that focused on universities. None of the existing studies engaged the students' perspective regarding perceived hindrances in implementing BIM technology via Revit in training Nigeria's built environment polytechnic undergraduates. Apart from the exclusion of the students, the current emphasis on BIM application focuses on Nigerian universities to the detriment of the polytechnics (middle-level workforce HEIs) that ought to drive the economy via technology and innovation. The study intends to fill this theoretical gap. Preliminary findings show that besides the architecture curriculum and course specifications for the National and Higher National Diploma, revised June 2021 edition of the National Board for Technical Education (NBTE), other built environment programmes regarding BIM application via Rivet or other digital software are lax. There is often none, and students are taught theory without practice. The practical exposure is lax even in the architecture programme, at the National Diploma level. Many factors may have contributed. This includes available software in the faculty/department laboratory, the absence of a personal laptop to continue practice after class, etc. Also, previous studies that considered BIM benefits to the built environment professions from the perceptions of scholars and polytechnic undergraduates are uncommon. Hence, studies about BIM technology via Revit training middle-level workforce in Nigeria's built environment higher institutions are scarce. The research investigated the relevance of BIM technology and proffer measures to promote digitalisation in Nigeria's built environment polytechnic undergraduates via Revit application. The research seeks to answer the following research questions:

RQ1. What are the benefits of BIM technology via Revit in training Nigeria's built environment polytechnic undergraduates?

RQ2. What issues hinder implementing BIM technology via Revit in training Nigeria's built environment polytechnic?

RQ3. How can BIM technology be promoted to train undergraduates in Nigeria's built environment polytechnics?

In providing solutions to the research questions, the researchers reviewed relevant literature, and the researchers used a qualitative approach for the primary data collected from participants. The study is split into seven main sections. Section 1 focuses on the introduction, including part of the study's motivations and research questions. Section 2 highlights previous-related literature. This includes the BIM relevance and hindrances facing BIM. Next, Section 3, is the research method that collects data from 37 participants via in-depth virtual interviews across Nigeria. Section 4 is the analysed results via a thematic approach and discussion with reviewed literature. The study's implications were captured in the Section 5. The study's limitations follow in Section 6. Lastly, the concluding section, Section 7, comprises the study's conclusion and recommendations.

2. Literature review

2.1 Building information modelling relevance

The relevance of BIM cannot be over-emphasised in the built environment. BIM incorporation into HEI teaching is vital in preparing trained graduates for future competitive work in the built environment (McGraw Hill, 2010). This was corroborated by Han and Bedrick (2015) and may threaten BIM implementation and sustainability without incorporating it into the higher education curriculum. Implementing a BIM construction project demands new components of discipline professionals compared to conventional construction projects (Puolitaival and Forsythe, 2016). BIM education flourishes in HEIs built environment programmes (Lee and Dossick, 2012; Panuwatwanich *et al.*, 2013; Shelbourn *et al.*, 2017). The built environment stakeholders should use more BIM ultimate advantages (Ghaffarianhoseini *et al.*, 2017).

In Nigeria, few studies (Abdullahi *et al.*, 2011; Abubakar *et al.*, 2013; 2014; Fung *et al.*, 2014; Olanrewaju *et al.*, 2020; 2021) have been conducted on BIM implementation in the construction industry. Abdullahi *et al.* (2011) appraised BIM application and discovered a low awareness of BIM presence in the built environment industry. Abubakar *et al.* (2013) assessed the willingness of building design organisations to implement BIM software and found that design organisations are willing to fulfil BIM applications in their practices. Abubakar *et al.* (2014) focused on BIM awareness level and encumbrances to its application from Nigeria's contractors' viewpoints. Olatunji *et al.* (2010) and Zhou *et al.* (2018) affirmed that BIM could eliminate components of conventional QS activities. This includes bills of quantities production that may not be free from human errors. RICS (2014) and Zhou *et al.* (2018) avowed that BIM could enhance efficiency and promote integrated collaboration in the bill of quantities preparation. Thus, it enhances the speed with better quality, free from errors. BIM can potentially inspire the QS profession, a component of the built environment, regarding cost-effectiveness and value of construction processes (Pittard and Sell, 2017). Thomas (2010) identified reasons BIM should be encouraged. This includes:

- 30% of construction projects do not meet the budget;
- 37% of materials used in construction projects convert to waste;
- 10% of the project cost is because of change orders; and
- 38% of carbon emissions are from buildings.

2.2 Hindrances facing building information modelling implementation in higher education institutions

Digitalisation, including BIM technology and other drivers of the fourth industrial revolution (4IR) technologies, faces many encumbrances, especially in developing countries. Lack of basic infrastructure, insufficient human resources, lax legislation and policies, absence of a political will, poor awareness and stakeholder engagement and government attitude to support were identified as the hindrances facing digitalisation (Oesterreich and Teuteberg, 2016; Samsor, 2020). BIM is a component of digitalisation. Demirkesen and Tezel (2021) found high implementation costs, unclear usage benefits and resistance to change as the encumbrances of Industry 4.0 in the built environment. Penmetsa and Bruque-Camara (2021) classified the hindrances associated with digital into people related (scarcity, digital illiteracy, culture, adoption, awareness, citizen-centric focus and training and education) and technology related (digital infrastructure, IT standards, system integration, security and cyber insecurity and innovation ecosystem). Others are policy related (bribery and corruption, ICT systems and cyber security risks); institutional related (funds, government support, political willingness and leadership, organisational structure and mission); and economic related (high cost, economic value, funding and software maintenance). Sustainability-related encumbrances were the last categorised, including education, access to technology, digital literacy, inadequate education and power supply. Wong and Yew (2017) examined obstacles to executing BIM technology in Sarawak's QS organisations and found insufficient training and knowledge and high initial cost as the top-ranked hindrances.

Implementing BIM is challenging (Vass and Gustavsson, 2017), especially in developing country's higher educational institutions. Adamu and Thorpe (2016) argued that in higher educational institutions, especially universities, can access BIM training freely. It is economically sound to invest in undergraduate students to mitigate future issues of lack of funds for training and upskilling associated with the BIM adoption (Eadie *et al.*, 2015). Despite this benefit, there are practical challenges. Underwood and Ayoade (2015) and Puolitaival and Forsythe (2016) identified that lax upskilling and reskilling, inadequate expertise among staff and regular updates as BIM constantly evolves is germane. Sabongi (2009) and Puolitaival and Forsythe (2016) emphasised the issues connected with the existing curriculum and the inability to integrate BIM courses. This is because of the over-crowded existing curricula. Gier (2015) identified inadequate educational resources and a lack of institutional support. This is compounded by inadequate staff expertise. BIM technology evolves quickly and may confront students, instructors/lecturers (Sacks and Pikas, 2013). In all extant literature, besides the geographical gap, none addressed the challenges of a developing country's technical-based higher educational institutions. Technical-based higher educational institution graduates are critical players in driving a nation's economy.

Nigeria's built environment industry in West Africa is the largest (Saka *et al.*, 2020). This comprises skilled and unskilled workers. Studies such as Olanrewaju *et al.* (2020), Ebekozien and Aigbavboa (2021) and Ebekozien *et al.* (2022a; 2022b) found that the industry is slow in adopting emerging technologies associated with the 4IR technologies. This includes BIM, robotics, simulation, 3D, blockchain, big data, etc. Olanrewaju *et al.* (2020) discovered that the slow approach to adopting innovative technologies had affected the full implementation of emerging technologies like BIM. Onungwa *et al.* (2017) found low technical knowledge and poor BIM awareness as critical factors. Their findings validate the work of Anifowose *et al.* (2018). Anifowose *et al.* (2018) found that BIM awareness level is about 40% among built environment practitioners, even with the enormous benefits, which is not encouraging. This can be attributed to insufficient government programmes and policies, high cost of implementation, software accessibility issues and inadequate knowledge (Olanrewaju *et al.*, 2020). Many architectural, mechanical and electrical drawings are generated with 2D CAD, while few use 3D for visualisation (Hamma-adama *et al.*, 2017). Babatunde *et al.* (2021), Olanrewaju *et al.* (2020) and Ebekozien *et al.* (2022b) found that apart from the absence of policies to enforce or promote the use of BIM, the Nigerian government has not created an enabling environment for BIM adoption to grow compared to the UK, USA and Australia. It was found that though the level of awareness among construction professionals has increased, reaching maturity is far, as it experiences hindrances connected with BIM usage. The Eko Atlantic City project has fully implemented BIM in Nigeria (Anifowose *et al.*, 2018). The number is not encouraging and calls for concern.

3. Research method

This research adopted a qualitative research approach. The research is embedded in interpretivism (Chandra and Shang, 2019; Ebekozien, 2020a; 2020b). Schwandt (2003) asserted that interpretivism acknowledges subjectivity as a social variable. The research was addressed from a phenomenological-driven viewpoint (Neale, 2018). One reason is that only some stakeholders in Nigeria knew about BIM via Revit software. The study counts on extensive reviewed literature and semi-structured virtual interviews for the data collection. For the participants' selection, purposeful elite sampling was used. Elite sampling describes a scenario where interviewees are chosen based on being famous and informed about the subject matter (Marshall and Rossman, 2006). It is used for sensitive issues (Acar, 2016), such as the BIM technology via Revit in the construction industry. The data collected were from built environment professionals in academics and practices, top management staff of polytechnics academic planning unit/division, NBTE staff and selected students that understand the basic concept regarding BIM, as presented in Table 1 across Nigeria. The essence was to ensure the findings' acceptance and credibility. The virtual interviews via Team and WhatsApp video calls lasted between 36 and 50 min per meeting. Regarding ethical matters, the interviewees were informed about the study's aim and agreed to participate in line with Jaafar *et al.* (2021), Ebekozien *et al.* (2021) and Ibrahim *et al.* (2022).

Table 1. Summary of interviewees' background

Participant	Rank/firm	Years of experience	Geopolitical zone/location and participant code SS	SW	SE	NW	NC	NE	Total
Built environment professionals in academics (architecture, urban and regional planning, geo-informatics, quantity surveying, construction management, building and engineering)	Not below (NB) lecturer 1/equivalent	NB 10 years	1–2 (fed)	3–4 (state)	5–6 (fed)	7–8 (state)	9–10 (fed)	11–12 (state)	*12*
Built environment professionals in practice (architecture, urban and regional planning, geo-informatics, quantity surveying, construction management and engineering)	Directors, managing partners, partners	NB 25 years	13	14	15	16	17	18	*6*
Higher education institutions (State and federal Polytechnics)	Academic planning unit/division	NB 18 years	19 (fed)	20 (state)	21 (fed)	22 (state)	23 (fed)	24 (state)	*6*
NBTE	NBTE senior staff	NB 15 years	–	–	–	–	25	–	*1*
Built environment undergraduates (architecture, urban and regional planning, geo-informatics, quantity surveying, construction management, building and engineering)	Year 1 and 2 in higher national diploma	Minimum of one-year industrial training	26–27 (fed)	28–29 (state)	30–31 (fed)	32–33 (state)	34–35 (fed)	36–37 (state)	*12*
Total									*37*

Notes: SS = South-South; SW = South-West; SE = South-East; NW = North-West; NC = North-Central and NE = North-East
Source: Authors' work

As reported previously, 37 semi-structured virtual interviews were conducted across Nigeria. The study focuses on selecting at least one polytechnic (state or federal) from each zone. The emphasis here is on polytechnic representation and both (state and federal) use the same curriculum. The programmes in the curriculum, including construction-related programmes are regulated and upgraded by the NBTE in Nigeria. The NBTE is the regulatory agency for polytechnics and monotechnic in Nigeria. The method adopted had limitation because it was virtual interview with 37 participants. However, the attributes of the participants like being BIM knowledgeable, years of experience and ranks speak volumes, apart from P26 – P37. These would add to fortify the study's results. Data collection took place from April 2022 to early June 2022. The study's saturation was established when "new data" perceptions from the study were no longer forthcoming from the interviewees. This practice aligns with Braun and Clarke (2019). They affirmed that the study had achieved saturation when there was no evidence of more new perceptions. The investigators engaged only interviewees experienced in the built environment and BIM technology. To address the problem of "what" and "how," the research asked questions around BIM via Revit relevance within the built environment with emphasis on polytechnic-built environment students, perceived implementation challenges and possible measures to improve BIM education on polytechnic undergraduates and by extension the middle-level workforce to boost the economy. The semi-structured questions aided the research in investigating the underlying problems hindering BIM technology implementation via Revit in training Nigeria's built environment polytechnic undergraduates from the participants' perspective. Appendix shows the interview questions and cover letter. Thirty-seven documents were collected, and the most relevant documents are quoted in the finding and discussion sub-sections. This aligned with Gorbacheva and Sovacool (2015) and asserted that the small interview sample could be compensated with thoroughly reviewed literature as applied in this research.

In creating the codes, this study adopted thematic analysis. The researchers analysed data collected from the participants manually. The investigators read 37 documents several times. The researchers were the coders who recounted the interviewees' views regarding the phenomenon. Two coding phases were used. Firstly is open coding (Saldana, 2015). Secondly, the categories (sub-themes) that emerged from the open coding phase were used to re-read the transcript and find the vital variables in line with the study's plans. Triangulation, researcher reflexivity and member checking were used as the validity techniques (Creswell and Creswell, 2018). The research adopted narrative, theming and *in vivo* techniques (Saldana, 2015). Sixty-nine codes were developed. They were re-grouped into eight sub-themes. Three themes emerged.

4. Results and discussion

Literature showed that BIM technology via Revit could proffer answers to the hindrances in the built environment sector. Thus, findings from this study are presented as follows:

4.1 Theme one: building information modelling relevance

In this sub-section, the study's interviewees agree that BIM technology relevance via Revit cannot be over-emphasised in the built environment of polytechnic undergraduates in the 21st century driven by digitalisation. This is key and timely in the history of Nigeria because more middle-level workforce via polytechnic training in technology, applied science and commerce and management in practical knowledge and theory with support from research are needed to drive the economy towards sustainable technological development (P1, P9, P25 and P34). P25 says, " [. . .] the Nigerian polytechnics stand out when training and developing their undergraduates for self-reliant manpower for sustainable technological development because of the vast practical knowledge for meaningful contribution to local and national development. Thus, BIM will enhance this role appropriately [. . .]" Findings show that BIM can enhance the built environment practitioners' efficiency and productivity (Participants P4, P9, P13, P18 and P34). Among the testimony of BIM technology application via Revit are reliable and more accurate work and immediate details with an alternative approach. P13 says, "[. . .] I am a quantity surveyor by background. I can tell you categorically that BIM (Revit Cost) enhances my duties regarding contract administration, pre-tender documentation, estimating and cost planning, procurement advice, measurement, preparation of bills of quantities, interim valuation preparation, and material schedule charts. Other benefits are improved cost database management, rapid identification of design changes, data storage in the centrally coordinated model, improved visualisation, and reduced requests for information [. . .]" Findings agree with Olatunji *et al.* (2010), Zhou *et al.* (2018) and Babatunde *et al.* (2018). They affirmed that BIM could eliminate components of conventional QS activities. BIM can enhance efficiency and promote integrated collaboration in main QS functions (Zhou *et al.*, 2018).

Findings show that one of the benefits of Revit software is the multiple usages (majority). Participant P14 says, "[. . .] we have the Revit Architecture for architectural model and applied by an architect for design and other related works. Also, there is Revit MEP for the mechanical, electrical, and plumbing (MEP) model and applied by mechanical, electrical, and plumbing experts for MEP model and other related works. Lastly is the Revit Cost for resources and cost model and applied by quantity surveyor for costing and estimating and other related works [. . .]" Findings agree with Eastman *et al.* (2011), Kushwaha (2016) and Olugboyega (2017). Eastman *et al.* (2011) and Kushwaha (2016) asserted that BIM offers solutions to several problems inherent in the built environment. The technology is unique because the industry is dynamic. Olugboyega (2017) developed the framework for creating a BIM environment and categorised the various BIM authorising software technologies. "[. . .] BIM technology via Revit benefits training Nigeria's built environment polytechnic undergraduates cannot be challenged. Integratng BIM education into the curriculum will improve sustainability practices on construction projects [. . .]" said Participant P24. Findings agree with Olawumi and Chan (2018). They examined the perceived advantages of integrating BIM and sustainability practices in projects. Olawumi and Chan (2018) found that BIM could advance project quality and proficiency and simulate building performances.

Participant P16 says, "[. . .] BIM technology knowledge via Revit could be used to promote the training of middle-level workforce in Nigeria's built environment polytechnics. The truth is that polytechnic undergraduates lag behind their university counterparts. This technology can create an atmosphere for information model development, interoperability, integration and collaboration, and healthy communication for a construction project [. . .]" Findings agree with Fung *et al.* (2014). They emphasised a paucity of studies into BIM potentials in the QS profession in HEIs. Findings show that this is pronounced in Nigerian polytechnics offering built environment programmes. The polytechnic undergraduates should be more attentive to BIM education and its application (Participants P9, P17, P20, P24, P24, P25, P35 and P37). This is because polytechnic education focuses on technical and practical sciences training rather than theory based. This is where most middle-level workforce are trained and the pillar of any economy. The engine room of a vibrant economy is based on technology and innovation (Participants P1, P10, P15, P19, P25, P30 and P34). BIM education and application will enhance productivity. Findings reveal that BIM via Revit will inspire the built environment undergraduates in their future careers. Findings agree with Pittard and Sell (2017). They opined that BIM could inspire every aspect of the QS profession regarding cost-effectiveness and value of construction processes. The QS profession is a component of the built environment professions. "[. . .] one cannot use Revit (BIM) to compare conventionally (e.g., manual) concerning project development, precise, actionable costing information that defines during preliminary project phases. Apart from the time spent, not less than 50%, this process is highly disposed to error and could enhance construction project inaccuracies [. . .]" said Participant P13. Results agree with Nagalingam *et al.* (2013). They acknowledged that besides cost savings, BIM optimises construction project resources. The technology is all-inclusive with a teaching tool for key built environment professionals' functions (P4, P8, P13, P17, P19, P23, P25, P30, P33 and P37).

4.2 Theme two: issues hindering building information modelling implementation in higher education institutions (polytechnics)

In promoting the applications of BIM technology in polytechnics, this sub-section attempted to discover the perceived issues hindering BIM technology education in Nigerian polytechnics. One pertinent point is the identified issues hindering BIM implementation technology. The issues were grouped into government/polytechnic regulatory agency (NBTE)-related, polytechnic management-related and polytechnic undergraduate student-related hindrances in Nigeria's built environment context, as presented in Table 2. A total of 24 main issues emerged from the study. From the 24 issues, 21 were government/polytechnic regulatory agency related, 24 were polytechnic management related and 7 were polytechnic undergraduate student related. Table 2 shows that some identified issues cut across the three groups: low awareness of BIM, lax BIM collaboration between industry professionals and the academic world and resistance to change. Others are unclear advantages and gains to many stakeholders, high-security risks regarding data protection and cyber issues, insufficient investment in research and development and financial constraints. The government and the polytechnic managers need to demonstrate more leadership and political willingness for polytechnic BIM education (P6, P9, P16, P26, P28, P30 and P34). P34 says, "[. . .] in many developed and some developing countries that have recorded progressive output in education digitalisation, the government leads and gives direction with support to drive education digitalisation from HEIs to practices. This is not the case in many Nigerian polytechnics. I know that in some schools, some polytechnic students enrol for training in a private outfit. Also, few schools' students were forced to pay a certain amount to be eligible for BIM training [. . .]" The concerned schools rebuffed these allegations. Findings agree with Smart Nation and Digital Government Office (2018), and it was reported that the Singaporean Government fashioned an enabling environment and maintained the thriving of digitalisation via many programmes and platforms. "[. . .] thus, the government refusal or lax approach to creating the enabling environment for stakeholders to promote BIM is one critical issue. I am not against BIM education; can the graduates practice BIM fully if the enabling environment is not there? This brings us back to one of the root issues, government should lead [. . .]" said Participant P3. Findings agree with Babatunde *et al.* (2021), Olanrewaju *et al.* (2020) and Ebekozien *et al.* (2022b). They discovered that apart from the absence of policies to enforce or promote the use of BIM, the Nigerian government has not created the enabling environment for BIM adoption to grow compared to the UK, USA and Australia. The outcome has affected the rate of construction projects reaching maturity regarding BIM usage (Anifowose *et al.*, 2018). This is a call for concern. Participant P12 alleges academic staffers are encouraged to self-sponsorship for BIM training in some schools. This is not encouraging. (P3, P12 and P15).

Table 2.
Emerged major issues facing BIM technology implementation in training Nigeria's built environment polytechnic undergraduates

S/Nos	Emerged issues	Categorisation Govt/poly regulatory agency related	Polytechnic managementt related	Polytechnic Undergraduate student related
1	Lack of IT infrastructure or weak internet connectivity	√	√	
2	BIM is capital intensive	√	√	
3	Lax government and management lead/direction	√	√	
4	Cost of training staff/lecturers "train the trainers scheme"	√	√	
5	Availability of competent and qualified academic staff to teach BIM, including practical class	√	√	
6	Mechanism to upgrade BIM software	√	√	
7	Lax accreditation standards and requirements as framework for BIM implementation within a curriculum	√	√	
8	Erratic power supply	√	√	
9	Lax BIM collaboration between industry professionals and academic world	√	√	√
10	BIM problematic for weak IT users	√	√	
11	High security risk regarding data protection and cyber issues	√	√	√
12	Academic staff and students' resistance	√	√	√
13	Financial constraints	√	√	√
14	Low awareness	√	√	√
15	Lax BIM education curriculum policy	√	√	
16	Inadequate investment in research and development	√	√	√
17	Unclear benefits and gains to many stakeholders	√	√	√
18	Insufficient manpower for BIM education in polytechnics		√	
19	Lack of basic ICT driven policy and facilities to drive BIM education		√	
20	BIM demands new teaching method	√	√	
21	Integrating different areas of the curriculum to realise the multidisciplinary aspect of BIM is problematic	√	√	
22	Absence of enabling environment	√	√	
23	Absence of political will	√	√	
24	High cost of software maintenance		√	
	Total	*21*	*24*	*7*

Source: Authors' work

"[. . .] many young built environment graduates, especially engineers, architects, and quantity surveyors from polytechnic backgrounds, cannot use the BIM platform to manage projects. The level of the novice is alarming [. . .]. We operate a consortium, and it cuts across. The root cause is that BIM technology was not integrated into their curriculum [. . .]. Come to think of it, how many instructors/lecturers understand the basic concept of BIM? These issues should be addressed to increase the chances of polytechnic graduates getting competitive jobs because the world is now global [. . .]" said Participant P17.

Results agree with Hamma-adama *et al.* (2017) and Babatunde and Ekundayo (2019). Hamma-Adama *et al.* (2017) discovered that few design team members use 3D for visualisation while the majority still generate their drawings via 2D CAD. The many functionalities of BIM, such as clash detection, energy analysis and cost estimation, are left unexploited. Babatunde and Ekundayo (2019) found that the high training cost of academic staff, insufficient competent staff to teach BIM, absence of accreditation standards within a curriculum and challenging BIM for people with weak IT skills were among the top ten ranked hindrances. More work is expected from the root, BIM education should be encouraged across all built environment HEIs, especially polytechnics that train most of the middle-level workforce for the economy (Participants P6, P14, P18, P22, P24, P25, P33 and P37). There is a long way to go concerning BIM implementation. The polytechnic management should revamp ICT centres in their institutions to enhance BIM implementation.

4.3 Theme three: solutions to promote building information modelling technology

From the extensive reviewed literature and results, BIM education technology is one driver of construction digitalisation that is unmatched if well implemented for the built environment polytechnic undergraduates because of what the training institution stands and represents. Despite the enormous advantages of BIM technology usage, the level of BIM technology education and awareness in built environment programmes in Nigerian polytechnics is abysmal. This calls for concerns. During the pre-primary data collection, the researchers found that some senior academic staffers and final-year students need help understanding the concept of BIM. This exercise ensured that only knowledgeable persons regarding BIM and polytechnic education were engaged in the virtual interviews. Therefore, the sub-section provides measures to promote BIM technology via Revit usage in Nigeria's built environment polytechnic undergraduates' training and digitalisation. The theme generated six sub-themes/measures. This includes government/regulatory agencies (NBTE) and polytechnic managers (Rectors), an institutional framework to drive policy and programme, ICT infrastructure, training (upskilling and reskilling), collaboration and joint venture with stakeholders and sincerity in research investment.

Participant P8 says, "[. . .] the regulatory agencies, polytechnic managers, and the academic staff should agree to embrace BIM education as one way to revamp the economy and make the built environment polytechnic graduates more employable in the 21st century. This can be done by developing an institutional implementation framework integrating BIM education into all vital courses. This is presently missing. Also, the government policy support to enhance accreditation standards and requirements should be backed with feasible financial budget [. . .]" Findings show that emphasis should be on awareness and practical implementation concurrently (P12, P16, P19, P23, P30 and P37). Besides awareness, achieving a reasonable record in BIM education in Nigerian polytechnics requires an integrated collaboration between academia/government, industry and students (P16). Joint ventures and collaboration are pertinent, with the government leading as the team leader. Local and international software developers should be engaged via government efforts to make the tool readily available and affordable for the end users. "[. . .] this will motivate construction practitioners to patronise and embrace future new construction technologies knowing that support will come from the government regarding usage and cost [. . .]" said P33. Findings agree with Babatunde *et al.* (2021) and affirmed that government involvement via support demonstrates a significant enabler of BIM implementation.

Most participants agree that training (upskilling and reskilling) of academic staff in the built environment to transfer BIM education knowledge (practical and theory) to the students is germane in promoting Nigeria's built environment polytechnic undergraduates' training and digitalisation. Participant P12 says, "[. . .]. BIM education training should be a continuous exercise. This is because the software is dynamic and can be upgraded. In my institution, not up to one-tenth of the academic staff understand BIM nomenclature. So, you do not expect them to teach it even if the curriculum says so without adequate training. The era of imposing charges on staff to pay for such training should be discouraged because it is anti-motivator [. . .]." As previously discussed, understanding BIM technology via the Revit mechanism is key and has many benefits. Findings agree with Lee and Dossick (2012), Ayinla and Adamu (2018) and Oyewole and Dada (2019). Lee and Dossick (2012) recommended that academic staffers should stay in contact with the industry to reflect the trends and practices. Ayinla and Adamu (2018) found that training will answer hindrances faced by several countries and help them acquire the correct skills for BIM implementation. Oyewole and Dada (2019) found that BIM technology training could enhance integrated construction project delivery.

BIM technology is a capital-intensive project. Thus, collaboration is required from all stakeholders to get it right. "[. . .]. from ICT infrastructure to software procurement and maintenance requires high cost and complicated with scarcity of specialists [. . .]" Government and private organisations should integrate into this regard (P2, P15, P25 and P33). Results agree with Khoshfetrat *et al.* (2020), and it was suggested that apart from collaborative efforts in training BIM software users, the government, software developers and construction companies should increase their investment in BIM technologies. The technology has output augmentation capacities. Findings agree that polytechnic managers should do more concerning ICT infrastructure to enhance BIM technology education. "[. . .] a computer-friendly environment is important for BIM implementation. This includes connectivity, stable power supply, standby alternative, and smart infrastructure to align with BIM nomenclature [. . .]" said Participant P20.

5. Study's implications (theory, practice and social)

This section presents BIM technology via Revit in the Nigerian built environment polytechnic undergraduates' training and digitalisation, and their contribution to theory and practice.

5.1 The study's theory implication

The study examined the relevance and perceived issues hindering the implementation of BIM technology via Revit and offered measures to promote BIM usage in Nigeria's built environment polytechnic undergraduates' training and digitalisation. Findings reveal that BIM technology's relevance via Revit in training Nigeria's built environment polytechnic undergraduates and improving integrated project delivery cannot be overstated. This indicates that the technology is pertinent to developing the built environment stakeholders' collaboration from HEIs to practices. Hence, there is a need for more training in Nigeria's built environment polytechnic undergraduates using BIM technology. Twenty-four issues emerged as the possible factors hindering BIM technology implementation in training Nigeria's built environment polytechnic undergraduates. The 24 issues were grouped into government/polytechnic regulatory agency (NBTE)-related, polytechnic management-related and polytechnic undergraduate student-related hindrances in Nigeria's built environment context, as presented in Table 2. Besides the previous studies not covering polytechnic undergraduates, categorisation of perceived issues was missing in past studies and formed part of the theoretical implications. The findings show that BIM technology can improve cost database management and enhance integrated collaborative measurements. Also, BIM provides effective and efficient automatic quantification of contract documents and improved visualisation for a better understanding of designs. Exposing the intending middle-level manpower to the pre-career phase (polytechnic undergraduates) while still in HEIs is vital. The study will fill this gap.

5.2 The study's practice implication

Regarding the study's practical/managerial implication, the study provides polytechnic management, polytechnic regulatory agencies, built environment researchers, construction experts and policymakers with a detailed list of issues hindering the implementation of BIM technology via Revit in training Nigeria's built environment polytechnic undergraduates. The findings and recommendations might benefit polytechnic managers, policymakers, regulatory agencies, researchers and other stakeholders to start looking beyond BIM technology applications and focus on policies and programmes that will promote the full digitalisation of Nigeria's built environment programmes in the polytechnic. The policymakers and professionals might benefit from the identified issues and the measures to promote Nigeria's built environment polytechnic undergraduates' training and digitalisation. It forms part of the study's practical implication. From the international perspective, other countries with similar perceived BIM technology implementation issues in their technical/polytechnic institutions may modify and adapt the measures.

5.3 The study's social implication

For the study's social implication, the research offers the polytechnic management, polytechnic regulatory agencies, built environment researchers, construction experts, policymakers and students to appreciate the barriers facing BIM implementation via Rivet in the built environment programmes despite the benefits and its relevant to the medium workforce capacity building in the digitalisation era. Appreciating these issues may stir the regulatory agency (NBTE) in charge of Nigeria's polytechnics to review most of the curriculum, not just the built environment programmes but all to align with the 21st century where operations are achieved via digitalisation (software and electronic tools). Also, it would stir policymakers and other relevant authorities (Rectors) to invest more in technical/polytechnic BIM technology and upgrade existing facilities to a global minimum standard. The social impact of implementing some of the findings and recommendations might benefit polytechnic management, policymakers, regulatory agencies, researchers, students and industry. From the international perspective, it would expand the built environment graduates' employment opportunities because of the training and exposure to BIM applications regarding each discipline.

6. Limitations and areas for future study

The research covered BIM relevance, perceived issues impeding BIM technology implementation and proffered measures to promote BIM technology in Nigeria's built environment polytechnic undergraduates' training and digitalisation. The study's main limitation is the virtual interview approach adopted with 37 participants, reflecting the perspective of a small study group. Nevertheless, the findings were generalisable because apart from the interviewees being BIM knowledgeable, their years of experience and ranks speak volumes, apart from P26 – P37. The participants' experience has added to fortify the study's results. As part of the future study, a mixed methods research design is suggested to validate the findings and consider wide coverage to validate the findings. Constructs such as "scale of culture change," "inadequate enabling environment," "BIM demands new teaching method" and "staff resistance" should be further validated in future studies. Validating these variables in the future will form part of the study's contribution to the existing BIM technology frontier of knowledge.

7. Conclusion and recommendations

This study investigated the relevance of BIM technology, the issues hindering BIM implementation in training Nigeria's built environment polytechnic undergraduates and proffered measures to promote BIM technology in Nigeria's built environment polytechnic undergraduates' training and digitalisation. Findings show that BIM technology is germane in training Nigeria's built environment polytechnic undergraduates in the 21st century, but its usage in Nigeria's polytechnic is low. From the 37 participants engaged, 24 issues emerged and were categorised into government/regulatory agency-related, polytechnic management-related and polytechnic undergraduate students-related hindrances in Nigeria's built environment context.

The study proffers measures to improve BIM technology via Revit usage being promoted in Nigeria's built environment polytechnic undergraduates' training and digitalisation as follows:

- Firstly, the governments (polytechnic managers and regulatory agencies) should brace-up regarding training academic staff with BIM technology theory and practical knowledge. Upskilling and reskilling regarding BIM education and "train the trainers" scheme should not be self-sponsored affair. The Nigerian built environment polytechnic academic staff and students should specialise in BIM compliant software packages. This is germane and should be well documented in the curriculum. The NBTE (polytechnic regulatory agency) and the polytechnic managements should reset BIM education and training as a top priority in their mission statement and be supported with adequate funding. This is pertinent to drive the implementation. Training will proffer answers to perceived hindrances and improve the skills essential for BIM implementation. The BIM training outcome will enhance competence and lead to integrated project delivery.
- Secondly, collaboration and stakeholders' all-inclusiveness are germane to achieve education digitalisation in training middle-level workforce in Nigeria's HEIs. The government should collaborate with local and international BIM software developers. The outcome will ensure that the software is affordable and available. This will stir construction practitioners to embrace new construction technologies such as BIM. The government role regarding this is pertinent, especially in a developing country like Nigeria. It will demonstrate that the government supports the initiative. This is one pillar or enabler of BIM implementation.
- Empirical research is vital to monitor innovation and development. To achieve this, requires a level of investment. Thus, investment in BIM research to enhance its knowledge and develop localised BIM for implementation in the polytechnics cannot be over-emphasised. Thus, government and construction firms should invest in BIM technology, including BIM software training and development. It will promote great productivity, enhance construction project delivery efficiency and increment potentials.

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Appendix. Virtual interview questions

Dear Participant,

Request for virtual interview

Studies show that BIM technology can improve construction productivity regarding the design, construction and maintenance of a project life cycle in the 21st century. Revit has been identified as a frequently used tool for delivering BIM in the built environment. Studies about BIM technology via Revit are scarce in training middle-level workforce higher education institutions. Therefore, this research is titled: **BIM implementation for Nigeria's polytechnic built environment undergraduates: challenges and possible measures from stakeholders.** Specifically, the researchers will achieve this research through the following research objectives:

- to examine the benefits of BIM technology via Revit in training Nigeria's built environment polytechnic undergraduates;

- to investigate issues hindering the implementation of BIM technology via Revit in training Nigeria's built environment polytechnic undergraduates; and
- to proffer measures to promote digitalisation in Nigeria's built environment polytechnics via BIM implementation.

Note that the interview questions will be within the stated research questions. Responses provided by you will be collated and analysed with those of other engaged participants. It will make up the value and contribution to achieving the success of this research. The researchers will treat the information provided with confidentiality.

Thanks for the anticipated participation.

Regards.
Yours faithfully,
(Researchers)

Basic questions for the participants

- Please, for record purposes, what is the name of your organisation?
- Please, what is your position in the organisation?
- Please, how long have you been working?
- Are you knowledgeable regarding the BIM technology via Revit associated with the built environment?
- If yes to question 4, in general terms, from your perception, how can you describe the relevance of BIM technology to the built environment in Nigeria's polytechnics?
- Can you evaluate the BIM implementation level of importance to the built environment in Nigeria?
- As a stakeholder in the construction sector, are you satisfied with the applications of BIM technology in the training of the middle-level workforce via the polytechnics in Nigeria?
- If no to Question 7, what are the likely root causes from your perspective?
- From your perspective, what issues hinder BIM technology implementation of blockchain in Nigeria's built environment polytechnics?
- Please, what role can the key stakeholders play to mitigate these encumbrances facing BIM technology implementation in the Nigerian built environment polytechnics?
- What feasible policies can improve the applications of BIM technology in the Nigerian built environment polytechnics?
- If the applications of BIM technology in the Nigerian built environment polytechnics become successful, can it become a model for other developing countries' polytechnics with similar challenges?
- If yes, how can this be achieved?

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