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Status and Perceptions of the Application of Building Information Modeling for Improved Building Projects Delivery in Nigeria

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ABSTRACT: *Building Information Modeling (BIM) is a new and innovative approach to building design, construction, and management. It is a cutting-edge, state of the art technology that is not only transforming, but improving the building delivery/production process in developed countries of the world. Sadly, Nigeria is yet to adopt this revolutionary technology in her construction industry. This study thus, sought to evaluate the present status of application of BIM in building projects in Nigeria, with a view to betoning its importance in improving the present state of building delivery in the country. This was effected by means of a field survey of building professionals in which their perceptions were analyzed, based on a structured questionnaire administration; in order to elicit their level of awareness of BIM application, determine their extent of participation in BIM projects, identify and rank the most suitable procurement method that encourages BIM application, the barriers to the application of BIM and the benefits of BIM application to building delivery in Nigeria. Results/Findings revealed that knowledge of BIM application among professionals is very poor (33%), participation/use of BIM in projects is non-existent, the collaborative method of procurement best supports BIM application, lack of awareness remains the major barrier to BIM application, while simultaneous access to project database by stakeholders is the highest ranked benefit of BIM application. The study concludes that Nigeria still has a long way to go in understanding, embracing and applying BIM to improve the traditional and stagnant state of her building delivery process. Hence, all hands should be on deck; the government, professional bodies, construction organizations and the academia to ensure that BIM becomes a priority with respect to legislations, training, research and use in the Nigerian building industry.*

Key Words: *Building Information Modeling, Building, Innovative technology, Nigeria, Project delivery.*

I. INTRODUCTION

The building construction industry has over the years witnessed revolutions in its production processes and operations [1] [2]. Building which is the core product of this industry floats in a stream of innovations, transformations and evolutions from its conception through its delivery (completion) processes. Building Information Modeling or BIM for short is one of these recent developments. According to [3], BIM is a new and innovative approach to building design, construction, and management that has changed the way industry professionals worldwide think about how technology can be applied to building design, construction, and management.

[4] surmises that the recent emergence of BIM constitutes one of the most exciting developments in building design, management, maintenance and operations. These advances have offered project teams a multi-sensory collaborative tools and opportunities for new communication structures. They have become powerful analysis and interdisciplinary decision-making tools [5], designed to represent and simulate existing or hypothetical buildings and settings. BIM thus, has far reaching consequences on building procurement [6].

BIM is a revolutionary technology and process that has quickly transformed the way buildings are conceived, designed, constructed and operated [7] [8]. The National Building Information Modeling Standards (NBIMS) committee of USA also defines BIM as follows: "BIM is a digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life cycle; defined as existing from earliest conception to

demolition. A basic premise of BIM is collaboration by different stakeholders/professionals at different phases of the life cycle of a facility/Building to insert, extract, update or modify information in the BIM to support and reflect the roles of that stakeholder [9] [10].

[11]further reports that for each of the three major phases in the building life cycle—design, construction, and management—building information modeling offers access to the following critical information:

• Design phase - design, schedule, and budget information
• Construction phase - quality, schedule, and cost information
• Management phase - performance, utilization, and financial information.

The ability to keep this information up to date and accessible in an integrated digital environment gives architects, engineers, builders, and owners a clear overall vision of their projects, as well as the ability to make better decisions faster—raising the quality and increasing the profitability of projects (Building SMART, 2010). It supports the continuous and immediate availability of project design scope, schedule, and cost information that is high quality, reliable, integrated, and fully coordinated.

Several BIM tools are in existence [12][13][14]. Table 1 depicts some BIM authoring tools and their primary building functions. They include architectural, structural, electrical, mechanical and site work 3D modeling softwares. Some of these softwares are also capable of scheduling and cost estimation.

Table 1: BIM tools

Product Name	**Manufacturer**	**Function**
Cadpipe HVAC	AEC Design Group	3D HVAC Modeling
Revit Architecture	Autodesk	3D Architectural Modeling and parametric design.
AutoCAD Architecture	Autodesk	3D Architectural Modeling andparametric design.
Revit Structure	Autodesk	3D Structural Modeling and parametric design.
Revit MEP	Autodesk	3D Detailed MEP Modeling
AutoCAD MEP	Autodesk	3D MEP Modeling
AutoCAD Civil 3D	Autodesk	Site Development
Cadpipe Commercial Pipe	AEC Design Group	3D Pipe Modeling
DProfiler	Beck Technology	3D conceptual modeling with real time cost estimating.
Bentley BIM Suite (MicroStation, Bentley Architecture, Structural, Mechanical, Electrical, Generative Design)	Bentley Systems	3D Architectural, Structural, Mechanical, Electrical, and Generative Components Modeling
Fastrak	CSC (UK)	3D Structural Modeling
SDS/2	Design Data	3D Detailed Structural Modeling
Fabrication for AutoCAD MEP	East Coast CAD/CAM	3D Detailed MEP Modeling
Digital Project	Gehry Technologies	CATIA based BIM System for Architectural, Design, Engineering and Construction Modeling
Digital Project MEP Systems Routing	Gehry Technologies	MEP Design
ArchiCAD	Graphisoft	3D Architectural Modeling
MEP Modeler	Graphisoft	3D MEP Modeling
HydraCAD	Hydratec	3D Fire Sprinkler Design and Modeling
AutoSPRINK VR	M.E.P. CAD	3D Fire Sprinkler Design and Modeling
AutoSPRINK VR	M.E.P. CAD	3D Fire Sprinkler Design and Modeling
FireCad	Mc4 Software	Fire Piping Network Design and Modeling
FireCad	Mc4 Software	Fire Piping Network Design and Modeling
CAD-Duct	Micro Application	3D Detailed MEP Modeling
Vectorworks Designer	Nemetschek	3D Architectural Modeling
Duct Designer 3D, Pipe Designer 3D	QuickPen International	3D Detailed MEP Modeling
RISA	RISA Technologies	Full suite of 2D and 3D Structural Design Applications
Tekla Structures	Tekla	3D Detailed Structural Modeling

Affinity	Trelligence	3D Model Application for early concept design
Vico Office	Vico Software	5D Modeling which can be used to generate cost and schedule data
Power Civil	Bentley Systems	Site Development
Site Design, Site Planning	Eagle Point	Site Development

Source: Adopted from [15].

[16] submit that since its inception nearly 25 years ago, the presence of building information modeling (BIM) technology in Architecture/Engineering/Construction has revolutionized the way structures are built. From conception and design, to coordination and construction, the use of these intelligent computer imaging tools have opened avenues of communication and clarity previously unavailable to the industry [17] [18]. Though BIM technology systems have seen an increase in adoption and implementation in developed countries of the world, the ways in which these principles have been applied has remained stagnant in many developing countries, including Nigeria [19].

A 2010 study of BIM use on construction projects indicated that majority of surveyed participants used BIM for visualization, clash detection, and building design [20], relegating beneficial BIM capabilities to pre-construction and prefabrication activities with little to no regard for field applications. These limitations toward the use of BIM in the planning and completion of site work also mirrors a knowledge gap in the Nigerian building industry.

The Nigerian building industry is yet to fully embrace the adoption of BIM to enhance or improve her building projects delivery. [19]. In fact, the Nigerian building industry is notoriously conservative and slow to change. Her traditional procurement and building delivery methods have largely remained the same for decades.

Building construction is undoubtedly a team work. It has been acknowledged worldwide that the process of building an edifice is the collaborative responsibility of various professionals/stakeholders and integration of the various phases/stages of a project to offer best quality products. The traditional building design is largely reliant upon two-dimensional drawings (plans, elevations, sections etc.). This denies having a virtual information model of the building project from the design team (Architect, Engineers, Builders, Surveyors, etc); (where each professional adds discipline-specific data to the single shared model) to the main contractor and subcontractors and then on to the owner/operator. This scenario gives rise to loss of information which occurs when a new team takes ownership of the project. The present system of building process (traditional method) in Nigeria restricts communication to work in one direction only.

This research work seeks to proffer solution to the information–share, communication and collaboration problems among stakeholders/professionals across the various phases/stages (Design, Construction and Management) of building construction projects in Nigeria. The study is expected to provide effective tools for the Nigerian building industry to operate successively in this competitive economy. It will help to enhance collaboration and communication among stakeholders, ensure clarity, quality, facilitate take-offs and estimating, visualization of alternative solutions and options, reduce fabrication cost and errors. It will also aid in the decision process by providing a virtual playground through which project teams can test and evaluate multiple sequencing and scheduling alternatives for cost and/or feasibility of building production.

This study aims to evaluate the present status of application of BIM in building projects in Nigeria, with a view to betoning or emphasizing its importance, in order to improve the present state of building delivery in Nigeria. The following objectives are the premise for achieving this aim:

i. To assess the level of awareness of Nigerian building professionals of the concept/application of BIM
ii. To determine the extent of participation or use of BIM by Nigerian building professionals.
iii. To identify and rank the most suitable building procurement method that encourages the application of BIM in Nigeria.
iv. To identify and rank the barriers to the application/use of BIM for building delivery in Nigeria.
v. To identify and rank the benefits of BIM application to building construction projects in Nigeria.

II. METHODOLOGY

The study employed the survey design. According to [21], survey design is one in which group of people or items considered being representative of the entire group are studied by collecting and analyzing data from them. [22] asserts that describes survey research describes the situation as it is. It describes the characteristics, behaviours, attitudes and opinions of the population based on the data gathered from the sample. Similarly, [23] submits that the survey approach is concerned with a generalised result when data is abstracted from a particular sample or population.

For the study, a survey of expert opinion on major issues of concern with respect to the knowledge, use, application, benefits and barriers of BIM in Nigerian building projects was conducted. A well structured

questionnaire was designed and administered to building professionals: Architects, Engineers, Quantity Surveyors, Builders, Estate Surveyors and Town-Planners the survey was in construction companies/firms, ministries and parastatals within Anambra and Enugu states of Nigeria who have a good network, base of operation and solid reputations in execution of building projects throughout the country. They were selected by means of a simple random sampling.

A total number of one hundred and fifty five (155) copies of the questionnaire were distributed out of which one hundred and thirty five(135) representing 87.1% were duly completed and returned (*see table 2*). A total of twenty (20) copies were either not returned or were inadequate for analysis.

Table 2: Respondents (professionals) composition and questionnaire response

Professional affiliation	**Number of copies of questionnaire administered**	**Number returned**	**Number not returned**
Architects	45	38	7
Engineers	60	52	8
Builders	25	24	1
Quantity Surveyors	12	9	3
Estate Surveyors	5	5	0
Town planners	8	7	1
Total	**155**	**135**	**20**

2.1 Data Analysis Procedure

The data collected was analysed using the mean score method and ranking, a descriptive statistical tool. Some of the questions in the questionnaire involved assessing some issues or indices of BIM application on a four (4) point Likert's scale. Some responses were also presented in frequency and expressed in simple percentages.

The mean score for each factor is calculated by summing up the scores assigned to it by respondents and then, the rank for each factor is assigned. It is computed using the following equation:

$$(1) \qquad MS = \frac{\sum_{i=1}^{4} ai.ni}{\sum_{j=1}^{N} xj} \quad X \quad 100$$

Where xj = sum of the jth factor; j = the factors 1,2,3,4,……N; N= total number of factors or issues examined ; a_i = constant expressing the weight given to the ith response: i = 1, 2, 3, 4

for a response of 'strongly agreed' $a_1 = 4$
for a response of 'agreed' $a_1 = 3$
for a response of 'disagreed' $a_1 = 2$
for a response of 'strongly disagreed' $a_1 = 1$

n_i = the variable expressing the frequency of the ith response, n_1 = the frequency of 'very high' response, n_2 = the frequency of 'high' response, n_3= the frequency of 'medium' response, n_4= the frequency of 'low' response.

III. DATA PRESENTATION AND ANALYSIS

3.1 Awareness of Nigerian building professionals of the concept/application of BIM

Table 3 shows the responses of building professionals with respect to their awareness of the existence of BIM.

Table 3: Level of awareness of Nigerian building professionals of BIM

Response	Frequency	Percentage
Yes	91	67%
No	44	33%
Total	**135**	**100%**

From table 3, 91 respondents representing 67% of the total respondents know about BIM while 44 respondents representing 33% of the total respondents don't know or have never heard of BIM.

3.2 Participation of Nigerian building professionals in BIM

Table 4 shows the responses of building professionals with respect to the extent of their participation or involvement in BIM projects.

Table 4: Extent of participation/use of BIM by building professionals in Nigeria.

Response	Frequency	Percentage
Yes	0	0%
No	135	100%
Total	**135**	**100%**

As shown in table 4, none of the respondents have participated in a building project in Nigeria where BIM was applied.

3.3 Procurement methods that best promote the application of BIM in Nigeria.

Table 5 shows the opinions and ranking of Nigerian building professionals with respect to the type of procurement that best encourages the use of BIM.

Table 5: Ranking of the procurement methods that promote /accommodate the application of BIM in Nigeria.

S/N	Procurement methods	SA 4	A 3	D 2	SD 1	Mean score	Rank
1	Collaborative(relational)	86	42	7	0	3.59	1
2	Management (Packaged)	65	58	12	0	3.39	2
3	Design and construct (Integrated)	25	52	47	11	2.67	3
4	Traditional (Separated)	0	15	85	35	1.85	4

From table 5 above, the traditional method of procurement ranked below 2.50 and was the least in the rank, which means the respondents disagreed that this method promotes the application of BIM while the rest methods ranked well above 2.5 which means that the respondents are in agreement that these methods promote the application of BIM. However, the number one ranked variable was collaborative procurement methods.

3.4 Barriers to the application of BIM in the building delivery process in Nigeria.

Table 6: Ranking of the barriers to the application or use of BIM in building delivery in Nigeria.

S/N	Barriers	SA 4	A 3	D 2	SD 1	Mean score	Rank
1	Lack of awareness of BIM among stakeholders	90	45	0	0	3.67	1
2	Frequent power failure and poor internet connectivity	61	72	2	0	3.44	2
3	Lack of skilled BIM trained staff	78	30	26	1	3.37	3
4	Lack of industrial standards	64	58	10	3	3.36	4
5	Cost of training and high cost of software	42	65	21	7	3.05	5

6	Lack of clients demand of BIM in their projects	35	54	20	26	2.73	6
7	Lack of new amended condition of contract and procurement method	26	40	62	7	2.63	7

From table 6, all the variables (barriers) tested ranked well above 2.50. This is corroboration to the fact that the respondents are in agreement with all the listed variables. However, the number one ranked variable was lack of awareness of BIM among the stakeholders while the least ranked variable was lack of new amended condition of contract and procurement method.

3.5 Benefits of the application of BIM to the building delivery process in Nigeria.

Table 7: Ranking of the benefits of BIM application to building delivery in Nigeria.

S/N	Benefits	SA	A	D	SD	Mean score	Rank
1	Simultaneous access to project database by all stakeholders.	125	10	0	0	3.93	1
2	Project visualization	123	12	0	0	3.91	2
3	Robust information	121	14	0	0	3.90	3
4	Quality communication	112	23	0	0	3.83	4
5	Project documentation	96	32	5	2	3.64	5
6	Clash detection	71	54	10	0	3.45	6
7	Multi-dimensional integration	75	41	12	7	3.36	7
8	Digital facilities management	64	55	10	6	3.31	8
9	Auto-quantification	52	68	9	6	3.23	9
10	Time and cost reduction	45	36	39	15	2.82	10

From table 7, all the variables (benefits) tested, ranked well above 2.50. This means that the respondents are in agreement with all the listed variables. However, the number one ranked variable was simultaneous access to project database by all stakeholders while the least ranked variable was time and cost reduction.

IV. CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

There is no gainsaying the fact that the benefits of applying BIM to the building delivery process are innumerable. Sadly, the Nigerian building industry is yet to fully acknowledge, embrace and adopt this new technology. Application of BIM as an information system in the building construction industry is really a reengineering factor to the sub-sector. Improved profitability in the building construction business and more successful delivery of projects to clients are benefits of applying BIM in the industry. The factors responsible for late delivery of projects, overruns cost estimate, risk management, safety and even compromise in quality are grossly taken care of by the application of BIM. The management of construction industry is also in a better position with BIM.

BIM approach to project design and construction simplifies workers jobs. The application of BIM is very suitable and useful for all sizes and types of construction projects; simple or complex, small or big construction projects. From the design stage to the completion, BIM provides smooth flow of information with effective organizational and control structures within the project construction team and the management of the facility through the life cycle of the facility. The application of BIM is economical and easy. It is a solution to some of the problems facing the industry and thus, leading to improvement, enhanced technical and general management of construction projects and addressing some strategic issues in the sector. The total control of cost estimates, prompt delivery of projects and quality are the most important key performance indicators in construction.

The use of BIM in the construction industry results to; clients' satisfaction, zero defects in projects, predictability in terms of cost and time of projects, productivity and efficiency. Presently, construction industries using the BIM have experienced improved performance and are achieving higher goals in benchmarking and realizing their best practices. No doubt that BIM can now be considered and adopted as another dimension to the overall contributory agenda aimed at modernizing project construction by re-engineering the industry. It is therefore pertinent to emphasize, that by applying BIM in Nigerian construction industry, successful projects implementation and delivery will be assured.

4.2 Recommendations

Based on the foregoing findings of the study, the following corrective propositions are advanced:

- The federal government of Nigeria through the legislative arm should enact laws, making the application of BIM in building projects a necessity. There should be proof of a company's competency in using BIM during the bidding process in order to qualify for tendering and award for any building contract.
- Professional bodies such as the Nigerian Institute of Quantity Surveyors(NIQS), Nigerian Institute of Building(NIOB), Nigerian Institute of Architects(NIA) and the Nigerian Society of Engineers(NSE), that are vested with the responsibilities of overseeing the activities of professionals and building construction works in Nigeria all have major roles to play. They should make BIM a priority to all professionals to learn and put to use.
- Construction companies in Nigeria should embark on training and re- training of their staff so that new skills and construction methods like BIM and virtual reality can be acquired to impact positively on the construction industry at large.
- Construction companies and relevant government agencies and parastatals in Nigeria should procure all necessary software for BIM and virtual reality to facilitate the learning and use of BIM for application in construction projects in the country.
- Research study should be routinely conducted by academics or concerned individuals and organizations to establish the extent to which BIM is known and applied in building projects in Nigeria.

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