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BARRIERS TO THE ADOPTION OF BUILDING INFORMATION MODELING IN NIGERIAN CONSTRUCTION INDUSTRY

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ABSTRACT
Building Information Modeling (BIM) involves the development and use of computer generated n-D models to simulate, plan, design, construct, adapt, operate, maintain, renovate, and ultimately beneficially deconstruct a building at the end of its life cycle. BIM represents a new paradigm in construction, it encourages the integration of roles of construction stakeholders enabling them to visualize the project to be built and further identifying potential issues that may occur during the operational phase of buildings. This study assessed the barriers to the adoption of BIM in the Nigerian construction industry and further highlighted ways to improve its adoption. A total of 50 questionnaires were administered to construction professionals in Abuja, Nigeria. Forty (40) retrieved questionnaires were analysed using Statistical Package for social Sciences (SPSS 21) and used for this study, it was revealed that there was generally a low awareness on the use of BIM among construction professionals. The major barrier to using BIM was lack of skilled personnel while the major means of ensuring its adoption was Provision of basic BIM infrastructure. These problems can be effectively tackled by increased support from government and construction industry stakeholders for its use; stressing the benefits derivable, training and retraining of key construction professionals taking into consideration peculiarities to the Nigerian construction industry.

Keywords: *Building Information Modeling, construction, Nigeria.*

1 INTRODUCTION

The construction industry in Nigeria is growing rapidly as a result of increasing population and demand for infrastructure. Recent performance studies have revealed an alarming rate of clients' dissatisfaction concerning time and cost overrun in construction projects. According to Mbachu and Nkado (2004) it is as a result of the use of inefficient procurement and project delivery, poor project management, incomplete documentation, discord between the design and construction teams and frequent design changes. This has led to the adoption of Building Information Modeling (BIM) by some countries around the world. However, the level of awareness and adoption of BIM in Nigeria's private, public sector and amongst different building professionals has been very slow despite the numerous benefits enjoyed by the various countries that have adopted it fully (Alufohai, 2012).

A BIM is a digital representation of the physical and functional characteristics of a facility, it represents a shared knowledge resource or a process of sharing vital information about a facility. This forms a reliable basis for taking decisions during the life cycle of the facility. Some definitions portray BIM as "Process", "Product", "Technology", "Innovation", or a "Strategy". It is however a digital representation of the physical and functional characteristics of a facility, its major goal is to produce complete and detailed model of a facility in a digital environment with the sole aim of providing a collaborative platform through which Building information can be managed throughout the facility's life cycle (Ibrahim and Abdullahi, 2016). The promotion of BIM's adoption among key construction industry stakeholders in Nigeria by increasing public awareness on the techniques, the tools employed and the benefits associated with its use becomes timely and justifiable. Hence, this study is conducted to investigate the barriers to the successful implementation of BIM and suggest ways of promoting its adoption within Nigerian Building Construction Industry.

Building Information Modeling (BIM) involves the use of computer-generated models to simulate planning, design and construction of projects. According to Autodesk (1999) "Building information modeling is a design methodology that maintains a single database of information about a building design. All information for a building design, from geometry to construction data is stored in a project file. This information includes components used to design the model, views of the project, drawings of the design and related documentation". Internationally, the building industry is transforming rapidly with the introduction of BIM. It is changing the process of design and construction of buildings.

Globally BIM usage is transforming the construction industry, it is changing the process of design and construction of buildings. Onungwa and Uduma-Olugu (2016) opined that BIM entails a seven dimensional process: the 3D modeling process extends to scheduling and sequencing (4D), cost estimating (5D), sustainable design also termed Green Design (6D) and facility management (7D). It explores the benefits, costs, risks

and rewards associated with BIM, interoperability and integration.

In order to understand the benefits of BIM to the construction industry, we must explore some of the global benefits. Globally one of the great advantages of BIM is its ability to create an accurate model which is useful throughout the entire life of the building, from initial design through occupancy and operation. A BIM ideally is created in the early stages of the design and updated as the design is refined and used by the construction team, it is refined continuously during the course of constructing the facility. Post-occupancy, the BIM is used by the owner and owner's maintenance team to improve understanding of the facility operation and to make adaptations, renovations, additions and alterations to the building faster and for less cost than through the conventional traditional processes (Conover *et al .,* 2009).

The power of BIM is in its ability to allow the entire building to be optimized in lieu of optimizing individual components. Each discipline and trade benefits through integration and optimization within a BIM and becomes more efficient by providing parametric responses to single discipline changes through the use of consistent data sets for calculation and decision making. The work of the Heating, ventilation and air conditioning (HVAC) industry has an impact on every other design and construction discipline and trade including the following: architecture, electrical engineering, lighting design, roof and envelope consultation, fire protection, civil engineering, structural engineering, security consultants, acoustical engineering and others. BIM can benefit these associated and complimentary disciplines and trades through precise interdisciplinary coordination using parametric geometric modeling (Conover *et al.,* 2009).

According to Conover *et al.* (2009) the benefits of BIM are evident in its ability to capture, organise, integrate, maintain and grow the vast amount of knowledge, data and information required to conceive, plan, design, construct, adapt, operate, maintain, renovate, maintain and, ultimately, beneficially deconstruct a building at the end of its life cycle.

BIM enabled Software's

According to Conover *et al.* (2009) commercially available application software's are presented on Table 1. However, the list is not an exhaustive one because the concept of BIM is still evolving as such improvements and development keeps occurring. The choice of the best software to use is dependent on several criteria ranging from production practices, interoperability, functional capability of the design organization to undertake particular types of projects (Ibrahim and Abdullahi, 2016).

TABLE 1: COMMERCIALLY AVAILABLE BIM SOFTWARE'S (CONOVER *ET AL.,* 2009)

Organization	Product
Autodesk Inc	Revit MEP AutoCAD MEP Auto desk Navis Works Manage Auto desk Green Building Studio Auto desk Ecotect Auto desk Buzzsaw Auto desk Constructware
Bentley Solutions	Bentley Architecture MicroStation Auto Pipe AutoPlant Bentley building Mechanical systems Hevacomp simulator V8i Hevacomp M&E Designer V8i Bentley Tas Ambeins CFD Bentley Tas Simulator V8i Bentley Building Electrical systems
Bentley Systems	Architecture Structural Civil Mechanical Electrical HVAC Instrumentation and Wiring Geospatial (GIS) and Facilities
Graphisoft	ArchiCAD 11
Granlund	RIUSKA Integrated Building Solutions
CADPIPE	ArTrA BIM
Wrightsoft	Right-Suit Universal

Global adoption of BIM and Implementation

The concept of BIM and its implementation is on the rise globally, many countries have realized this procedural and technological evolution in the construction industry (Gerges *et al*., 2017). In the USA, UK and some other developed countries, BIM has become mandatory. It is a criteria for evaluation in the industry. European countries like Finland, Denmark, Norway and Sweden are the leaders in BIM implementation (Arayici, 2012). According to Chan (2014) BIM is still in its early stages of implementation in Hong Kong although moving rapidly. The clients are gradually getting to discover the benefits and advantages of BIM: they can conduct different tests on BIM models, generate different design options and early detection of design faults in order to forestall changes or

renovations in the future. Africa has witnessed a generally low acceptance and implementation of BIM, in South Africa the concept faces huge challenges attributed to personal inadequacies in terms of education, training and skills development, contractual issues and population growth. Nigeria however experiences a very low level of implementation of both process and technology due to some peculiarities to the country's construction industry (Ogwueleka, 2015).

2 METHODOLOGY

The research was conducted in Abuja, Nigeria's Federal Capital Territory; a well structured questionnaire was used in soliciting data from the respondent in this study. A total of 50 questionnaires were issued to construction professionals on the sites visited. 40 questionnaires representing 80% response rate were retrieved and analysed using Statistical Package for Social Sciences (SPSS) version 21. The response rate is deemed adequate according to Ahmadu (2014) who opined that a response rate of 30 was adequate for construction industry studies. The mean scores of each factor were computed from the analysis of the ratings provided from a five point likert scale.

3 RESULTS AND DISCUSSION

Characteristics of Respondents

The characteristics of respondents were assessed under their profession, duration in construction and type of project executed. Table 1 shows that majority of the respondents were Engineers. Majority of the construction professionals had 1-5 years (52.5%) experience in the industry, followed closely by 6-10 (25%) years experience, 11-15 years (15%) and over 21 years (7.5%) experience. Information about the type of project executed by these respondents also revealed that they engaged mainly in all types of construction (62.5%), the remaining engaged in residential (27.5%), commercial (2.5%) and other (7.5%).

TABLE 2: PROFESSION OF RESPONDENTS

Profession	Frequency	Percent (%)
Architect	5	12.5
Engineer	12	30
Quantity Surveyor	6	15
Builder	4	10
Surveyors	6	15
Others	7	17.5
Total	**40**	**100**

Use of BIM software

33 (82.5%) of the respondents use BIM software in their practice while 7 (17.5%) indicated to have never used any BIM software in their practice.

Industry Clarity on the use of BIM

Since most of the stakeholders testified to be conversant with the available BIM software it is safe to assume that assume that the industry would be very clear on the concept of BIM however, result revealed the stakeholders Agreed (45.9%) the Nigerian construction industry is not yet clear on the workings and operation of BIM. 21.6% Strongly agreed, 16.2 % were neutral, while 10.8% and 5.4% Disagreed and Strongly Disagreed respectively that the industry was clear about BIM. This result shows that although many stakeholders use BIM software in their practice, nevertheless, the industry is not yet clear enough of what BIM actually is and how to maximize the components of BIM as a tool to ensure efficient project performance.

Impact of BIM on construction Performance

The mean score ranking was used to asses the impact of BIM on construction performance. Table 2 shows the mean scores and rankings of the identified construction performance assessment variables. From the Table it can be inferred from the relatively high mean scores that the listed factors have a significant impact on construction performance. BIM has a greater impact on construction programming ranking first with a mean score of 4.32 from the analysis of the data followed by collaboration with other consultants and Quality of Completed Jobs which ranked 2nd and 3rd respectively with mean scores of 4.18 and 4.03. Cost estimation ranked 4th while Project completion time ranked 5th. Job supervision, Safety and Energy efficiency ranked 6th, 7th and 8th respectively with mean scores of 3.49, 3.48 and 3.41 respectively. This shows that the respondents believe if efficiently utilized, BIM would improve all the listed performance criteria most importantly improving on construction programming activities.

TABLE 3: ASSESSMENT OF IMPACT OF BIM ON PROJECT PERFORMANCE

Construction Performance Variables	Mean Score	Rank
Construction programming	4.23	1
Supervision of Jobs	3.49	6
Quality of Completed Jobs	4.03	3
Energy Efficiency	3.41	8
Project completion time	3.87	5
Collaboration with other Consultants	4.18	2
Cost Estimation	3.88	4
Safety	3.48	7

Barriers to the successful adoption of BIM in Nigerian construction industry

The mean score ranking was adopted in analysing the barriers to the successful implementation of BIM in the construction industry. As seen from Table 4, Lack of Skilled personnel emerged first with mean score of 4.11. Poor awareness of technology emerged 2nd while Inadequate design process was 3rd with mean scores of 3.79 and 3.16 respectively. Lack of BIM object libraries, Fear of Change, inadequate planning and budgetary all tied in the 4th rank with mean score values of 3.05, 3.05, 3.05 and 3.05 respectively. These were closely followed by Cost, Power Failure, Stakeholders reluctance to use BIM, Lack of contractual documents on BIM and Poor internet connectivity with mean scores of 3.08, 3.00, 2.92, 2.85 and 2.68 respectively.

TABLE 4: BARRIERS TO ADOPTION OF BIM

Perceived Barrier	Mean Score	Rank
Lack of Skilled Personnel	4.11	1
Poor Internet Connectivity	2.68	12
Stakeholders reluctance to use BIM	2.92	10
Lack of BIM Object Libraries	3.05	4
Poor Technological Awareness	3.79	2
Cost	3.08	8
Power Failure	3.00	9
Lack of Contractual BIM documents	2.85	11
Fear of Change	3.05	4
Inadequate design process	3.16	3
Fragmented nature of Construction industry	3.05	4
Inadequate planning and Budgetary provisions	3.05	4

Solutions to improve BIM adoption in Nigerian Construction Industry

Table 5 gives a summary of perceived solutions to the implementation of BIM in the Nigerian Construction industry. Provision of Basic BIM infrastructure was perceived as the most effective measure to improve its adoption, ranking 1st with a mean score of 1.84. The government and industry stakeholders should key into this and provide the necessary infrastructure for BIM implementation. Sensitization and Adaptation to change ranked 2nd with a score of 1.64 followed by research on construction methods that will encourage the use of BIM, Seminars, lectures, demonstrations on the use of BIM and Training and awareness with mean scores of 1.63, 1.58 and 1.55 respectively.

TABLE 5: PERCEIVED SOLUTIONS TO BIM ADOPTION

Perceived Solution	Mean	Rank
Research on Construction methods that will encourage the use of BIM	1.63	3
Seminars, lectures, demonstrations on the use of BIM	1.58	4
Provision of basic Infrastructure	1.84	1
Training and awareness	1.55	5
Sensitization and adaptation to change	1.64	2

4. CONCLUSION

The concept of BIM is clearly gaining momentum as it evolves with the possibility of better interoperability between the various software systems. It is an expansive domain of knowledge in the design and construction industry, useful to both the Architects and Construction Engineers. It is slowly gaining acceptance in the Nigerian construction industry, based on the result of this study it can be concluded that there is generally low awareness of the concept of BIM as it is still evolving and gaining grounds in Nigeria. The major barrier identified as hindering its adoption is lack of available skilled personnel. As such the duty of training construction professionals by the government and key industry stakeholders on the operation and benefits of the various commercially available BIM software becomes timely. The major way to enhance its adoption is the Provision of basic infrastructure for practicing construction professionals. The future of the design and construction industry lies in the utilization of technology and BIM is expected to shape this effectively.

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