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A STUDY OF BIM CAPABILITIES FOR QUANTITY SURVEYING PRACTICE IN NIGERIA

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ABSTRACT

Purpose: *This study investigates the impact of Building Information Modelling (BIM)–based cost estimating software on quantity surveying (QS) practice in Nigeria. It aims to evaluate the level of awareness, usage, and efficiency of BIM in cost management, while also identifying barriers and recommending strategies for wider adoption in the Nigerian construction industry.*

Design/Methodology/approach: *A descriptive survey research design was adopted, targeting construction professionals such as quantity surveyors, engineers, architects, and project managers. Data were collected using structured questionnaires, with responses analysed through Mean Item Score (MIS) and Pearson correlation tests using SPSS and Microsoft Excel. The reliability of the instrument was confirmed with a Cronbach's alpha value of 0.96, indicating a high degree of internal consistency.*

Findings: *Results revealed that while 96.3% of professionals were aware of BIM, only 36.2% actively used it for cost estimation. A slight majority (55.9%) had adopted BIM-based estimation methods, while 44.1% continued to rely on traditional approaches. Autodesk, QS CAD, and Revit were the most recognised software. BIM demonstrated significant positive impacts on cost accuracy, planning efficiency, collaboration, and timely project delivery. However, challenges such as high training and implementation costs, lack of skilled personnel, inadequate ICT infrastructure, and resistance to change hindered broader adoption.*

Research Limitations/Implications*: The study was limited to a relatively small sample size and focused mainly on professionals within Nigeria. Broader regional comparisons and longitudinal studies could provide deeper insights into BIM adoption trends across developing countries.*

Practical Implications: *The findings highlight the need for investment in training, supportive policies, ICT infrastructure, and affordable software solutions to enhance BIM integration in cost estimation and QS practices.*

Originality/Value*: This study provides empirical evidence on BIM adoption in Nigeria's QS practice, offering actionable insights for policymakers, construction stakeholders, and professional bodies seeking to bridge the gap between traditional and modern cost management practices.*

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Keywords: BIM software capabilities, Quantity Surveying practices, Quantity surveying, Cost estimation, Nigeria

1.0 INTRODUCTION

Several previous studies by various economists found that the construction industry forms a critical backbone of many nations' economies. This is mostly seen in developing countries where the construction industry directly affects the nation's GDP. Despite the surprising fact, some construction industries are not operating at their full potential due to several deficiencies in the layout plans, construction, procurement, and delivery of these projects (Ismail et al., 2016). Over the last decades, project managers realised that there were challenges in monitoring and delivery in the construction industry. This was characterised by multifaceted and fragmented challenges that seemed to involve many parties in a single project. With the rise of technology in the 21st century, there has been an eminent need to optimise the use of funds, time and labour in the construction industry by using computer-aided software.

This gap in the building sector has been filled by the Building Information Modelling software (BIM). BIM is simply referred to as the steps of making a digital model of a building or an infrastructure. Ever since the introduction of BIM, it has steadily been accepted in the construction sector around the world. This is due to its efficient and successful working processes that analyse different building and construction setups in an accurate and timely manner. BIM is widely recognised to have contributed to the success of many projects as it allows for coordination among project partners. Thereby, BIM reduces the chances of incompatibilities during the project design and implementation stages. BIM systems can insert, alter, update, or remove information from project models (Martins, 2014).

Previous researchers like Azhar (2011) and Olatunji et al. (2010) have made arguments that BIM has moved the traditional construction boundaries to more modern and efficient boundaries. Gayathri et al. (2013) identified some of the impacts BIM has had on the traditional construction industry, including the integration of construction and design, improved communication channels, and improved construction planning. BIM is widely accepted worldwide since it is a cost-effective and readily available tool for use. Despite the marvels BIM has achieved, many developing nations have yet to embrace BIM technology fully. Some of the challenges researchers have found include a lack of skilled personnel, a lack of favourable government policy towards its adoption, a lack of BIM education or experts, high implementation costs, resistance to change by existing professionals and possibly a lack of demand (Dawson, 2019).

One of the developing countries is Nigeria, which is located in the West African region. Nigeria has a huge infrastructure deficit of about 30% of the nation's GDP compared to the international benchmark of 70% of GDP set by the World Bank. This necessitates the dire need for transformative technology in Nigeria's construction industry to improve its infrastructure. Even with the poor performance of Nigeria's infrastructure, its construction market is expected to grow by 3.2% annually for the 2021 – 2025 period. In accordance with a study carried out by the World Bank, Nigeria would require about $3 trillion in investment in its construction industry to reduce the infrastructure deficit (Anthony, 2021).

Studies by Anifowose et al. (2018) discovered below 50% of quantity surveyors in Nigeria were acquainted with concepts of BIM. Some of the other deterrents to the discovery of BIM adoption include a lack of investment by both the public and private sectors in BIM technology, high implementation cost, poor internet connectivity, a lack of standard measures that facilitate BIM implementation, the belief that BIM is effective for major projects and a lack of trained professionals.

1.1 AIM OF THE STUDY

The study aims to investigate the impact of BIM-based cost estimating software in Quantity Surveying practice in Nigeria.

Objectives of the study

i. To evaluate the level of awareness of BIM usage in the construction sector in Nigeria.
ii. To explore challenges and barriers behind BIM implementation in Nigeria. iii. To evaluate the efficiency of BIM utilisation in quantity surveying roles in Nigeria.
iv. Compare the efficiency of BIM-based cost estimating with the traditional estimating approaches.
v. To critically appraise the best practice in cost estimating and develop a framework for quantity surveying service delivery in Nigeria.

2.0 LITERATURE REVIEW

2.1 BIM-BASED COST ESTIMATING SOFTWARE

BIM-based estimation consists of the use of programmatic progression that adopts data, links data to their unit costs, and exports the data. The use of BIM adopts a different estimation process, contrary to the conventional approaches used in estimating quantities (Ashworth, 2010). Manual cost estimation involves taking off to preparing a draft bill of quantities.

According to Morovvati (2021), through the integration of BIM-enabled estimators in construction project activities, it is possible to reduce the cumbersome manual methods previously used by many professionals. Previous researchers have recommended that BIM-enabled estimators demand proper knowledge and skills different from traditional techniques previously used. BIM cost estimators provide a fast, accurate and cost-effective solution when compared to previously used techniques. BIM automates the cost estimation approaches, making it more efficient than all traditional methods employed to perform the same job. BIM software can automatically estimate quantities by overruling the enormous traditional methods of cost estimation, leaving the estimator with an easy time to generate estimates and review the output. Studies done by Eastman et al. (2011) and Autodesk (2007) identify some ways of conducting a detailed BIM cost estimation.

2.2.1 Linking BIM software to estimating software

It involved directly linking BIM estimation software to the BIM input software; some of the linking is done through the use of Plugins and programs that may be integrated into others to perform secondary tasks. Some of the applications that can be linked include Innovaya, Timberline Tocomanilink and Revit, which would generate quantities and design tools that would aid in visualising the estimates of the structures. This method is convenient as any quantity not automatically generated can be visually identified and manually entered into the software.

2.2.2 Exportation of quantities generated to the estimating software

Here, quantities are extracted from 3D BIM software into estimation software, where unit rates are given, and then cost estimates are generated. According to Moses and Hampton (2017), "importing

of quantities from a BIM environment to estimating software involves the selection of elements as a group or individually."
An example of an application capable of this is Microsoft Excel. Research by Eastman et. al. (2011) discovered that several BIM software can export quantities to a spreadsheet, which enables surveyors to price quantities. However, it is ineffective to export generated quantities if the spreadsheet and BIM model are not directly linked, whereby any changes made on the model are directly reflected in the spreadsheet (Hardin, 2009).

2.2.3 Quantity take-off approach

It adopts the application of quantity take-off characteristics that use information obtained from a 3D model, depending on the amount of information the models provide, and also allows for adjustments to be made based on user preferences. Some of the software capable of quantity take-off includes Vico, Exactal QTO and Autodesk QTO.

2.2 BIM USE AND CONSTRUCTION PROFESSIONALS

BIM is an important tool used in the modern-day construction industry by various stakeholders. Its usage varies from the project inception stage to its completion stage. Various professionals, such as structural engineers, facility managers, architects, estate surveyors, quantity surveyors and many other professionals whose duties interact during the construction of buildings, use BIM. Some of the uses of BIM at various stages of a building are highlighted below.

2.4.1 Design Stage

Building designs are usually conducted by structural engineers, architects, and builders, depending on how complex the proposed structure is. The design stage is one of the most critical stages during the life of a building, as all decisions on geometry and structure are made during the design stage. According to Foster (2011), BIM is used at the design stage in construction planning, cost estimation, concept visualisation, prefabrication, incorporating sustainability issues, constructability analysis and 3D coordination. The design team would then produce the project requirements for the client and project stakeholders in a more understandable format. This is important as the client is the project financer and must feel confident in the viability of his/her undertaking. The design team may use BIM to ensure client confidence by displaying the aesthetics, structural functionality, structural ability and buildability (Babarinde, 2017).

2.4.2 Construction / Building Stage

This stage comes after completion of the design stage, whilst the building was being constructed, when issues concerning construction, management and funding of the structure were addressed. At this stage, the contractor is selected, and the client's design team assumes a supervisory role. The contractor provides a detailed design and 3D model of the building, and offers his/her expert opinion on constructability and other construction-related issues based on his/her experience (Babarinde, 2017).

Some of the key uses for BIM during the construction stage would include fabrication, modelling and monitoring. BIM modelling would enable the contractor's team of experts (structural engineers, architects, quantity surveyors) to visualise the stage-by-stage construction process simulation. Through his efforts, there would be an ease of work as all experts involved would settle issues surrounding the building at the appropriate time through planning.

2.4.3 Operation / Facility Management Stage

Previous research has indicated that this stage of construction receives the highest levels of neglect by professionals and may lead to gross infrastructural decay. BIM-compliant software can incorporate management and operation decisions in managing buildings effectively. BIM can effectively plan and schedule maintenance, and also check that the functionality of the inherent components of the facility meets the expected population without deficiencies. The future of facility management rests on the industry's willingness to adopt BIM technology for building management (Patacas et al., 2014). This is especially in high-rise buildings that are under development in various states all over the world. BIM is a convenient tool for facility managers as the structures usually pose great challenges due to the numerous components and aspects that warrant consideration.

Therefore, with the help of BIM technology, facility managers can schedule maintenance using the Construction Model Building System Analysis. The BIM software would be able to determine the condition of the building at any point in time, and the asset management functions of the structure would be able to adequately allocate floor space to its intended use through visual simulation tools and incorporate all changes made to the building. The record model would track all the alterations to the structure spaces and be used at the post-construction stage (Jordani, 2010). Some of the BIM software that exists in the construction industry, and their respective applications, are highlighted in

Table 1 : BIM Software, their use and services they offer

Software	Use	Professionals	Services Available
Tekla Structures	It is used for Steel and Concrete Detailing of structural models	Structural, Steel and Civil Engineers	Structural Designer, Tedds, BIMSight
Archicad	Architectural BIM CAD	Architects and Civil Engineers	Parametric Modelling and Design, Data Interchange, Remote Access and Collaboration
ArchiFM	Asset Planning, Maintenance, Reporting	Services Facility Managers, Estate Surveyors	BIM Computer Aided Facility Management Software
Green Building Studio	Analysis of Green Building requirement, Energy Analysis, Interoperability	Green Building Experts, Designers, Contractors and Planners	BIM-Green Building Standards Integration Module.
Masterbill	Integrated CAD and BIM-enabled measurement Module	Quantity Surveyors, Estate Surveyors, Project Schedulers	BIM Enabled estimating and Scheduling (4D BIM)
Revit Architecture	Architectural Designs, Structural and MEP modelling	Architects, Services and Civil Engineers	4D BIM modelling and Parametric Design
Sketchup	Architectural and Mechanical Design and Models, Interior design	Architects, Mechanical and Interior Designers.	3D modelling
PowerCivil	Integrated site, building and aerial planning	Design Team	Site Development
Digital Project	Information Sharing and Interoperability of various CAD software	Architects, Modelers, Schedulers	Architectural computer-aided design
Navisworks Manage	Complement 3D Design Packages, 4D Time simulation	Architects, Quantity Surveyors, Scheduler, Project Managers	Roamer, Publisher, Clash Detective, Autodesk Renderer, Quantification, Timeliner, Animator, Scripter
Autodesk Quantity Takeoff	Quantity Take-offs	Quantity Surveyors, Scheduler	3D and CAD enabled quantity taking of
VICO Software	Virtual Construction, Quantity Take-offs, Project Scheduling, Cost Estimation, Production Control	Contractors, Quantity Surveyors, Scheduler	5D BIM Virtual Construction
Bentley BIM Suite	Architectural Designs, Structural and MEP modelling	Architects, Services and Civil Engineers	Architectural, engineering and Construction, 3D Modelling
QS CAD	Quantity Take-offs	Quantity Surveyors	3D and CAD enabled quantity taking of

Source: Babarinde (2017)

2.3 COST ESTIMATION

Cost estimation is a critical part of most construction projects. Costs always determine the feasibility of a construction project, as the available resources can be compared against the cost of construction. Traditional methods of cost estimation were identified as subject to the estimator's knowledge, inaccurate and lacking standardised methodology and procedures, thus unsuitable for construction cost decision making (Akintoye & Fitzgerald, 2000). Traditional cost estimations are subordinate to BIM-based cost estimation as they consume lots of time and produce lower quality cost estimates (Elbeltagi, 2014).

When manual methodologies are used, there is a delay between the delivery of designs as estimation inputs and the cost estimation outputs. This has been attributed to the slow and inefficient manual cost estimation (Forgues et al., 2012). The increased application of BIM by designers aided the cost estimation process by producing quantity take-offs that are relatively accurate at reduced times. Microsoft Excel is extensively used for cost estimation after quantity take-offs are exported from the BIM model, thus preserving traditional methods of cost estimation (Eastman et al., 2018).

3.0 METHODOLOGY 3.1 Research Design

A descriptive survey design was adopted to ensure accurate reporting and measurement of all relevant elements and information in the study. The descriptive survey allows for accurate, valid and reliable collection of data on BIM cost estimating in Nigeria (Anthony, 2021).

The questionnaire was distributed to construction professionals who were deemed to be the most knowledgeable. The study adopted the Likert scale in capturing questionnaire responses.

3.2 The Population of Study

The target population for this study consisted of construction professionals such as quantity surveyors, engineers, architects, project managers, and any other construction professionals not identified above. A sample was chosen from the population of the study.

Sample and Sampling Techniques

This study adopted both the judgment and convenience sampling methods. The convenience sampling method was selected because all potential respondents had to be willing to create time to respond to the data collection tool. On the other hand, judgment sampling was selected as the researcher had to filter respondents based on their ability to inform the study (Creswell & Creswell, 2017).

Professional	Populaation	% of Total Population
Quantity Surveyors	36	60%
Architects	8	13.3%
Project Managers	11	18.3%
Other professionals	5	8.3%
Total Population	60	100%

Table 2: Population of Study

3.3 Method of Data Analysis and Presentation

Data analysis was conducted through the use of SPSS and Microsoft Excel. Mean Item Score and inferential analysis (Pearson Correlation) were used to analyse the data (Schober et. al., 2018). MIS uses a scale for individual factors to ascertain the ranks of various factors. MIS is mathematically depicted below.

$$MIS = \frac{5n_5 + 4n_4 + 3n_3 + 2n_2 + n_1}{(n_5 + n_4 + n_3 + n_2 + n_1)}$$

Where, n_1 = Very Low Impact n_2 = Low Impact n_3 = Average Impact

n_4 = High Impact n_5 = Very High Impact

3.4 Reliability of the questionnaire

The reliability of the questionnaire was analysed with the use of Cronbach's alpha (α). An overall value of Cronbach's alpha for the questionnaire above 0.7 was considered as reliable (Cronbach, 1951). Cronbach's alpha was determined as follows.

From the determined Cronbach alpha value of 0.96, the questionnaire was determined to be reliable

$$Cronbach\ Alpha\ (\alpha) = \frac{No.of\ Questions}{No.of\ Question - 1}\ X\ \frac{1 - Sum\ of\ Variance}{Variance\ of\ Total\ Score}$$

From Excel Data Analysis,

No. of Questions = 30

Sum of Variances = 38.1474

Variance of Total Scores = 508.57

$$Cronbach\ Alpha\ (\alpha) = \frac{30}{30 - 1}\ X\ \frac{1 - 38.1474}{508.57}$$

$$\boldsymbol{Cronbach\ Alpha\ (\alpha) = 0.96}$$

(0.96 > 0.7). The value is displayed in the appendix attached at the end of the report.

L58 | 4

	A	K	L	M	N	O	P
1	Unique Response Number	10.1. Improved planning process	10.2. The ability to link the relevant quantities and cost information to the building model and update them simultaneously to design changes	10.3. Advice on procurement	10.4. Tender documentation preparati	10.5. Supervision of construction works.	10.6. Time of task/project completi
62	Total	60	60	60	59	59	60
63	Maximum	5	5	5	5	5	5
64	Minimum	1	1	1	1	1	1
65	Mean Score	3.933333333	3.966666667	3.633333333	3.830508475	3.576271186	3.95
66	Standard Deviation	1.191305603	1.301455074	1.365018987	1.219843721	1.28925787	1.294381601
67	Variance	1.41920904	1.693785311	1.863276836	1.488018703	1.662185856	1.675423729
68	Median	4	4	3	4	3	3.5
69	Mode	5	5	5	5	5	5
70	No. Of responses	60	60	60	59	59	60
71	No. of Questions	30					
72	Sum of Variances	38.14735868					
73	Variance of Total Scores	508.570339					
74	Cronbach Alpha	0.956887229	RELIABLE				

Sheet 1 | Project Demographics

4.0 RESULTS AND ANALYSIS 4.1 BIM Adoption in Nigeria

55.9% of the respondents adopted BIM cost estimation for their projects. This was rivalled by 44.1% of the respondents who did not adopt BIM for cost estimation in their projects. This showed that barely more than half of the population had adopted the use of BIM in cost estimation. The other great percentage of professionals were still using traditional methods that are cost-inefficient, timeconsuming and vulnerable to human error. These results indicated a slow rate of BIM adoption in the country when compared to developed countries, whose adoption of BIM is greater. These outcomes are displayed in Figure 4.1

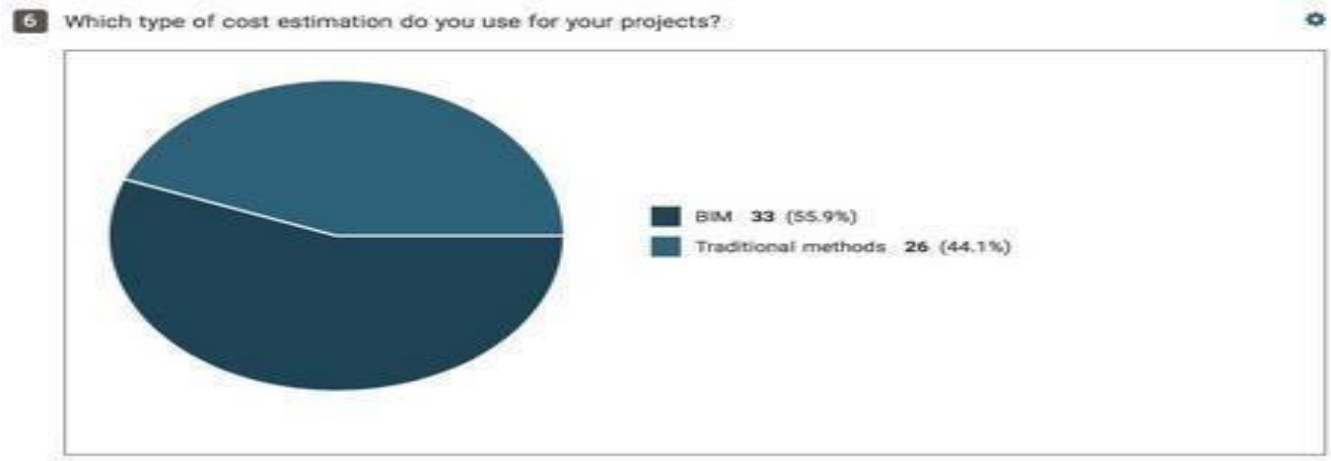


Figure 4. 1 Method of Cost Estimation Adopted

4.2 BIM Software Used in Nigeria

The majority of Nigeria's construction professionals are familiar with Autodesk, which was known by 28% of the respondents, QS CAD, which was known by 19.4% of the professionals, followed by this. Revit was known by 18.3% of the respondents, while Master Bill was understood by only 108% of the population. 23.7% of the professionals were familiar with other cost estimation software available in the construction market. There were no professionals familiar with Archaised, as it had a 0% response rate. These outcomes are displayed in Figure 4.2

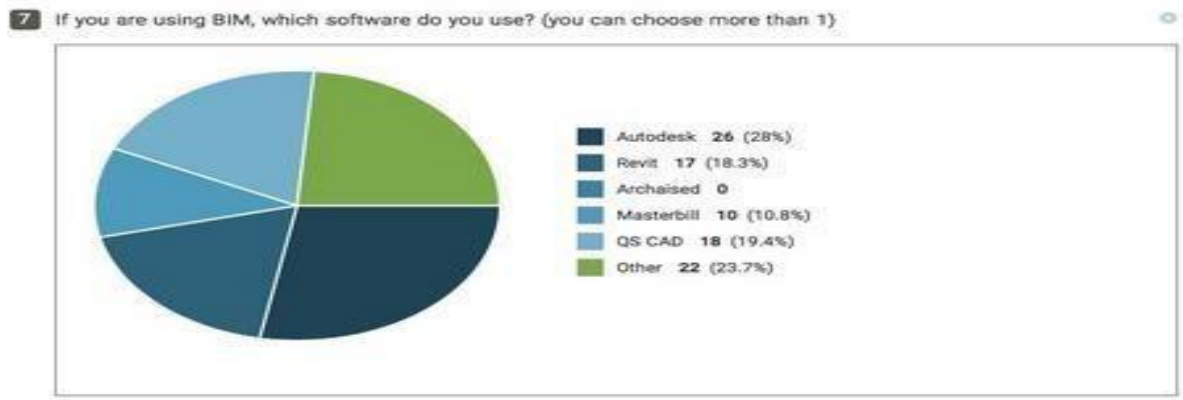


Figure 4. 2 BIM Software used in Nigeria

4.3 BIM Awareness

The majority of the responders were aware of BIM but had not used it before. This group contributed to about 46.6% of the respondents. 36.2% of those polled were aware of BIM and were already employing BIM in cost estimation practices. Another 13.8% of the respondents have heard of BIM but had used it before for purposes other than cost estimation. Only 3.2% of the respondents were not aware of BIM. It was encouraging that only 3.4% of the respondents had not heard of BIM. However, more measures should be put in place to increase the usage of BIM, as the majority of the respondents have heard of BIM but have not used it before. The results in Figure 4.8

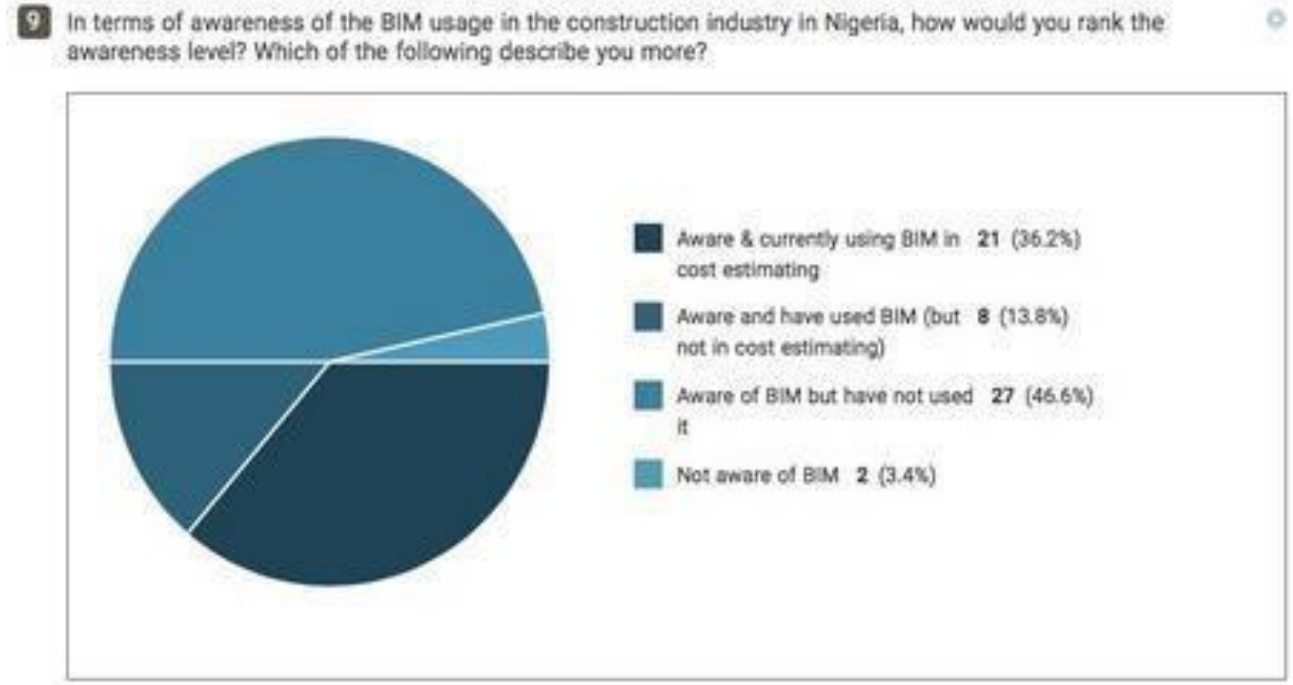


Figure 4. 4 Awareness of BIM in cost estimation

Participant number	(Not aware of BIM)= 0 (Aware of BIM but have not used it) =1 (Aware and have used BIM (but not in cost estimating)) = 2 (Aware & currently using BIM in cost estimating) =3
	Q11.1.1
	9. In terms of awareness of the BIM usage in the construction industry in Nigeria, how would you rank the awareness level? Which of the following describe you more?
1	2
2	2
3	1
4	1
5	1
6	2
7	1
Participants from 10--56 are hidden for brevity	
57	2
Count	57
Minimum	0
Maximum	3
Range	3
Overall total Score (Sum)	106
Median	2
Mode	1
Standard Deviation	1
Variance	0.91
Mean Score	1.86
Percentage Mean Score	46%

Figure 4.5 Responses on BIM Awareness in Nigeria

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Participant number	(Very low impact) =1 (Low impact) = 2 (Average impact) =3 (High impact) = 4 (Very High impact) = 5										Count	Minimum	Maximum	Range	Median	Mode	Standard deviation	Variance	Mean score	Overall total score B to P	Total Percentage AF/21/6*100
	10.1.	10.2.	10.3.	10.4.	10.5.	10.6.	10.7.	10.8.	10.9.	10.10.											
	Improved planning process	The ability to link the relevant quantities and cost information to the building model and update them simultaneously to design changes	Advice on procurement	Tender documentation preparation	Supervision of construction works.	Time of task/project completion	Estimation of project costs	Quality of completed tasks/projects	Ease of collaboration with other consultants	Project and overall construction safety											
1	3	4	4	3	5	5	3	4	4	5	10	3	5	2	4	4	0.82	0.67	4.00	40	80%
2	4	4	2	2	2	5	4	3	4	2	10	2	5	3	3.5	4	1.14	1.29	3.20	32	64%
3	4	4							4	4	10	4	4	0	4	4	0.00	0.00	4.00	40	80%
59	5	5							5	4	10	3	5	2	5	5	0.84	0.71	4.40	44	88%
60	5	5	4	5	4	5	5	5	5	5	10	4	5	1	5	5	0.42	0.18	4.80	48	96%
Count	60	60	60	59	59	60	60	60	60	60											
Minimum	1	1	1	1	1	1	1	1	1	1											
Maximum	5	5	5	5	5	5	5	5	5	5											
Range	4	4	4	4	4	4	4	4	4	4											
Overall total Score (Sum)	236	238	218	226	211	237	241	218	233	224	2282										
Median	4	4.5	4	4	4	4.5	4	4	4	4											
Mode	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00											
Standard Deviation	1	1	1	1	1	1	1	1	1	1											
Variance	1.42	1.69	1.86	1.49	1.66	1.68	1.54	1.83	1.66	1.59											
Mean Score	3.93	3.97	3.63	3.83	3.58	3.95	4.02	3.63	3.88	3.73	3.82										
Percentage Mean Score	79%	79%	73%	77%	72%	79%	80%	73%	78%	75%	**76%**										

Participants from 4-58 are hidden for brevity

Figure 4.5 Analysis Use of BIM in the Construction Process

Table 4. 1 Use of BIM in the Construction Process

Q. No.	Statement	Median	Mode	Standard Deviation	Variance	Mean Score	Percentage Mean Score
10.1.	Improved planning process	4	5	1.19	1.42	3.93	78.67%
10.2.	The ability to link the relevant quantities and cost Information to The building model and update them simultaneously to design changes	4.5	5	1.30	1.69	3.97	79.33%
10.3.	Advice on procurement	4	5	1.37	1.86	3.63	72.67%
10.4.	Tender documentation preparation	4	5	1.22	1.49	3.83	76.61%
10.5.	Supervision of construction works.	4	5	1.29	1.66	3.58	71.53%
10.6.	Time of task/project completion	4.5	5	1.29	1.68	3.95	79.00%
10.7.	Estimation of project costs	4	5	1.24	1.54	4.02	80.33%
10.8.	Quality of completed tasks/projects	4	5	1.35	1.83	3.63	72.67%
10.9.	Ease of collaboration with other consultants	4	5	1.29	1.66	3.88	77.67%
10.10.	Project and overall construction safety	4	5	1.26	1.59	3.73	74.67%

Most respondents agreed that BIM improved the planning process; they agreed that BIM was able to connect the pertinent quantities and building cost information and update them simultaneously. Some of the respondents agreed that BIM could offer advice in the procurement process.

Some of the respondents knew that BIM was useful during the tender documentation. Many respondents barely knew that BIM could be used as a supervision tool. BIM also aided the timely conclusion of tasks and the general project; many respondents seemed to agree with this statement. Many respondents agreed that BIM ensured that tasks performed met the desired quality standards. BIM also eased communication between stakeholders, which was validated by the respondents who agreed with that fact. Finally, most of the respondents agreed that BIM being used improved the project's overall safety.

Barriers to BIM Implementation.

Participant number	(Very low impact) =1	(Low impact) = 2					(Average impact) =3			(High impact) = 4			(Very High impact) = 5			Count	Minimum	Maximum	Range	Median	Mode	Standard deviation	Variance	Mean score	Overall total score B to P	Total Percentage AF/21/6*100
	11.1.	11.2.	11.3.	11.4.	11.5.	11.6.	11.7.	11.8.	11.9.	11.10.	11.11.	11.12.	11.13.	11.14.	11.15.										
	Lack of Skilled personnel	Lack of awareness of BIM technology	Frequent power failure	Lack of internet connectivity	Lack of BIM object libraries	High implementation cost (training, software and hardware)	Resistance to change to modern technology by construction professionals	Reluctance of stakeholders towards the use of BIM	Lack of trained professionals to handle BIM cost estimation tools	Lack of proof of financial benefits	An erroneous belief that BIM is effective for big projects	Data exchange issues in BIM tools	Standardization challenges	Substandard quality of BIM models	Cost of Training & education										
1	5	5	4	4	5	5	4	5	5	4	4	5	5	3	4	15	3	5	2	5	5	0.64	0.41	4.47	67	89%
2	3	2	2	2	3	4	Participants from 4 to 58 are hidden for brevity					3	2	2	4	15	2	4	2	3	3	0.74	0.55	2.87	43	57%
3	4	4	4	4	4	4						4	4	4	4	15	4	4	0	4	4	0.00	0.00	4.00	60	80%
59	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	15	4	5	1	5	5	0.26	0.07	4.93	74	99%
60	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	15	5	5	0	5	5	0.00	0.00	5.00	75	100%
Count	60	60	60	60	60	60	60	60	60	60	59	58	59	60	60											
Minimum	1	2	1	1	1	2	1	1	1	1	2	1	1	1	2											
Maximum	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5											
Range	4	3	4	4	4	3	4	4	4	4	3	4	4	4	3											
Overall total Score (Sum)	249	237	233	231	237	256	246	238	246	231	241	218	220	215	259	3557										
Median	5	4	4	4	4	5	4	4	4	4	4	4	4	4	5											
Mode	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	4.00	4.00	5.00											
Standard Deviation	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1											
Variance	1.25	1.34	1.73	1.25	1.34	0.91	1.07	1.52	1.14	1.08	1.04	1.41	1.17	1.30	0.90											
Mean Score	4.15	3.95	3.88	3.85	3.95	4.27	4.10	3.97	4.10	3.85	4.08	3.76	3.73	3.58	4.32	3.97										
Percentage Mean Score	83%	79%	78%	77%	79%	85%	82%	79%	82%	77%	82%	75%	75%	72%	86%	79%										

Figure 4. 1 Analysis of Barriers Towards BIM Implementation

Table 4. 2 Barriers towards BIM Implementation.

Q. No.	Statement	Median	Mode	Standard Deviation	Variance	Mean Score	Percentage Mean Score
11.1	Lack of Skilled personnel	5	5	1.12	1.25	4.15	83.00%
11.2	Lack of awareness of BIM technology	4	5	1.16	1.34	3.95	79.00%
11.3	Frequent power failure	4	5	1.32	1.73	3.88	77.67%
11.4	Lack of internet connectivity	4	5	1.12	1.25	3.85	77.00%
11.5	Lack of BIM object libraries	4	5	1.16	1.34	3.95	79.00%
11.6	High implementation cost (training, software and hardware)	5	5	0.95	0.91	4.27	85.33%
11.7	Resistance to change to modern technology by construction professionals	4	5	1.04	1.07	4.10	82.00%
11.8	Reluctance of stakeholders towards the use of BIM	4	5	1.23	1.52	3.97	79.33%
11.9	Lack of trained professionals to handle BIM cost estimation tools	4	5	1.07	1.14	4.10	82.00%
11.10	Lack of proof of financial benefits	4	5	1.04	1.08	3.85	77.00%
11.11	An erroneous belief that BIM is effective for big projects	4	5	1.02	1.04	4.08	81.69%
11.12	Data exchange issues in BIM tools	4	5	1.19	1.41	3.76	75.17%
11.13	Standardization challenges	4	4	1.08	1.17	3.73	74.58%
11.14	Substandard quality of BIM models	4	4	1.14	1.30	3.58	71.67%
11.15	Cost of Training & education	5	5	0.95	0.90	4.32	86.33%

From the data collection tool, it was discovered that inadequately skilled personnel were part of the difficulties BIM usage encounters in Nigeria's construction industry. Most of Nigeria's construction professionals were also attributed to a lack of understanding of BIM technology. The nation had frequent power failures that might have hindered the use of computers in BIM costing. This was also coupled with a lack of Internet connectivity that limited respondents' ability to access online BIM materials.

It was noted that Nigeria's construction professionals lack BIM object libraries that may be used to develop the respondents' skills and knowledge on the subject. There was a high implementation cost of BIM in the country due to existing taxes, tariffs and generally unfavourable infrastructure that may be used in the training of professionals, purchase of software and hardware. Some of the professionals were also resistant to the change to modern technology.

There was also some reluctance among stakeholders towards the use of BIM in cost estimation. Some experts were insufficiently trained to handle BIM cost estimation tools in Nigeria. Due to the small sample size of projects that have adopted the use of BIM, there is limited proof of financial benefits that may be accrued by the use of the software. Some construction experts believed that BIM is effective only for big projects. A few cases of data exchange issues in BIM tools were noted. Some construction professionals reported that there were challenges facing the adoption. Another challenge discovered was that people produced a substandard quality of BIM models, which might influence respondents' dissatisfaction. Finally, the respondents agreed on the cost of training & education.

Participant number	Offering training and awareness programs for construction professionals towards adoption of BIM.	Increased support from organisational leadership towards building information modelling.	Commitment of construction industry stakeholders towards investing in software, hardware and training of professionals.	Improved government policies and investment towards software, hardware and relevant ICT technology.	Software affordability and availability at professional levels to ensure smooth implementation.	Count	Minimum	Maximum	Range	Median	Mode	Standard deviation	Variance	Mean score	Overall total score B to F	Total Percentage O/5/5*100
1	5	5	4	4	4	5	4	5	1	4	4	0.55	0.30	4.40	22	88%
2	5	4	4	3	2	5	2	5	3	4	4	1.14	1.30	3.60	18	72%
3	4	Participants from 7--56 are hidden for brevity					4	4	0	4	4	0.00	0.00	4.00	20	80%
4	5						5	5	0	5	5	0.00	0.00	5.00	25	100%
5	1	2	3	5	5	5	1	5	4	3	5	1.79	3.20	3.20	16	64%
6	4	4	3	4	3.75	5	3	4	1	4	4	0.43	0.19	3.75	18.75	75%
57	5	5	5	5	5	5	5	5	0	5	5	0.00	0.00	5.00	25	100%
58	5	5	5	5	5	5	5	5	0	5	5	0.00	0.00	5.00	25	100%
59	5	5	5	5	5	5	5	5	0	5	5	0.00	0.00	5.00	25	100%
60	5	5	5	5	5	5	5	5	0	5	5	0.00	0.00	5.00	25	100%
Count	58	59	60	60	60											
Minimum	1	2	1	2	2											
Maximum	5	5	5	5	5											
Range	4	3	4	3	3											89%
Overall total Score (Sum)	266	265	266	272	276.75	1345.75										
Median	5	5	5	5	5											
Mode	5.00	5.00	5.00	5.00	5.00											
Standard Deviation	1	1	1	1	1											
Variance	0.81	0.70	0.96	0.52	0.59											
Mean Score	4.59	4.49	4.43	4.53	4.61	4.53										
Percentage Mean Score	92%	90%	89%	91%	92%	89%										
Internal reliability Coffecient																

Figure 4. 2 Analysis of Solutions Towards BIM Implementation

4.4.3 Solutions Towards Implementation

Table 4. 3 Solutions Towards Implementation of BIM

Q. No	Statement	Median	Mode	Standard Deviation	Variance	Mean Score	Percentage Mean Score
12.1.	Offering training and awareness programs for construction professionals towards adoption of BIM.	5	5	0.89	0.80	4.58	91.53%
12.2.	Increased support from organisational leadership towards building information modelling.	5	5	0.84	0.70	4.49	89.83%
12.3.	Commitment of construction industry stakeholders towards investing in software, hardware and training of professionals.	5	5	0.94	0.87	4.47	89.49%
12.4.	Improved government policies and investment towards software, hardware and relevant ICT technology.	5	5	0.65	0.42	4.58	91.53%
12.5.	Software affordability and availability at professional levels to ensure smooth implementation.	5	5	0.69	0.47	4.67	93.45%

Most of the respondents believe that challenges in Nigeria's construction industry may be overcome through the offering of training and awareness programs for construction professionals towards the adoption of BIM. They also believed that increased support from organisational leadership towards Building Information Modelling would greatly help integrate BIM in the industry. They also recommended the commitment of construction industry stakeholders towards investing in software, hardware and the training of professionals. They believed that improved government policies and investment towards software, hardware and relevant BIM-related ICT technology would improve its integration in the construction industry. Finally, the software's affordability and availability at professional levels should be assessed to ensure smooth implementation of the BIM technology in cost estimation in Nigeria.

4.4 Discussions

More than half of the respondents are reported to have transitioned to using BIM in construction cost estimation. This was represented by a response rate of 55.9% of respondents who reported using BIM in cost estimation. This transition was encouraging as most third-world countries had lower BIM usage (Ezeokoli et. al., 2021). Nigeria's construction industry is encouraged to continue adopting BIM as an alternative to the traditional methods used, as it is more efficient, convenient and accurate. The BIM software mostly used in Nigeria is Autodesk, which had a response rate of 28%. This was closely followed by QS CAD and Revit with 19.4% and 183% response rates. Master Bill had a response rate of 10.8%. None of the respondents used Archaised for cost estimation. The remaining 23.7% of the respondents reported using other cost estimation software.

The development of BIM in cost estimation threatened only 11.7% of the respondents, as they felt that they were at risk of losing their jobs. This was rivalled by 88.3% who were assured of their job security, even with the growth of BIM in Nigeria's construction sector. Construction professionals are encouraged to adopt BIM to assure them of job security, as this is the trend used by modern-day cost estimators, such as project managers and quantity surveyors.

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Table 5. 1 Summary of Data Analysis

Summary sheet for all the objectives				
Objective number	Section 9	Section 10	Section11	Section 12
Description / Participant number	Awareness	The impact of BIM in construction planning	Barriers of BIM implementation for cost estimation in Nigeria	Solutions to improve the adoption of BIM in Nigeria
1	2	80%	89%	88%
2	2	Participants 3 to 56 are hidden for brevity	57%	72%
57	2		65%	100%
58	Missing value	100%	81%	100%
59	Missing value	88%	99%	100%
60	Missing value	96%	100%	100%
Overall total average	46%	76%	79%	89%
Summary of the results	High score means, high level of awarness in cost estimation in Nigeria	High score means high agreement on the impact of BIM in construction planning	High score means high agreement on the research suggested barriers of BIM implementation for cost estimation in Nigeria	High score means high agreement on the solutions suggested in the research to improve the adoption of BIM in Nigeria

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4.4.1 BIM Usage in Nigeria

When assessing the usage of BIM, only a mere 36.2% of the responders were aware of BIM cost estimation software and were currently using it. 13.8% of the responders were aware of BIM but had not used it in cost estimation. A further 46.6% had heard of BIM but had not used it at all. About 3.4% of the respondents had not heard of BIM. From the statistics, it was clear that there was interest in BIM usage in Nigeria. With the small percentage of respondents lacking information on BIM, it is easier to advocate the use of BIM because many people are aware of it but may not have made any efforts to incorporate it into their daily practices.

BIM had a huge impact on the construction planning process. It was discovered that BIM had its largest impact on cost estimation, with a percentage mean score of 80.3. %, This was closely followed by the capacity of BIM to connect pertinent quantities and cost information to the building model updated concurrently, which had a percentage mean of 79.33%. BIM's impact on timely task completion was observed to have a percentage mean of 79.0%. This was closely followed by BIM's ability to improve the construction planning process, which had an average of 78.67%. Next was BIM's ability to ease collaboration among experts, with a percentage mean of 77.67%. BIM's impact on the tender document preparation and the project's overall safety, followed by a percentage mean of 76.61% and 74.67% respectively. The quality of completed tasks due to the use of BIM provides advice on procurement, and each had a percentage mean of 72.67%. BIM was reported to have had the lowest impact on the supervision of the construction works, with a percentage mean of 71.53%.

Overall, BIM was reported to have a huge positive impact, as all the responses were above the average percentage response of 50% which would have meant its impact was neutral. This was very encouraging as a positive impact meant that it was easily marketable to prospective users in Nigeria's construction market. Further, the percentage mean of the responses shows that the user's experience was positive, which was encouraging.

4.4.2 Challenges Facing BIM Implementation in Nigeria

The greatest challenge to adopting BIM in Nigeria's construction sector is the cost of training and education on BIM technology, with a mean response of 86.33%. This was followed by the high implementation cost of BIM, with a percentage mean score of 85.33%. Nigeria also had challenges due to a lack of skilled personnel to handle BIM cost estimation (percentage mean = 83.0%). The results showed that both resistance to change towards modern technology by Nigeria's construction professionals and the lack of trained professionals who could handle BIM cost estimation tools were major challenges, as their mean percentage was 82.0%. There also existed a misconception that BIM was effective for big projects (the mean percentage was 81.69%). Reluctance of stakeholders towards the use of BIM had a percentage mean score of 79.33%. This was closely followed by inadequate understanding of BIM technology, including a lack of BIM object libraries, with a percentage of 79.0% each.

Other challenges, such as recurring electricity outages, inadequate Internet connectivity and lack of proof of financial benefits, had a percentage mean score of 77.67% 77.0% and 77.0% respectively. There were challenges of data exchange and standardisation, each with a percentage mean score of 75.17% and 74.17% respectively. The least challenge was the substandard quality of BIM models. From the challenges, it was discovered that all the challenges were significant as they exceeded the neutral percentage mean of 50%. Challenges in infrastructure, education and technology form some of the key issues that should be addressed by Nigeria's construction bodies. These are some of the

most important concerns that facilitate BIM adoption. Failure to address these challenges may limit the growth of BIM due to the hostile environment that does not facilitate BIM growth.

Table 5. 2 Rank of Challenges affecting BIM implementation

Rank	Challenge
1	Cost of Training & education
2	High implementation cost (training, software and hardware)
3	Lack of Skilled personnel
4	Resistance to change to modern technology by construction professionals
4	Lack of trained professionals to handle BIM cost estimation tools
6	An erroneous belief that BIM is effective for big projects
7	Reluctance of stakeholders towards the use of BIM
8	Lack of awareness of BIM technology
8	Lack of BIM object libraries
10	Frequent power failure
11	Lack of internet connectivity
12	Lack of proof of financial benefits
13	Data exchange issues in BIM tools
14	Standardization challenges
15	Substandard quality of BIM models

4.4.3 Solutions towards the Adoption of BIM in Nigeria

The possible solutions towards the adoption of BIM were offered to the respondents. The solution that seemed to offer the most impactful positive outcome was software availability and affordability at professional levels (Percentage mean = 93.45%). This was related to the high costs of software acquisition, which is controlled by the software developers. Possible incentives by the developers in terms of discounts, gifts, training, and favourable costing would effectively encourage the adoption of BIM in cost estimation in Nigeria.

Training and awareness programs aimed at encouraging construction professionals towards adopting BIM were also seen as a suitable solution. This went hand in hand with improving government policies and investment towards fostering the growth of BIM in the country through ICT. They both had a percentage mean response of 91.53%. Further, all construction-related companies/organisations are encouraged to increase their support towards adopting BIM.

Table 5. 3

Rank	Solutions
1	Software affordability and availability at professional levels to ensure smooth implementation.
2	Offering training and awareness programs for construction professionals towards adoption of BIM
2	Improved government policies and investment towards software, hardware and relevant ICT technology
3	Commitment of construction industry stakeholders towards investing in software, hardware and training of professionals.
4	Increased support from organizational leadership towards building information modelling

Rank of Solutions towards the Adoption of BIM in Nigeria

Summary of Findings

From the findings of this study, it was evident that BIM cost estimation was barely used by a majority of experts in Nigeria. Many experts reported having been aware of BIM but had not used it in quantity surveying-related practices such as project cost estimation. Several challenges were identified to have

hindered the widespread adoption of BIM in Nigeria, challenges such as finances for setting up the required software, hardware and training were found to be major hindrances to the growth and use of BIM in Nigeria. Many of the proposed solutions were widely agreed upon as viable in promoting the growth of BIM in Nigeria. Most of the experts who reported having used BIM in cost estimation agreed that it improved their efficiency and accuracy of the projects. Several respondents also suggested that they would recommend the use of BIM over traditional methods of cost estimation. Thus, it could be argued that the adoption of BIM cost estimation would improve quantity surveying practices in Nigeria.

5.0 CONCLUSION AND RECOMMENDATION 5.1 Conclusions

The number of professionals who were aware of BIM stood at 96.3% of the sampled population. Among these, only 36.2% had used BIM in cost estimation, which was a very small number of respondents. Further, only 13.8% had used BIM in accomplishing other tasks. The vast majority of responders who had heard of BIM (46.6%) had heard of BIM's existence but had not taken any steps towards familiarising themselves with the software.

When evaluating cost estimation practices in the country, construction professionals averagely used BIM 55.9% in cost estimation. This statistic probably implied that a majority of the professionals knew an expert who did cost estimation using BIM, as they were aware of BIM but had not used it. This was rivalled by 44.1% of the professionals who used traditional methods of cost estimation. The BIM usage levels were below the averages of developed countries. However, it is commendable that more than half of those polled had already adopted BIM in cost estimation practices.

The integration of BIM cost estimation in Nigeria's construction industry is generally low due to the industry's difficulties. The most dominant challenge was determined to be the cost of training and education on BIM technology. This was expected as BIM technology is not cheap and requires huge organisational financial investment for proper implementation. However, there are prospects for better performance of BIM-based cost estimation practices, as a majority of the respondents were aware and willing to include BIM-based practices in their professional skill set.

Construction stakeholders are encouraged to adopt newer, better and more efficient technology used in cost estimation. This should be done through investment in the necessary ICT technology, development of training and educational opportunities that are focused on educating professionals on BIM. Further, Nigeria's government should develop an enabling environment that fosters the growth of BIM. This may be through the development of necessary legislation, developing electricity infrastructure and investing in ICT technology that would aid the industry to grow.

5.2 Recommendations

5.2.1 Capacity Building

Organisations should conduct training and educational programs that develop the skills of their employees. Software affordability and availability in Nigeria should be addressed by professional bodies in the country to enable their professionals to transition to better and more efficient practices adopted in other parts of the world.

5.2.2 Industry Stakeholders

The government, through its ministries, should provide dependable electricity to improve the use of computer technology in the building sector. They should also develop legislations that encourage the transition from traditional cost estimation practices to modern BIM-based estimation. They should also establish bodies that look into the professional welfare of the construction professionals and ensure the sustained growth of the industry to adopt modern practices and methodologies of construction. Lastly, stakeholders should offer training programs that popularise BIM among construction professionals.

5.2.3 Construction Professionals

Construction professionals should aspire to develop their skills and competencies by undergoing training activities geared towards understanding and adopting BIM-based software in the construction industry. They should also encourage their clients, peers and professional bodies to adopt modern standard practices such as using BIM in cost estimation. This will foster the growth of Nigeria's construction industry.

Finally, the researcher encourages the full adoption of BIM-based cost estimation practices in Nigeria's construction industry. This will ensure the professional growth of experts and will enhance safety, affordability and foster teamwork in construction projects in the country.

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