Awareness Level of Building Information Modelling Tools to Construction Consultants in Abuja, Nigeria

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***Abstract*—Construction consultants are the core professionals responsible for overseeing the construction projects from conception to maintenance management stages. With the advent of current technology in construction project such as Building Information Modelling (BIM), Radio Frequency Identification Devices (RFID), and Geo Informatics System (GIS) the consultants' services need to be improving in terms of quality and performance through constant utilization of BIM software to meet the construction project goals. The aim of this study is to determine the awareness level of BIM tools and the extent to which these tools are utilize among construction consultants in Abuja Nigeria. Quantitative research design through descriptive survey was used in analyzing 66 structured questionnaires. The data were tested for reliability and the questionnaire administration attained 81.2% success rate. It was found that the degree of BIM awareness is low and yielded a slow BIM adoption; several numbers of BIM tools with many features attached to, have been revealed and the level of familiarity with these tools ware also measured but the most known software were Graphisoft ArchiCAD and Autodesk products. Thus, the study recommends that the regulatory bodies Architect Registered Council of Nigeria, (ARCON), Council of Registered Builders of Nigeria (CORBON), Council of Registered Engineers of Nigeria (COREN), and Quantity Surveyors Registration Board of Nigeria (QSRBN) should make BIM tools as part of mandatory applications to utilize by construction professionals in their respective organizations. In the same vein, they should compel construction consultants to pay more attention to the use of other BIM tools apart from those engaged in, since the BIM vendors are constantly updating and producing new versions with several features attached to. Lastly, the government at all level should authoritatively, mandate the use of BIM in both public and private construction projects**

***Key words*— Building Information Modelling, Construction, consultants, awareness, tools, familiarity, Autodesk products, Graphisoft Archi CAD, professionals, construction projects**

I. INTRODUCTION

The construction process usually grouped into different phase's ranges from conception, design, construction and the facility management phases. [1], highlighted the construction phases to be the conception and design phase i.e. where the construction decisions that influence the performance of the building is taking place, similarly [2] asserted that, the construction phase is the execution or actualization stage of any construction project where much of the capital and time are wasted in the absent of professionals, in the same vein [3] described the facility management phase as the greatest proportion of time period of the building life cycle.

According to [1], building practice entails the entire system that defines procedure and standards for all the phases of construction process; as well as spells out the impact, responsibilities and interaction among the building industry professionals. [4] affirmed that, construction consultants are the core professionals responsible for overseeing the construction projects from conception to maintenance management stages. With the advent of current technology in construction project such as Building Information Modelling (BIM), Radio Frequency Identification Devices (RFID), and Geo Informatics System (GIS) the consultants' services need to be improving in terms of quality and performance through constant utilization of BIM software to meet the construction project goals

It is important to fully understand Project Consultancy services, the construction consultants have a wide variety of roles to play during the construction process, they are hired by owner and engaged them within the area of expertise to oversee and control the whole construction process from inception to completion [5]. According to [3]"Construction consultants have varied qualifications. Some have an architectural, engineering, building, and quantity surveying background, the owner can utilize the consultant's services in reviewing plans, budgets at the various stages of construction work. These services need to be improving significantly, using modern tools to meet the construction project goals, objective and the client's satisfaction".

Arrival of ICT in the construction sector brought and set new challenges for consultants to collaborate and share a model base modelling with different interoperability flat form ([6]. These shared models will improve and change the whole system in construction activity to obtain buildings of better quality, reduce cost, minimize project time and improve productivity [7]. According to Interoperability is the ability to manage and communicate electronic product and project data between collaborating firms' and within individual companies' design, construction, maintenance, and business process systems [8]. According to [9] BIM interoperability, is the ability of all construction players including owners, consultants, contractors, sub contractors, professional associations and software manufacturers to collaborate

together to develop, expand and operate BIM softwares at various construction phases. Interoperability can also be seen as the seamless sharing of information or construction documents between multiple applications in building projects. This showed that, the basic argument of BIM interoperability is the collaboration of different stakeholders to use different tools from different vendors during different phases of construction.

"Building Information Modeling is the digital representation of physical and functional characteristics of a facility creating a shared knowledge resource for information about it forming a reliable basis for decisions during its lifecycle, from earliest conception to demolition" [10]. BIM can also be seen as digitally enabled approach that involves applying and maintaining an integral digital representation of all building information for different phases of the project life cycle in the form of a data repository. [10] Further categorizes BIM in three ways; as a product, a process, and as a technology. As a product, BIM is an object-based digital representation of the physical and functional characteristics of a facility that serves as a shared knowledge resource for information about a facility, forming a reliable basis for decisions during its life cycle from inception onward.

[11] Described the familiarity with BIM quantification tools in Nigeria as very minimal to provide empirical data. [2] Further emphasis that, the majority of BIM adopters in Nigeria are construction consultants and their adoption level is at stage two of BIM evolution.

This paper aimed at determining the awareness level of BIM tools and the extent to which these tools are been utilized among construction consultants in Abuja Nigeria with a view to improve their collaboration and effectiveness level in BIM-based projects.

II. REVIEW

The BIM model contains the physical and functional characteristics of a structure composed of intelligent objects rather than convectional lines, arcs, and text in the CAD [12]. BIM is able to render multiple views of data, including 2D drawings, lists, text, 3D images, animation and time/scheduling (4D) and cost (5D) [13]. A model containing more than three dimensions is called n-Dimensional (nD) modelling technique [14]. An nD model is an extension of the BIM that incorporates multi-aspects of design information required at each stage of the lifecycle of the building facility [10].

This tool will enable construction stakeholders to cohesively and comprehensively work within their own specialised discipline on one model.

[15] Stated that, the combination of time and 3D is called 4D model. The 3D model is linked to scheduling software and thereby given a start and finish date to each element or group of elements in a 4D model. A 5D model is when a 3D constructability analysis, quantity take-off and estimating and schedule are combined into one system. If there is a design change, quantities are updated, resulting in an automated cost and time effect [16].

Bentley

Bentley offers software tools for design, fabrication, and construction for a long time. The main product offered by Bentley today is called "MicroStation TriForma" [17]. Triforma is an extremely robust and stable 3D platform that provides all requirements to produce and assemble construction projects. Bentley claims its applications to help engineers, architects, contractors, governments, institutions, utilities and owner-operators design, build and operate more productively, collaborate more globally and deliver infrastructure assets that perform more sustainably

NavisWorks

Its collaborative 3D/4D Design Review software, which some stakeholders thinks is the best place to begin the initial explorations into BIM. However, "NavisWorks" software helps new users to learn to view, navigate, and understand virtual environments. It can read different files format from different sources.

Google SketchUp

It is free, simple, so powerful and mostly irresistible. Currently, it is owned by "Google" and it seems to be a supportive marriage. Although it could be used as a BIM tool, "SketchUp" ability to quickly convey the essential information about a situation (related to size, location, and look) into a 3D model makes it a BIM tool

Autodesk

Autodesk's "Revit" is their main BIM product. Most of the BIM users claims, it is probably the most widely used of the modelling tools; thus it is the newest on the market among tools discussed as well as the least mature. It is designed to exchange scheduling information bi-directionally as well as the ability to export its model quantities to cost-estimating software.

Vico

"Vico" Software helps building owners and general contractors reduce risk, manage cost and shorten project schedules. "Vico" Software's 5D technology provides unprecedented integration of design, construction and management processes, thus improving project predictability, providing early identification of constructability problems; and synchronizing design, cost and schedule. The software consists of the modeling engine "ArchiCAD" and several management modules including: Estimator (a cost database), Project Control (a Line of Balance scheduling software), and 5D presenter (facilitates project presentations). Most

importantly, all these modules have a bidirectional link to each other and the model.

Tekla,

"Tekla" Structures is the first structural BIM system which deals with the entire structural process from conceptual design to detailing, fabrication and construction. The software main aim is dealing with structural steel, steel reinforcing in concrete and precast concrete modelling. Its tools allow users to design and create an intelligent building model of any size or complexity. Tekla also uses parametric modelling which means components contained in the model can be customized and edited at any time to suit the requirements of the project. It is relatively easy to learn and there are three models that can be added to its structures which are steel detailing, precast detailing, and reinforced concrete detailing.

Nemetschek

"Nemetschek" main BIM product is "Nemetschek Allplan BIM 2008 for Architecture", which is an object -oriented 3D planning software package for BIM. It addresses all commonly used design types, from simple 2D design all the way to virtual building modeling with integrated quantity take-off and cost estimating. "Nemetschek" alleges that unlike any other CAD software, "Nemetschek Allplan BIM 2008" symbolizes interdisciplinary planning by architects, construction engineers, design professionals and facility managers. In addition to traditional exchange formats, "Nemetschek Allplan" supports PDF and IFC, which ensures a smooth data exchange process among planning partners

Most importantly, vendors and software producing bodies are considering compatibility and allowing for data exchange abilities with other related products although, some elements once shared with other software, allow for a little or no modification at all [8].

III. METHOD

The level of BIM awareness and tools utilization as well as the familiarity level with BIM tools reviewed in the literature were translated into questions and administered quantitatively to construction consultants in Abuja Nigeria. Abuja was selected as the study area because of the high concentration of construction projects. A total of sixty six (66) structured questionnaires were administered through purposive non-probability sampling, fifty four (54) questionnaires were retrieved and represent 81.8%, with four (4) questionnaires being rejected due to incomplete filling out. Therefore a total of 50 properly filled questionnaires were used for analysis which represents 75.8% response rate.

The data generated for this study were subjected to analyses using mean score and standard deviation, SPSS version 20 was used as tool for the analysis. The data were further subjected to ranking analysis to determine the most familiar BIM tools utilized by the construction consultants. Relative Importance Index Method (RII) was used in this research and the formula was computed as

$$\textit{Relative importance index (RII)} = \Sigma w / (A \times N) \text{ - - - , } (0 \leq \textit{index} \leq 1)$$

Where: w = *weighting given to each factor by the respondents*,

A = *highest weight (i.e. 5 in this case), and*

N = *total number of respondents (i.e. in this case 50)*.

The rating of all the factors for degree of utilization will be based on the value of their respective relative importance index (RII). The item with the highest RII is ranked first followed by the next and so on.

IV. RESULTS

Table 1: below represents respondent's perceptions on the ***Level of BIM Awareness***

The Table shows the average mean score, frequencies, and percentages of the level of BIM awareness by the respondents; it can be seen clearly from the frequency and percentage table that 46.0% of the respondents described their level of awareness as being low. Thirty percent (30.0 %) described their level of BIM awareness as being medium, while 16% of the respondents, their level of awareness are high. Very few of the respondents representing 10.0% described their level of BIM understanding as zero. The average means score of the awareness level is 2.50.

Table 1: Level of BIM Awareness

S/n	Scale	Frequency	Percent (%)	Mean value
1.	None	5	10.0	
2.	Low	23	46.0	2.50
3.	Medium	14	28.0	
4.	High	8	16.0	

Source: Research: 2018

Level of BIM Tools Utilization by Respondent's

Table 2 shows the level of BIM tools utilization by respondents, 48.0% described the level of BIM tools utilization as low, 28.0 described their level of BIM tools utilization as being medium, while14.0% of the respondents are not utilizing any BIM tools and 10.0% of the respondents are fully utilizing BIM tools. The average mean value recorded is 2.62 as shown in table 2 below.

Table2: Level of BIM Tools Utilization by the Respondents

S/n	Scale	Frequency	Percent (%)	Mean
1.	None	7	14.0	
2.	Low	24	48.0	2.62
3.	Medium	14	28.0	
4.	High	5	10.0	

Source: Research: 2018

Plan towards BIM Adoption

Table 3 shows responses of respondents plan towards adopting BIM, 58.0% described that they have no plan to adopt BIM, 24 % of the respondents described that, they have strong plan towards adopting BIM while 18% described that they are currently demonstrating BIM mostly in architectural and structural services. The average means score of the plans toward the adoption of BIM is 2.06.

Table 3: Plans toward BIM Adoption

S/n	Plans	Freq	(%)	Mean
1.	No any plan for BIM adoption	29	58	
2.	Strong plan for BIM adoption	12	24	2.06
3.	Already adopted BIM	9	18	

Source: Survey 2018

Familiarity with BIM software's / Applications

Table 4 shows responses of respondents on BIM software familiarity, from the table, it can be seen that the most familiar BIM tool is archiCAD having the mean score of 4.40, with second most familiar being revit architecture with mean score of 4.34. Autodesk revit structures and naviswork scored equal mean of 3.940 and ranked third most familiar BIM applications. The fifth being autodesk revit MEP having mean score of 3.48, the BIM tool vico ranked sixth most familiar tool with mean score of 3.41. The seventh most familiar BIM tool is the nametschek All Plan with mean of 3.30, the eigth most familiar BIM tool is the Tekla application which has a mean of 3.26, however, the ninth most familiar BIM tool is bently micro station with mean of 3.12. The tenth BIM tool known by the consultant is vector work having the mean score of 2.96. The last BIM tool with least familiarity is cost x with mean score of 2.84 and ranked eleventh. The computed means of BIM tools revealed low values for the standard deviations (ranges from 0.689-1.091) indicating a high degree of consistencies in the respondents' opinions, thus signifying that, each of the respondent opinion on the assessment is similar to the mean. The analysis of the BIM tools utilizations show that the 3D BIM tools (archiCAD & revit architecture), structural design & analysis tool (revit structure) and 5D BIM tool (naviswork) were widely used by consultant architect, structural and cost consultants. Autodesk revit MEP were fairly utilized by M&E consultants but project managers were utilizing BIM tools more widely than M&E as their engagement level was quite similar to that of consultant architects and structural consultants because, they are utilizing other BIM tools apart from those used by consultant architects, and structural engineers. Although, these were not enough for full adoption as a result, the widely used software's do not provide sufficient workflow for collaboration rather, their features create flat form for individual operations. Other BIM tools like Bentley micro station, vector works and nemestchek are advanced parametric 3D modeling with many features attached to, and create work flow for collaboration with other BIM tools but consultant architects demonstrated low adoption; in the same vein, very few of the cost consultants were utilizing vico & cost-x . Similarly, structural consultants' status with respect to tekla and nemestchek-all plan utilization was low despite their ability in analyzing complex structural model.

Table 4: Familiarity with BIM tools

S/n	BIM Tools	Mean	Standard Deviation	Rank
1.	Graphisoft ArchiCAD	4.40	0.855	1st
2.	Revit Architecture	4.34	0.982	2nd
3.	Revit Structure	3.94	0.689	3rd
4.	Naviswork	3.94	0.876	3rd
5.	Revit MEP	3.48	0.842	5th
6.	Vico	3.41	0.792	6th
7.	Nemestchek All Plan	3.30	0.694	7th
8.	Tekla	3.26	0.731	8th
9.	Bently Micro Stations	3.26	0.699	9th
10.	Vector works	2.96	1.091	10th
11.	Cost-x	2.87	0.992	11th

Source: Survey 2018

This study was to examine the awareness level, and BIM tool utilization as well as the extent of familiarity with BIM tools among construction consultants. The result indicated that, majority of the consultants showed interest in BIM adoption but do not have strong plans to enhance the adoption, the level of awareness and tools utilization is also low. In accomplishing the stated objective, the study partly employed the used of literature searched of BIM tools. The analysis of the level of familiarity with BIM tools by construction consultants indicated that, few consultants happened to use BIM softwares. The engagement levels were not enough for full adoption. Moreover, by analyzing the extent of BIM adoption by construction consultants and comparing the result with a BIM-based quality model and its applications developed by [18] construction consultant could be said to be at the beginner phase of BIM up take in Nigeria.

IV CONCLUSION AND RECOMMENDATIONS

In relation with the findings of the study, the following conclusions were made:

The survey suggested that Building Information Modeling (BIM) utilization by construction consultants is low due to low level of awareness hence the adoption is very minimal. However, few consultants happen to use BIM tools in their in-house design activities, more especially in architectural, structural and M&E design. The levels of utilization were not enough for full adoption as a result; there are several BIM tools with many features and interoperability platform but

were not utilized.

The study recommends the following:

i. The regulatory bodies ARCON, CORBON, COREN, and QSRBN should make BIM tools as part of mandatory applications to utilized by construction professionals in their respective organizations.
ii. Construction consultants should pay more attention to the use of other BIM tools apart from those engaged in, as BIM vendors are constantly updating and producing new version with several features attached to.
The government should address the issue of cost of purchasing BIM tools by subsidizing the price of the softwares to enable the practitioners to have appropriate choice of BIM tool that suits the practice's way of work.
iii. This paper has the limitation of a relatively small number of responses (construction consultants); this might not be the whole construction practitioners in Abuja. There is therefore, the need for further studies of similar nature to cover the whole construction professionals in Abuja

V. CONTRIBUTION TO KNOWLEDGE

Secondly, it also provides an insight about the benefit of adopting BIM in construction projects in Nigeria to construction consultants and other construction professionals at large. In order to assist the construction practitioners, this research helps in making selection on the choice of BIM tools with many features and interoperability platform.

Lastly, it also contributes to the existing literature in field relevant to the study that can enlighten professionals more about drivers and the barriers relating to its adoption. The result will also help construction consultancy firms in identifying these factors so as to provide strategy of overcoming them.

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REFERENCES

[1] Khalfan, M. A. and Anumba, C. J. (2000). Development of a Readiness Assessment Model for Concurrent Engineering in Construction, Benchmarking: An International Journal 8(3), 223 - 239.
[2] Shuaibu, I. & Malumfashi, B. I. (2012), Review of Using Building Information Modeling in Nigerian Construction Industry. *Journal of Environmental Sciences and Policy*
[3] *Evaluation 2*(2)Lee, G., Sacks, R., and Eastman, C. M. (2006). Specifying parametric building object behavior (BOB) for a building information modeling system. *Automation in Construction, 15*, 758- 776
[4] Nuruddeen, U. and Usman, S. A. (2018). Barriers Affecting the Adoption of Building Information Modelling in Construction Consultancy Firms in Abuja, Nigeria: *International Journal of Innovative Research and Advanced Studies (IJIRAS) Volume (5) 13-17*
[5] B.N. Baker, D.C. Murphy, D. Fisher,(1983). Factors affecting project success, Project Management Handbook, Van Nostrand Reinhold, New York
[6] Kjartansdottir I. B. (2011). *BIM adoption in iceland and its relation to lean construction,* Unpublished Master's Thesis, School of Science and Engineering, Reyjakic University
[7] Oluwakiyesi, T. (2011). Construction Industry Report: A Haven of Opportunities *Vitiva Research* [online]. Avalable from t.oluwakiyesi@vetiva.com [Accessed 3rd January, 2012].
[8] Usman S.A and Ashiru A.M (2019) Drivers Affecting the Adoption of Building Information Modelling in Construction Consultancy Firms in Abuja, Nigeria *Global Scientific Journal*: Volume 7, Issue 12, December 2019, Online: ISSN 2320-9186 www.globalscientificjournal.com
[9] Muhammad A. (2015). Factors affecting the adoption of information and communication technology in Nigerian construction firms in abuja, nigeria. Unpublished Master"s Thesis, Abubakar Tafawa University, Bauchi
[10] Usman, S. A. (2017). *Factors affecting the adoption of Building Information Technology in construction consultancy firms in Abuja*. Master's Thesis, Abubakar Tafawa University, Bauchi
[11] Abdalla-Salem, S. B. (2009).*Computer-aided Planning and Building Process.* Unpublished master's thesis, in architecture and technology, University of Berlin
[12] Autodesk (2003) REVIT building information modelling. BIM in Action [online], Retrieved September 24, 2007 from:http://images.autodesk.com/latin_am_main/files/Revit_BIM_Oc
[13] Eastman, C., Teicholz, P., Sacks, R., & Liston, K.,(2008). BIM handbook : a guide to building information modelling for owner, managers, designers, engineers, and contractors. New Jersey: John Wiley and Sons, Inc.
[14] Howard, R. and Bjork, B. (2007) Building Information Models – Experts' view on BIM/IFC developments. ITC Digital Library. [online] Retrieved January 20, 2009 from: http://itc.scix.net/data/works/att/w 782007007043Howard. pdf
[15] NBIMS (2007). National Building Information Modelling Standards: Overview Principles, and Methodologies. National Institute of Building Sciences, United States (Version 1: Par1)
[16] Smith D.K & Tardiff M. (2009). Building information modeling:a strategic implementation guide for architects, engineers, constructors and real estate asset managers. New Jersey: John Wiley & Sons, Inc

[17] Usman S. A (2019) Perceived Benefit of Building Information Modelling to Construction Professional in Bauchi State Nigeria International Journal of Scientific & Engineering Research, Volume 8, Issue 1, January-2019

[18] Vanlande, R,. Nicolle, C,. Cruz, C,. (2008). "IFC and building lifecycle management"*Automation in Construction, iss: 18* pp. 70-78