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ASSESSMENT OF BUILDING INFORMATION MODELING (BIM) KNOWLEDGE IN THE NIGERIAN CONSTRUCTION INDUSTRY

[1]Ryal-Net, Marcus Balah & [2]Kaduma, Lot Akut
[1]Department of Architecture,
College of Environmental Studies, Kaduna Polytechnic, Nigeria
[2]Design Marks Concepts Ltd, Kaduna. Nigeria

Abstract
Building Information Modeling (BIM) is an innovative approach that is gradually being implemented across the globe. BIM aids the visualization of what is to be built in a simulated environment in order to identify potential design, construction or operational problems of a facility. Despite established benefits that BIM offers, the adoption of BIM in the Nigerian Construction Industry has been relatively slow. A field survey was conducted with the use of 90 structured questionnaires; self administered via stratified random sampling of stakeholders within the Construction Industry in Kaduna State, North-western Nigeria; all structured to identify the respondents' level of awareness of BIM, and extent of usage of BIM. 43 questionnaires were properly filled and returned. With a response rate of 44.77%, the results were analyzed using the Percentile and Relative Index (RI) methods. As a contribution to knowledge, the paper has established that there is a low level of knowledge of Building Information Modeling (BIM) in the Nigerian Construction Industry which is associated to the low level of awareness and utilization amongst stakeholders. As such, the paper recommended the need for increased awareness and utilization of BIM via the participation of relevant professional bodies; the integration of BIM into the Academic curriculum; and for the Nigerian Government to facilitate the implementation of BIM in Infrastructure projects, in order to ensure adequate knowledge of BIM towards improving productivity and efficiency in the Nigerian Construction Industry.

Keywords: *Building Information Modeling (BIM), Knowledge, Productivity, Nigerian Construction Industry, Kaduna State*.

Background to the Study

The need for increased productivity and higher Return on Investments (ROI's) in the construction industry has become a great concern for industry stakeholders. Such decline in productivity is bred by several factors resulting to increased wastages, rework, time overruns, cost overruns, and adversarial relationships between project stakeholders. More disputes and more adversarial positions are staked out because of actual or perceived changes in a construction project than for any other reason. Aggressive contractors will threaten slow-downs and work stoppages if they don't get paid. Overbearing owners will insist that unknown conditions, extra features and an expanded project are covered by the original "non-fluctuating" bid price (Berger, 2008; cited in Infocomm, 2011). Fragmentation in the construction industry, being responsible for poor communication between project stakeholders, leads to inefficiency and low productivity in construction project delivery (Latham, 1994). About two-thirds of construction problems are caused by inadequate communication and exchange of information as a result of fragmentation of the construction industry (Australian CD-ISR, 2004; cited in Mendez, 2006). An increase in maintenance costs can be attributed to faults in the operations of systems and components as a result of deficiency in design (Al-Hammad et al, 1997; cited in Mohammad A. M, & Mohammed A. H, 2010).

In the past, facility managers have been included in the building planning process in a very limited way whereby implemented maintenance strategies are based on the as-built conditions at the time the owner takes possession of the facility. And also, there are additional and valuable information required for operation and maintenance of the building which goes unrecorded during construction (Mendez, 2006). It is important to note that buildings are becoming more complex and are taking longer to build, which makes increased productivity and coordination in the construction industry an imperative (Infocomm, 2011). An innovative approach to building design, construction and management is gradually being implemented by major countries across the globe. This paradigm shift is referred to as "**Building Information Modeling**" or simply put "**BIM**".

Statement of the Problem

The move to adopt Building Information Modeling in Nigeria's private and public sector (client side) and amongst different building professionals (Architects, Quantity Surveyors, Engineers etc) has been very slow. Few Architects have adopted but mainly for enhancing the visual quality of their presentation. This is unfortunate because of its enormous potentials to enhance efficiency, reduce disputes, save costs and curb corruption (Alufohai, 2012). A major setback to the full implementation of BIM in the Nigerian Construction industry, as with every novel technological innovation across the globe, could be related to the lack of knowledge

of BIM technology - along with the benefits of improving productivity and efficiency in the Nigerian Construction sector - amongst stakeholders. It is thus imperative, as a first step, to determine the level of knowledge of BIM in the Nigerian Construction Industry. This in turn, will serve as a basis for developing strategies for increased awareness in order to encourage a holistic implementation of BIM by all industry participants, and thus, achieve the needed productivity and efficiency in the Nigerian Construction Industry.

Objectives of the Study

1. Highlight BIM as a concept for enhancing productivity in the Nigerian construction Industry.
2. Determine the level of awareness on BIM in the Nigerian Construction Industry.
3. Establish the extent of BIM usage in the Nigerian Construction Industry.
4. Ascertain suitable recommendations for increased knowledge of BIM towards improving productivity and efficiency in the Nigerian Construction Industry.

Literature Review

The Concept of Building Information Modeling (BIM)

The concept of BIM as an approach towards enhancing productivity in the Nigerian Construction Industry is highlighted via the following component units:

Definition of BIM

The Royal Institute of British Architects (RIBA), Construction Project Information Committee (CPIC) and Building Smart have jointly defined Building Information Modeling (BIM) as "*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 life cycle, from earliest conception to demolition*" (The BIM Hub, 2014).

Benefits of Building Information Modeling (BIM)

Table 1 below highlights the benefits of BIM throughout the building lifecycle.

Table 1: Benefits of BIM During Design, Construction, Operations and Maintenance of a Building Project

BENEFITS OF BUILDING INFORMATION MODELING

PRE-CONSTRUCTION STAGE

- Concept, feasibility and design.

- Increased building performance and quality.

- Creating time based simulation of construction activities.

DESIGN STAGE

- Earlier collaboration of multiple design disciplines.

- More accurate visualization of design changes.

- Reduction in errors in generating construction drawing.

- Early insight to design errors & omissions.

- Early extraction of more accurate cost estimation & bill of quantities
- Improved energy efficiency & sustainability.

- Blending geospatial and building information for planning.

- Information available earlier within the project.
- Improved information delivery; can be reused, repurposed, reviewed, revised, corrected, controlled, checked and validated.

CONSTRUCTION STAGE

- Synchronization of design & construction revealing potential problems & possible improvements.
- Clash detection.

- Reduction in errors in generating construction drawing.

- Improved co-ordinated approach between participating designers and contractors.

- Using design model as basis for fabricated components.

- Better implementation and lean construction techniques.

- Substantial cost savings, time saving and waste on site.

- Enhanced coordination.
- Enhanced productivity.
- Enhanced business operations.
- Flexibility of output documentation.
- Quick simulations.
- Use of digital product data in manufacturing and assembly of structural systems.

POST-CONSTRUCTION STAGE

- Better managed and operated facilities after completion.

- Streamlined approach where data is shared in a collaborative approach.
- Savings in design coordination, drawing production, information management & exchange.
- Improved design quality, sustainability and client communication.

- Reduces information loss when handing over project from design team to construction team to owner.

-Controlled whole-life cost and environmental data.

[**Source :** Mandhar. & Mandhar, (2013)]

One key competitive advantage of BIM is its ability to promote greater transparency and collaboration between contractors and suppliers, and thereby reduce waste (procurement, process and material) through all levels of the supply chain. A key driver of the rapid adoption of BIM by clients and industry is that the benefits it creates are shared by the client and the entire supply chain – with downstream benefits to customers who make use of built assets and to society at large (GOV.UK, 2012). The principal difference between BIM and 2D CAD is that the latter describes a building by independent 2D views such as plans, sections and elevations. Editing one of these views requires that all other views must be checked and updated, an error-prone process that is one of the major causes of poor documentation (Azhar et al, 2008).

At the technical core of BIM is the software that enables 3D modeling and information management (WSP Group, 2013). A basic premise of BIM is collaboration by different stakeholders during different phases of project life cycle which makes it possible to insert, extract, update or modify information in the BIM process to support and reflect the roles of that stakeholder. BIM was conceived to remedy the problem of fragmentation and error by creating a system to house or manage all of the information needed in a particular project in a single repository that could be accessed by all project participants and readily incorporated into all project documents (Cyon Research, 2003; Khemlani, 2003; NBIMS Project Committee, 2006; cited in Alufohai, 2012). 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 (Autodesk, 2003).

BIM and the Construction Industry in Nigeria

The main contribution of BIM to the Nigerian Construction Industry will be in enhancing relationships between clients and building professionals as disputes sometimes arise over scope of work, modifications, over-runs and associated costs. Such disputes are more common between building professionals and sponsors of real estate projects. In the public sector, the main challenges regarding efficiency and productivity here are poor budgeting and corruption. Also, Construction projects in Nigeria often involve wild inflation of costs. As such, the adoption of BIM will greatly enhance transparency, allowing different stakeholders (bidding contractors, parliament, civil society organizations etc) to have a better idea of true scope of projects (Alufohai, 2012).

The Nigerian National Planning Commission is working on a National Integrated Infrastructure Master Plan (NIIMP) that aims to develop infrastructure throughout the country between 2014 and 2043, which will require $871 billion in core infrastructure through 2030 to support an upside GDP growth scenario (Ryal-net & Kaduma, 2014). The current rebasing of the Nigerian economy shows that construction contribution to GDP growth from 2010-2013 has risen to 7.2%. This cannot be compared to Manufacturing, with a contribution to GDP growth of 14.3% (Mckinsey Global Institute 2014). The low productivity in the Nigerian Construction Industry is attributed to the inefficiency in production processes that are prevalent in construction projects. Whereas, the Manufacturing Industry boasts higher productivity due to increased efficiency via the implementation of leaner and innovative methods of production in a well integrated environment. As such, BIM serves as a practical and innovative approach whereby the planning, designing, building and management of infrastructure is done in a coordinated and integrated manner which improves efficiency and reduces waste, and thus, enables the increased productivity to support GDP growth in Nigeria.

Methodology

A field survey was conducted between June and August 2014 with the use of structured questionnaires, self administered randomly to a sample of stakeholders within various sectors of the Nigerian Construction Industry in Kaduna State, North-western Nigeria, and the respondents were drawn within the three (3) regions with active construction practices i.e. Kaduna metropolis (50%), Zaria City (30%) and Kafanchan (20%) – all based on observed level of construction activity and available number of professional practitioners. The research questionnaires were structured to identify the respondents' awareness of BIM, and the extent of usage of BIM. The questionnaire used a five-point Likert-type scale (as adopted by Abubakar, 2012; Oladapo, 2007) to measure a range of opinions from "Very weak" to "Very strong", "Very low" to "Very high", etc. as the case may be. The rating used assigns a numerical scale of 5 for highest and 1 for lowest. The results were analyzed using the Percentile and Relative Index (RI) methods. The RI technique was used by Liang (2005), in the same context of application using the formula:

$$RI = \sum \frac{1n_1 + 2n_2 + 3n_3 + 4n_4 + 5n_5}{5[n_1 + n_2 + n_3 + n_4 + n_5]}$$

Where, n_x = the number of respondent agreeing with the x choice. Thus;
n_1 = number of respondents for "Never"; n_2 = number of respondents for "Less Often"; n_3 = number of respondents for "Fairly Often"; n_4 = number of respondents for "Quite Often"; n_5 = number of respondents for "Very Often". Where; RI < 0.60 indicates low frequency in use; 0.60 ≤ RI < 0.80 indicates high frequency in use, RI ≥

0.80 indicates a very high frequency in use; as adopted by Faki et al (2010) and Kado & Avul (2010). This formula is used in relation with the Likert scale.

Data Presentation and Analysis

Table 2: Breakdown of Administered Questionnaires

No. Distributed	90
No. Properly filled and Returned	43
Percentage Response	47.77%

Source: Authors' Field Survey (2014)

A total of ninety (90) questionnaires were distributed by hand to the respondents out of which only forty three (43) were properly filled and returned, representing a response rate of 47.77%. This response rate is considered adequate as, according to Ellhag and Boussabaine (1999) and Idrus & Newman (2002), a response rate of 30% is good enough in construction studies (cited in Oladapo, 2007). So the total of forty three (43) questionnaires was used for the analysis.

Respondents' Profile

The bar chart as shown in figure 1 below describes the distribution of respondents based on their area of specialization. It can be seen that Quantity Surveying tops the list with 23.2% representation, followed by Architecture with 18.6%, Building Technology with 11.6%, Mechanical/Electrical Engineering with 11.6%, and Structural/Civil Engineering with 9.3%. However, Estate Management, Land Surveying and Urban & Regional Planning were tied at 7.0% each, while the "Others" category was last with only 4.7% representation which included individuals with academic qualifications in Marketing and Biology.

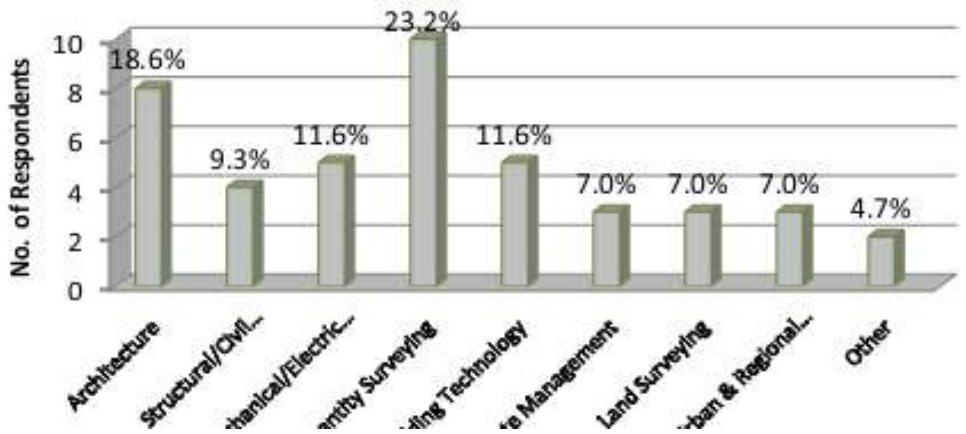

Figure 1: Area of Specialization of Respondents
(**Source:** Authors' Field Survey, 2014).

The bar chart as shown in figure 2 below describes the distribution of respondents based on their area of Practical experience in the Nigerian Construction Industry, where Consultants topped the list with 23.3% representation, followed by Contractors with 20.9%, Client/Developer with 18.6%. Both Education/Academics and Manufacturers/Fabricators/Subcontractors were tied with 11.6% each, while Planning/Regulatory Institution has 14.0% representation.

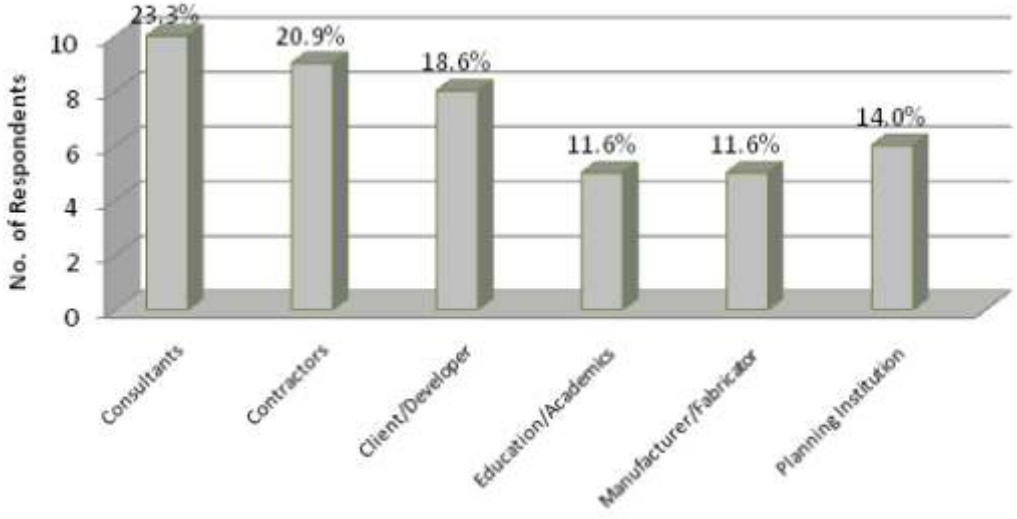

Figure 2: Area of Practical Experience
(**Source:** Authors' Field Survey, 2014).

Level of Awareness of BIM

The bar chart as shown in figure 3 below describes the distribution of respondents' BIM awareness based on their professional qualifications. It can be seen that Quantity Surveyors are the most aware with 14% representation. This is followed by Architects (i.e. 11.6%), Services Engineers (4.7%), and Structural/Civil Engineers (2.3%). The figure above also indicates that Builders, Estate Managers, Land Surveyors, Urban & Regional Planners, and Others are not currently aware of BIM. As such, only 30% of respondents are aware while 70% of the respondents are not aware. This indicates a very low level of awareness of the BIM amongst the various stakeholders in the Nigerian Construction Industry.

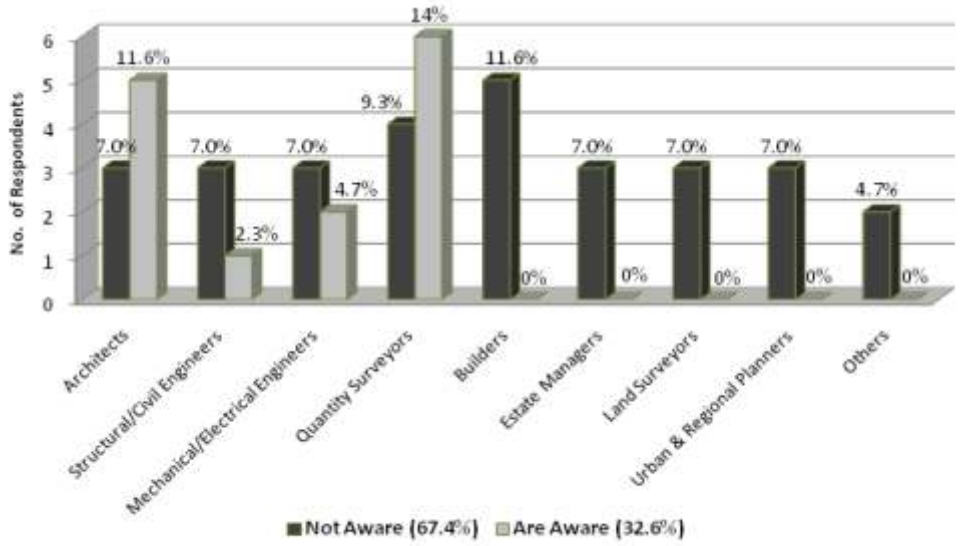

Figure 3: Respondents distribution of BIM awareness
(**Source:** Authors' Field Survey, 2014)

The pie chart as shown in figure 4 below describes the distribution of respondents based on their years of awareness of BIM. Out of the 13 respondents who claimed to be aware of BIM, 23% has been aware for less than a year, 69% have been aware between 1-5 years, only 8% has been aware between 6-10 years, while none of the respondents claimed to be aware of BIM since over 10 years ago. Thus, this indicates that the awareness of BIM amongst stakeholders in the Nigerian construction industry is a recent development.

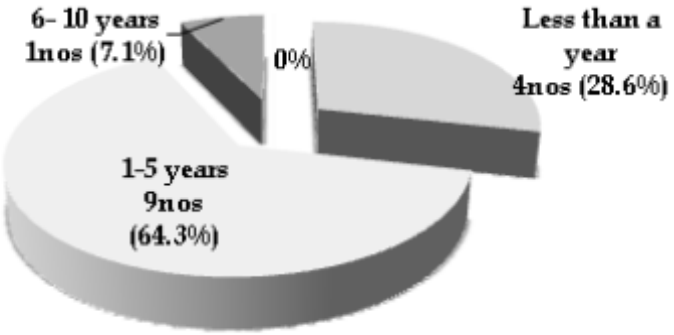

Figure 4: Years of awareness of the Concept of BIM
(**Source:** Authors' Field Survey, 2014)

The pie chart as shown in figure 5 below describes the distribution of respondents based on their description of the concept of BIM. Responses to the open ended question requiring the description of the concept of BIM showed that only 7% of the respondents gave correct responses to the description of the concept of BIM, while 23% of the respondents gave incorrect responses. Thus, the data indicates the lack of understanding of the concept of BIM amongst respondents who claimed to be aware, and as such, indicates a very low level of the knowledge of BIM in the Nigerian Construction Industry.

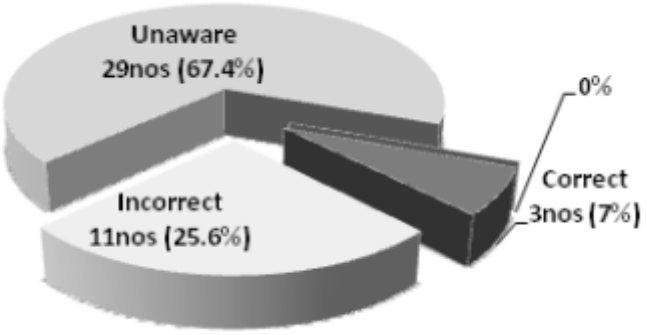

Figure 5: Responses regarding the description of the BIM concept
(**Source:** Authors' Field Survey, 2014)

Extent of BIM Usage

Table 3: BIM Software utilized by Respondents

BIM Software	No. of Respondents in Ordinance Scale					Total	Relative Index (RI)	Rank
	1	**2**	**3**	**4**	**5**			
AutoCAD Architecture	26	3	1	8	5	43	0.43	1
Revit Architecture	34	0	1	7	1	43	0.33	2
ArchiCAD	35	1	3	2	2	43	0.30	3
AutoCAD Civil 3D	33	4	3	2	1	43	0.29	4
Land Desktop Development	31	7	2	3	0	43	0.29	4
AutoCAD MEP	36	2	3	1	1	43	0.27	6
Orion	39	2	1	1	0	43	0.23	7
Revit MEP	37	6	0	0	0	43	0.23	7
Revit Structure	40	1	2	0	0	43	0.22	9
Navisworks	41	1	0	0	1	43	0.22	9
Staad Pro	40	3	0	0	0	43	0.21	11
Tekla	41	2	0	0	0	43	0.21	11
Catia	43	0	0	0	0	43	0.20	13
FM Desktop	43	0	0	0	0	43	0.20	13

Source: Authors' Field Survey (2014)

The most common BIM software often utilized by the respondents is AutoCAD Architecture (Ranked 1st), followed by Revit Architecture (2nd) and ArchiCAD (3rd). However, the fact that these BIM tools score below the 0.60 RI score thus indicates the low level of utilization of BIM software amongst stakeholders in the Nigerian construction industry.

Table 4: Purpose of Utilization by Respondents

Purpose of Utilization	No. of Respondents in Ordinance Scale					Total	Relative Index (RI)	Rank
	1	**2**	**3**	**4**	**5**			
3D Modeling/ Presentation	5	4	2	11	21	43	0.78	1
Construction Drawings	36	0	3	1	3	43	0.30	2
Engineering Analysis	35	4	1	3	0	43	0.27	3
As-Built Drawings	43	0	0	0	0	43	0.20	4
Budget	43	0	0	0	0	43	0.20	4
Clash Detection	43	0	0	0	0	43	0.20	4
Maintenance Programme	43	0	0	0	0	43	0.20	4
Master Planning	43	0	0	0	0	43	0.20	4
Programme Scheduling	43	0	0	0	0	43	0.20	4
Quantity Take-off	43	0	0	0	0	43	0.20	4

Source: Authors' Field Survey (2014)

The most common purpose of utilization of BIM by the respondents is for 3D Modeling/Presentation (Ranked 1st) with an RI score of 0.78 which indicates that BIM is only popularly used for Presentation purposes. However, the fact that the others rank well below the 0.60 RI score indicates the low level of knowledge of the benefits of utilization of BIM software amongst stakeholders in the Nigerian construction industry.

Suitable Recommendations for Increased Knowledge of BIM in the Nigerian Construction Industry

Table 5: Recommendations for Increased Knowledge of BIM.

Recommendations for Increased Knowledge of BIM.	No. of Respondents in Ordinance Scale					Total	Relative Index (RI)	Rank
	1	**2**	**3**	**4**	**5**			
Participation of relevant professional bodies.	2	0	1	13	27	43	0.89	1
Availability of well trained professionals	3	6	7	13	14	43	0.73	2
Full Integration into academic curricula	9	3	4	10	17	43	0.71	3
BIM Software availability	6	7	9	11	10	43	0.66	4
Government support through legislation	11	7	6	7	12	43	0.61	5

Source: Authors' Field Survey (2014)

The respondents highly recommended that the participation of the Relevant Professional Bodies (Ranked 1st) in the Nigerian Construction Industry would be the most important step towards increased knowledge of BIM. This is followed by availability of well trained professionals (2nd), Full integration into academic curricula (3rd), BIM software availability (4th), and Government support through legislation. However, the fact that these factors rank above the 0.60 RI score thus indicates their overall importance towards increased knowledge of BIM towards improving productivity and efficiency in the Nigerian Construction Industry.

Summary of Research Findings

1. The low productivity in the Nigerian Construction Industry is attributed to the inefficiency in production processes that are prevalent in construction projects. Whereas, the Manufacturing Industry boasts higher productivity due to increased efficiency via the implementation of leaner and innovative methods of production in a well integrated environment. As such, BIM serves as a practical and innovative approach whereby the planning, designing, building and management of infrastructure is done in a coordinated and integrated manner which improves efficiency and reduces waste, and thus, enables the increased productivity to support GDP growth in Nigeria.
2. Only 30 percent of stakeholders – mostly Quantity Surveyors, Architects, and Engineers – claimed to be aware of BIM where a majority of these stakeholders have been aware of BIM since 2010. This shows that BIM is a recent concept in the Nigerian Construction Industry. However, only 7% of the respondents possess a proper understanding of the concept of BIM, and thus indicates a very low level of BIM knowledge in the Nigerian Construction Industry.
3. The most common BIM software often utilized by the respondents is AutoCAD Architecture, Revit Architecture and ArchiCAD. However, the fact that they score below the 0.60 RI score indicates that these BIM tools maintain a low level of utilization in the Nigerian construction industry. As regards the extent of utilization of BIM, 3D Modeling/Presentation remains the popular choice for utilization with an RI score of 0.78. This indicates a low level of BIM knowledge in the Nigerian Construction Industry considering the several benefits that BIM offers.

Conclusions and Recommendations

As a contribution to knowledge, the paper has established that there is a low level of knowledge of Building Information Modeling (BIM) in the Nigerian Construction Industry which is associated to the low level of awareness and utilization amongst stakeholders.

In order to suggest strategies for increased knowledge of BIM towards improving productivity and increased efficiency in the Nigerian Construction Industry, the research seeks to recommend the following:

1. The need for increased awareness of the benefits of the adoption of BIM as an approach towards increased productivity and efficiency should be encouraged in the Nigerian Construction Industry. This will be achieved through the participation of relevant professional bodies.

2. There is also the need for well trained professionals in the utilization of BIM in order to ensure increased knowledge of BIM in the Nigerian Construction Industry.
3. The full integration of BIM into the curricula of Academic Institutions has been highlighted as a necessary step towards increased knowledge of BIM. This will ensure that Graduates have the background knowledge of the concept and implementation of BIM in the Nigerian Construction Industry.
4. Finally, it is imperative that the Nigerian Government supports the implementation of BIM in all capital projects through legislation. This can be achieved through the integration of BIM into the National Integrated Infrastructure Master Plan (NIIMP) which aims to develop infrastructure throughout the country between 2014 and 2043.

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