ASSESSMENT OF THE APPLICATION OF BUILDING INFORMATION MODELING (BIM) TO BUILDING PROJECTS DELIVERY IN NIGERIA

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ABSTRACT
The study assesses the level of awareness and application of Building Information Modeling (BIM) in building delivery process in Nigeria. The review explains in details, the structure of BIM and how it can be used as a factor to bring about the total change required in the Building construction and delivery process. Personal interview and administration of questionnaires were used to source primary data for this study. The analysis was done using descriptive statistical tool. The responses from questionnaires were presented using frequency/ percentage table and means score ranking. The findings identified low application of BIM in Nigeria building projects delivery process and various barriers to the application of BIM. Lack of awareness of BIM by the stakeholders ranked highest in the assessment of barriers. The collaborative procurement method ranked highest as method that best promotes BIM application and simultaneous access to project database by all stakeholders ranked highest as benefit of BIM application. Five recommendations were given to address the low application of BIM to Building project delivery in Nigeria. The following among others were recommended: the federal government of Nigeria through the legislative arm should enact a law, making the application of BIM in construction projects a requirement. There should be prove of a company's competency in using BIM concept during bidding process in order to qualify for tendering and award for any construction projects. The various professional institutes and the regulatory bodies like COREN, NSE, ARCON, NIA, NIOB, CORBON, NIQS etc. being the bodies that are vested with the responsibilities of overseeing the activities of the professionals and 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 in construction projects in Nigeria.

Keywords
Construction, Building, Professionals, Delivery, Information and Collaboration

INTRODUCTION
The Building Construction Industry has over the years witnessed revolutions in all of its production processes and operations. 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 (BIM) - an innovative new approach to building design, construction, and management has changed the way industry professionals worldwide think about how technology can be applied to building design, construction, and management.

Building information modeling broadly encompasses a series of technologies that are transforming design and construction. In essence, BIM uses information rich databases to characterize virtually all relevant aspects of a structure or system. It is qualitatively different from computer-assisted design and drafting (CADD) because it is not just a depiction, it is a simulation of the facility.

BIM has been defined by Lee et al (2006), as the process of generating and managing building data during its life cycle. Typically, it uses three-dimensional, real-time, dynamic building modeling software to increase productivity in building design and construction. The process produces the Building Information Model, which encompasses building geometry, spatial relationships, geographic information, and quantities and properties of building components.
BIM has also been defined as the digital representation of the physical and functional characteristics of a facility. As such, it serves as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle from inception onward (Nederveen et al, 2010).

The National Institute of Building Sciences NIBS (2015), defines building information modeling as follows: A Building Information Model, or BIM, utilizes cutting edge digital technology to establish a computable representation of all the physical and functional characteristics of a facility and its related project/life-cycle information, and is intended to be a repository of information for the facility owner/operator to use and maintain throughout the life-cycle of a facility.

The Building Information Model is primarily a three dimensional digital representation of a building and its intrinsic characteristics. It is made of intelligent building components which includes data attributes and parametric rules for each object. For instance, a door of certain material and dimension is parametrically related and hosted by a wall. Furthermore, BIM provides consistent and coordinated views and representations of the digital model including reliable data for each view. This saves a lot of designer's time since each view is coordinated through the built-in intelligence of the model. According to the National BIM Standard, Building Information Model is "a digital representation of physical and functional characteristics of a facility and 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" ("About the National BIM Standard-United States", 2010).

Building information modeling supports the continuous and immediate availability of project design, scope, schedule, and cost information that is high quality, reliable, integrated, and fully coordinated (Autodesk solutions, 2008). From technology perspective, a building information model is a project simulation consisting of the 3D models of the project components with links to all the required information connected with the project planning, design, construction or operation (Kymmell, 2008). The BIM technology hailed from the object-oriented parametric modeling technique. The term "parametric" describes a process by which an element is modified and an adjacent element or assembly (e.g. a door attached to a wall) is automatically adjusted to maintain a previously established relationship (Stine, 2011).

A building information model carries all information related to the building, including its physical and functional characteristics and project life cycle information, in a series of "smart objects". For example, an air conditioning unit within a BIM would also contain data about its supplier, operation and maintenance procedures, flow rates and clearance requirements (Azhar and Richter, 2009; CRC Construction Innovation, 2007).

Building Information Modeling (BIM) is a revolutionary technology and process that has quickly transformed the way buildings are conceived, designed, constructed and operated (Hardin, 2009). The National Building Information Modeling Standards (NBIMS) committee of USA 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 (NBIMS, 2010)."

The present system of building process (traditional method) in some developing countries and in particular Nigeria, allowed communication to work in one direction only. Project leadership calls for clear communication about goals, responsibility, performance, expectations and feedback. The construction industry today flaunts a plethora of project delivery methods among these methods, those which imbibe collaboration among stakeholders/professionals and integration of the various phases/stages of a project has been attested to offer best quality products. Hence, the Integrated Project Delivery (IPD) concept emerges as a natural companion to BIM.

These limitations toward the use of BIM in the planning and completion of site work represent a knowledge gap in the Architecture/Engineering/Construction industry in Nigeria.
This study is aimed at assessing the application of Building Information Modeling to Building Delivery process in Nigeria.

Uses of Building Information Modeling

Visualization

Building Information Modeling (BIM) is a great visualization tool. It provides a three dimensional virtual representation of the building. During the bidding phase of the project, the construction manager can provide renderings, walkthroughs, and sequencing of the model to better communicate the BIM concept in 3D (Mehmet, 2011). Visualization provides a better understanding of what the final product may look like. It takes away thought process of bringing the different traditional 2D views together to come up with the 3D view of a detail.

Construction Planning and Monitoring

According to Mehmet (2011), the construction planning involves the scheduling and sequencing of the model to coordinate virtual construction in time and space. The schedule of the anticipated construction progress can be integrated to a virtual construction. The utilization of scheduling introduces time as the 4th dimension (4D). There are two common scheduling methods that can be used to create 4D Building Information Model. These are critical path method (CPM) and line of balance ((Mehmet, 2011).

Design Efficiency

Although the greatest efficiencies are obtained when BIM is used collaboratively, BIM design can aid a traditional design process. BIM software can reduce the cost of preparing 2D drawings in a conventional project, especially when designs are changing rapidly. For example, in Revit®, any change in plan view automatically updates any section affected by the change. In Tekla Structures, changes in dimension or geometry automatically update details and related features (Howard, 2008). Moreover, using data-rich elements instead of drawn objects accelerates creation of contract drawings (Howard, 2008).

Consistent Design Bases

BIM modeling ensures that all parties working from the model share the same base. Under current practice, not all participants may be operating directly from the model. However, if the participants are using software that is compatible with the model, the base information can be

moved, imported, or exported from the model (Howard, 2008). Yan and Damian (2008) observed that design of buildings has been done in the traditional way with the use of simple tools such as pen, paper and ruler, until the advancement of mathematics and building material science in the mid nineteenth century when engineers begin to use computers to produce 2D CAD drawings.

3D Modeling and Conflict Resolution

Expressing the extent of relevance Howard (2008), noted that the BIM model can render the design in three dimensions and does not require separate software to explore the model visually. This allows better exploration of space, visualization of light studies, and improved communication and understanding of design concepts within the team and with project stakeholders.

Conflict Identification and Resolution

Building information modeling greatly reduces conflict issues by integrating all the key systems into the model. Design BIM systems can detect internal conflicts, and model viewing systems such as Navis- Works® can detect and highlight conflicts between the models and other information imported into the viewer (Howard, 2008). It provides for efficient communication and data exchange (Nederveen *et al*, 2010), auto quantification, improved collaboration, coordination of construction documents, improved visualization of design, (Olatunji, et al, 2010; Sacks et al, 2010) clash detection.

Reduced Fabrication Costs and Errors

The ability to use information in the model to directly create fabrication drawings avoids a problematic and difficult step in the construction process. In a traditional workflow, the fabricators must review the plans and specifications, prepare fabrication drawings, compare them to other fabrication and design drawings, have them reviewed by the design team, and eventually release the drawings for fabrication. Errors can occur at any stage. By using the data in the model, dimensional errors, conflicts, and integration errors can be avoided or significantly reduced (Howard, 2008). Cost reduction is greatly achieved applying BIM (Eastman *et al*; 2011).

Facilities Management

If the model is properly maintained during construction, it becomes a tool that can be used by the owner to manage and operate the structure or facility (Howard, 2008). Modifications and upgrades can be evaluated for cost-effectiveness. Data contained in the model can be used for managing remodeling, additions, and maintenance (Nederveen et al, 2010).

MATERIALS AND METHODS

Research Design

The literatures reviewed provided the definition of BIM, the use and its application in the building delivery process. Survey was carried out through the use of observation, oral interviews and structured Questionnaire. The data for the study was sourced from the construction industry Professionals. This was adopted to determine the extent of awareness and application of BIM by the professionals and companies in Building Construction Process in Nigeria.

Population of the Study

The population considered among these professionals (Architects, Engineers, Builders, quantity surveyors, town planners, land surveyors and Estate/property Managers) are those who practice as consultants, construction managers, contractors and those in the construction companies and civil service. In order to limit the extent of work involved with data collection for this study, the survey was narrowed to professionals in construction companies/firms, ministries and institutions within the South East States (Imo, Anambra, Enugu, Ebonyi and Abia) but have good network, base of operation and solid reputations in execution of building projects throughout Nigeria.

Data Collection

Primary Source of Data

Personal interviews, direct investigations and observations, the administration of questionnaires was used to source primary data for this study.

Secondary Sources of Data

Review of related textbooks, professional journals, conferences and seminar papers. These were sourced through the library and internet.

Sampling Technique

Stratified random sampling was used to select the sample size for this study. From the returned questionnaires a sample size of 135 professionals in the Building Construction Industry within the South East was considered.

RESULTS AND DISCUSSION

The frequency percentage table and mean scores ranking table was used to analyze the responses from the respondents.

Table 1: Which professionals are disposed to the use of BIM?

Response	Frequency	Percentage
Architects only	4	3%
Architects, Engineer & Builders	60	44.4%
Architects & Engineers	10	7.4%
All professionals in a Building Project	61	45.2%
Total	135	100%

From Table 1 above; 4 respondents representing 3% of the total respondents said BIM is disposed to only architects, 60 respondents representing 44.4% said BIM is disposed to the Architects, Engineers and Builders, 10 respondents representing 7.4% said BIM is disposed to Architects and Engineers while 61 respondents representing 45.2% acknowledged BIM is disposed to all the professionals in a Building Project.

Table 2: How can you appraise the level of application of BIM in the execution of Building Projects in Nigeria?

Response	Frequency	Percentage
High	0	0%
Average	15	11.1%
Low	95	70.4%
Not at All	25	18.5%
Total	135	100%

From table 2 above; no respondent believed the application of BIM is high in Nigeria, 15 respondents representing 11.1% of the total respondents believed there is an average application of BIM in Nigeria, 95 respondents representing 70.4% of the total respondents believed there is a low application of BIM in Nigeria while 25 respondents representing 18.5% of the total respondents believed BIM is not being applied at all in Nigeria.

Table 3: What are the barriers to the application of BIM in the Building Delivery Process?

SN	Barriers	SA 4	A 3	D 2	SD 1	Means Item score	Overall ranking
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 3 above all the variables (barriers) tested ranked well above 2.50. This is an attestation 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.

Table 4. Which procurement methods do you think that promote /accommodate the application of BIM?

SN	Procurement Methods	SA 4	A 3	D 2	SD 1	Means Item Score	Overall ranking
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 4 above, 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.

Table 5: What are the benefits of BIM application to Building Delivery Process?

SN	Benefits	SA	A	D	SD	Means Item score	Overall ranking
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 5, above all the variables (benefits) tested ranked well above 2.50. This is an attestation to the fact 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.

Conclusion and Recommendations

It is awkward that despite all the benefits of the application of BIM to building delivery process the Nigerian construction industry is yet to fully acknowledge the need for BIM application. Application of BIM as an information system in the construction industry is really a reengineering factor to the sector. Improved profitability in the construction business and more successful delivery of projects to clients are benefits of applying BIM in construction 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 in better position with BIM to manage building projects. 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. 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. However, BIM application by the construction industry in project developments in Nigeria as an operational management tool is seen as a strong application that will re-engineer the sector to enable improvement towards achieving the much desired success it deserves with respect to construction project delivery to its clients, the world over.

The following recommendations were provided as a forward to the application of BIM in the Nigeria construction projects:

1. The federal government of Nigeria through the legislative arm should enact laws, making the application of BIM in construction projects a necessity. There should be prove of a company's competency in using BIM concept during bidding process in order to qualify for tendering and award for any construction projects.
2. The Council for the regulation of various construction professionals (Council of Registered Engineers of Nigeria (COREN), Council of Registered Builders of Nigeria (CORBON) etc) and their training Institutes in Nigerian (Nigeria Society of Engineers (NSE), Nigerian Intitute of Architects (NIA), Nigerian Institute of Building (NIOB), etc) being the bodies that are vested with the responsibilities of overseeing the activities of the professionals and 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 in construction projects in Nigeria.
3. The construction companies in Nigeria should embark on training and re- training of their staff and workers on such new skills and construction methods like BIM and virtual reality to impact positively on the construction industry at large.
4. 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.
5. Research study should be routinely conducted to establish the extent to which BIM concept is known and applied in construction projects within the Nigerian construction industry.

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