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BUILDING INFORMATION MODELING IN NIGERIA AND ITS IMPACT ON COLLABORATION IN SCHEMATIC DESIGN STAGE AND POST CONTRACT STAGE OF DESIGN

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Abstract
Building Information Modeling (BIM) is a concept that is transforming the construction world internationally. As Nigeria develops technologically, the use of BIM in design and implementation of projects is also developing. BIM is used to develop a collaborative construction process that includes design, build, operate and maintenance of buildings. However the adoption of BIM in Nigeria is very slow; it is used mostly for schematic design and presentation drawings by Architects. Other professionals in the construction industry still produce their drawings with 2D AutoCAD. The purpose of this paper is to study the use of BIM in Nigeria and determine to what extent it has helped in improving efficiency and collaboration during schematic phase of design and provided effective co-ordination during the post contract stage. The research methodology involved using structured questionnaires to 30 Architectural firms selected through simple random sampling method. Results showed BIM has a high impact on client satisfaction, time for completion, quality and presentation of different concepts in schematic design. It also showed high impact on conflict resolution, supervision, construction programming and quality of completed jobs during post contract stage. Barriers to adoption of BIM were identified as lack of infrastructure, lack of skilled workers and lack of awareness of technology. For Nigeria to compete internationally in the construction industry, BIM should be adopted hence there is need for research on the subject. Recommendations include developing a curriculum that will incorporate the study of BIM in all construction courses. Learning centres should also be developed for private practitioners. Efforts should be made by the relevant professional bodies to increase awareness of the technology.

Keywords: Adoption, Building Information Modeling, Nigeria

1 Introduction

Building Information Modeling (BIM) is 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. "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)" (Hassan and Yolles, (2009).

BIM is a new approach to design depending on collaboration between the Architects, Client, Engineers, Building services, Manufacturers, Contractors and other consultants. It is a team approach where inputs of all the professionals in the design are captured in the same model. The most common softwares for BIM are Autodesk Revit, Microstation, ArchiCad, CBIM and Ruska.

1.1 Problem Statement

Building Information Modeling programs are being adopted by Architectural Firms in Nigeria. However, they are mostly used for sketch and presentation designs. Collaboration and improvement in communication and efficiency during construction is one of the major advantages of Building Information Modeling. It is also one of the major problems in the Nigerian construction industry. This research seeks to find out the challenges and barriers to adoption of Building information modeling in Nigeria, Factors impending adoption of building information modeling and provide solutions to these challenges.

1.2 Aims and Objectives

The purpose of this Research is to study the use of Building Information Modeling in Nigeria and determine to what extent it has helped in improving efficiency and collaboration during schematic phase of design and provided effective co-ordination during the post contract stage. The results will be measured according to primary key performance indicators used in construction industry. These include quality, on-time completion, safety, client/customer relationship, communication between consultants and other stake holders in the project.

Objectives of the research include:

1. To investigate if BIM use improves efficiency and collaboration during schematic design phase.
2. To determine the impact of BIM on supervision and co-ordination during the post contract stage of design.
3. To determine barriers to the full adoption of BIM in Lagos, Nigeria.
4. To identify solutions to challenges and barriers

2 Analysis of Literature Review

A lot of literature is available on Building Information Modeling (BIM). However, Literature on BIM in Nigeria is limited. "BIM can potentially increase the efficiency, quality and productivity of construction projects by reducing the number of mistakes and incompatibilities, providing more accurate and up-to date information, and by giving a more illustrative and accessible exposition of a building, (Eastman et al. 2011). Benefits of BIM include the ability to reuse information stored in a database, (Egbu and Sidawi, 2012). Automation through BIM also improves time and cost management. It streamlines the design process across the company and facilitates automation of emails via knowledge database.

Other benefits include ability to visualize what is to be built in a simulated environment, higher reliability of expected field conditions, allowing for opportunity to do more prefabrication of materials off site (Rajedran and Clarke, 2011). According to Gordon and Holness (2008), "The building design development can continue with the provision of automatic bills of material and generation of automatic shop drawings for everything from structural steel to sheet metal duct fabrication, to fire protection and piping fabrication, to electrical cabling and bus duct layouts".

Benefits of 'GIS-BIM' based site analysis (CICRP, 2009) include aid in determining if potential sites meet the required criteria according to project requirements and minimizing risk of hazardous materials. "The advances in smartphone and tablets technology have allowed contractors and subcontractors to frequently use BIM models at the jobsite for information

extraction and coordination. Some of the notable BIM apps include BIMX®, Bentley Navigator®, Buzzsaw®, " (Rubenstone, 2012).

2.1 Challenges to BIM Adoption in Nigeria

Challenges to BIM Adoption in Nigeria include interoperability risks between different programs used (Azhar et al., 2011). A lot of Architects and Engineers still use 2D AutoCAD in Nigeria. This affects collaboration of construction working drawings and limits use of BIM during post contract stage. A survey by AECbytes shows that despite each discipline working in 3D environment, collaboration is still primarily based on exchange of 2D drawings. (Khemlani, 2007).

Furthermore, the ownership of BIM data has not yet been determined. It is not yet clear if the BIM belongs to the client who paid for it to be done or the Architect who developed the model. This can create conflict if the client decides to get inputs from other consultants by himself. Most times the Architect has to bear the cost of changes in the model during construction as the client is not willing to pay for extra costs. This increases the cost of production for Architects. Most BIM in use do not have object libraries that are used in the Nigerian Market. Standards for drawing presentation have not been developed. Integrated concept of BIM increases risk and liabilities to different parties involved (Azhar et al., 2011). This creates problems when vendors and other consultants make input to the BIM. BIM systems create big files, management and transfer of these files with Nigerian internet and power problems is very difficult.

2.2 Barriers to adoption of BIM in Nigeria

Barriers to BIM adoption include lack of skilled personnel. There are not enough trained personnel in the industry. Most Architects train themselves or learn on the Job so they are not aware of all the capabilities of the software. Reluctance of other stake holders (Engineers, Contractors, etc.) to use BIM makes it difficult for Architects who are using BIM because they have to transfer their drawings to AutoCAD for the other consultants to do their work.

"Fear of change" is another barrier to adoption of BIM (Hassan and Yolles, 2009). Most people are very comfortable with the software they are using and find it very difficult to change .Using BIM means a change of mindset from developing drawings with lines to developing drawings in three dimensions putting in walls, windows, doors and other building components. Extra costs involved in hardware, software and developing office procedures are also barriers to adoption. Adopting BIM involves, purchasing of software and hardware that can be used .It involves training of staff already working in the office. This will lead to extra costs for the office.

According to Farley (2011), "lack of BIM object libraries" affects production of drawings because some products are not available in the software. , Lack of constant electricity and lack of internet connectivity affects output of work in the offices. (Abubakir et al., 2014). Constant use of generators increases cost of running the offices. Internet connection is necessary for BIM to be used adequately. Internet has to be connected to get drawings from a vendor site. Internet is not readily available in Nigeria Use of internet also increases cost of production. A lot of professionals in the construction industry are still not aware of the technology. For BIM to be used effectively, all the professionals involved in a project have to be aware of it.

2.3 Solutions to Challenges and barriers

The need to incorporate BIM education in our Universities is emphasized. One of the aims of this research is to establish an Autodesk authorized training centre in University of Lagos that will be used for training of Architects and other professionals in the construction industry. Building information modeling as a course should be introduced in all schools of Architecture

Engineering, quantity surveying and other construction disciplines. We need to create awareness within the professional bodies. Nigerian institute of Architects, Nigerian institute of quantity surveyors and other regulatory bodies in the construction industry need to get involved with Building Information Modeling and help in standardization of BIM in Nigeria.

The Government has to be involved. Most of the countries that have successfully adopted BIM have government participation. "Government has helped to achieve progress in most countries. The General Services Administration (GSA) in the U.S.A made the use of BIM a requirement on all major projects receiving significant public funding in 2007. In Finland, the Senate Properties, a government owned organization implemented BIM Requirements in October2007. Such a role has been played by governments in Northern Europe. In Singapore, the CORENET e-PLAN Check system (Construction Real Estate NETwork), launched by Singapore's Ministry of National Development) provides automated compliance checking against building codes for schemes designed using BIM." (Alufohai, A, 2012). Federal government of Nigeria and other building and construction agencies should enforce the use of BIM by organizing workshops and seminars to educate owners, Architects, Engineers, Contractors and other stakeholders on the uses and advantages of BIM for public and private construction projects in Nigeria. To improve the industry and make us more competitive in the World, there is need for more research on the use of Building Information Modeling in Construction in Nigeria.

3 Research Methodology

The Research was conducted with a structured questionnaire as a tool of data collection distributed to 30 Architectural firms. The questionnaire was divided into 4 parts. The first part gathered general information about the Architectural firm: Company Name, Address, Years in Business, Total No of Employees, kind of projects and software used for drawings. The second part of the questionnaire gathered data on the impact of BIM in schematic design using. The third part of the questionnaire gathered data on impact of BIM on post-contract design stage while the fourth part obtained information on the company's perception of barriers to the adoption of BIM in Nigeria. The factors identified through literature were used as variables for 3 tables on second, third and fourth part of the questionnaire.

Variables for impact on Schematic design were: collaboration with other consultants, client satisfaction, time of completion, quality of drawings, collaboration with other staff in the office, presentation of different design concepts. Variables for impact on post contract stage were: collaboration with other consultants, construction programming, estimation of costs, supervision of jobs, quality of completed project, time of completion, energy efficiency, safety, and conflict resolution. Factors affecting adoption of BIM were barriers to adoption listed in the literature review. Questionnaires were given to 30 companies randomly selected from list of Architectural firms by the Nigerian institute of Architects. The responses obtained were used to draw inferences. The firms were also asked to state their own contributions on the effect of BIM on sketch design and post contract design stage.

4 Findings and Discussion

4.1 Reliability Analysis of Questionnaire on Impact of Building Information Modelling (BIM) on Collaboration in Schematic Design and Post Contract Design Stage

Table 1. Reliability test results of instrument

Instrument	Scale Statistics					Reliability Statistics	Validity Statistics (ANOVA)	
Source	No. of Items	N of Samples	Mean	SD	CV	Cronbach's Alpha	F-value	P-value
Impact of BIM on Schematic Design Stage	6	16	26.81	2.040	0.08	0.737	140.904	0.000
Impact of BIM on Post Contract Design Stage	9	16	38.31	3.610	0.09	0.767	22.735	0.000
Factors Preventing Adoption	9	16	32.19	4.722	0.15	0.760	32.626	0.000

Key: SD (Standard Deviation); CV (Coefficient of Variation)
(Source: Field survey, 2015)

The test of reliability of the responses on study of Impact of Building Information Modeling (BIM) on Collaboration in Schematic Design and Post Contract Design Stage, using standardized Cronbach's Alpha is obtained for each section as 0.737 (73.7%), 0.767 (76.7%) and 0.760 (76.0%). These results suggest that the instrument of evaluation is highly reliable judging from the fact that 73.7%, 76.7% and 76.0%. > 70% threshold value, respectively. Further, the results implied that there is an internal consistency of the items in the instruments (questionnaires) used for data collection. These results are supported by the coefficient of variation (CV) values; 0.08, 0.09 and 0.15, which are respectively less than 0.50 threshold value, indicating homogeneity on how the respondents rated the items. Hence, there is an internal consistency of the answers from the respondents and therefore the data do not violate the assumption of reliability. The construct validation of the reliability results of instruments is carried out using analysis of variance (ANOVA) to test if there is no significance variation on how the respondents rated the items in each section of the instrument. The result of the analysis reveals that the test is significant at F-value = 140.904, 22.735 and 32.626, $P < 0.05$, respectively. The results suggest that there is no significance variation on the rating of the items by respondents in the instruments. Hence, the reliability of the instruments is significant, which validates the adequacy of the instruments.

Table 2. Analysis of socio-economic variables

Variable	Characteristics	Freq.	%	Mean	Total
Address	Within Lagos	12	75.0		
	Other South West	3	18.8		
	South South	1	6.3		16
Years in Business	1-5 years	5	31.3		
	6-10 years	2	12.5		
	11–15years	6	37.5		
	Over 21 years	3	18.8	10.8yrs	16
Total No of Employees	1-5 staff	8	50.0		
	6-10 staff	6	37.5		
	11–15 staff	1	6.3		
	Over 21 staff	1	6.3	7 staff	16
What kind of projects do you do?	mostly residential	1	6.3		
	mostly Commercial	1	6.3		
	all Building Types	14	87.5		16
Do you use any Building information modeling software in your practice?	Yes	16	100.0		16
If yes, which software do you use?	AutoCAD Revit	13	81.3		
	ArchiCad	3	18.7		16
If No, are you considering adopting BIM in the future?	No	15	93.8		
	Yes	1	6.3		16
Would you consider an applicant using BIM for employment before one that does not use it?	No	2	12.5		
	Yes	14	87.5		16

(Source: Field survey, 2015)

81.3% of the Architects interviewed use AutoCAD Revit in their office while 18.7% use ArchiCAD. 37.5% of the Architects interviewed have been in practice for 11 to 15 years while 18.8% have been in practice for over 21 years.56.3% of the firms have been in practice for more than 10 years. The architects who are not using BIM stated that they will consider Architects using BIM for employment before those not using it. This means that they consider BIM to be an important skill.

Research Question 1: How has the use of BIM solutions improved your drawings during schematic design stage?

Table 3. Analysis of impact of BIM on schematic design stage

Variables	Response					Descriptive			
	1	2	3	4	5	Mean	Rank	Relative Index	Extent
Client satisfaction	-	-	-	5	11	4.69	1	1.05	High
Quality of drawings produced	-	-	-	5	11	4.69	1	1.05	High
Time of completion of presentation drawings	-	-	1	6	9	4.50	2	1.01	High
Presentation of different concepts of design	-	1	1	3	11	4.50	2	1.01	High
Collaboration with other staff in your office	-	-	2	7	7	4.31	3	0.96	Low
Collaboration with other consultants	-	1	3	5	7	4.13	4	0.92	Low
Pooled						4.47		1.00	

Key: No effect (1), Worse (2), Negligible (3), Much (4), Very much (5)
(Source: Field survey, 2015)

From the results, client satisfaction, quality of drawings produced, time of completion of drawings and presentation of different design concepts were the main advantages of BIM on schematic design phase. Conflict resolution in drawings was the main advantage in post-contract stage of designing (Table 4). This reinforces the statement that BIM improves co-ordination and efficiency during the post contract design stage. The major factors preventing adoption of BIM were identified as lack of skilled personnel, lack of internet connectivity. Reluctance of other stakeholders, lack of awareness of technology and lack of BIM object libraries were also identified as factors preventing adoption. This confirms studies from literature reviewed.

Research Question 2: How has the use of BIM solutions improved your drawings during post contract design stage?

Table 4. Analysis of impact of BIM on post-contract design Stage

Variables	Response					Descriptive			
	1	2	3	4	5	Mean	Rank	Relative Index	Extent
Conflict resolution in drawings	-	-	1	4	11	4.63	1	1.09	High
Construction programming	-	-	2	7	7	4.31	2	1.01	High
Supervision of Jobs	-	-	1	9	6	4.31	2	1.01	High
Quality of completed jobs	-	-	2	7	7	4.31	2	1.01	High
Energy efficiency	-	-	2	7	7	4.31	2	1.01	High
Time of completion	-	-	2	8	6	4.25	3	1.00	High
Collaboration with other consultants	-	1	3	5	7	4.13	4	0.97	Low
Estimation of costs	1	-	1	9	5	4.06	5	0.95	Low
Safety	-	-	4	8	4	4.00	6	0.94	Low
Pooled						4.26		1.00	

Key: No effect (1), Worse (2), Negligible (3), Much (4), Very much (5)
(Source: Field survey, 2015)

Research Question 3: What premium would you place on these factors as the barriers to adoption of Building Information Modeling in Lagos, Nigeria?

Table 5. Analysis of factors preventing adoption of BIM

Variables	Response					Descriptive			
	1	2	3	4	5	Mean	Rank	Relative Index	Extent
Lack of skilled personnel	-	-	6	8	2	3.75	1	1.05	High
Lack of internet connectivity	2	-	2	8	4	3.75	1	1.05	High
Reluctance of other stake holders to use BIM	-	2	5	5	4	3.69	2	1.03	High
Lack of BIM object Libraries	-	2	4	7	3	3.69	2	1.03	High
Lack of awareness of technology	1	2	3	5	5	3.69	2	1.03	High
Extra costs involved in hardware, software and developing office procedures	-	3	4	6	3	3.56	3	0.99	Low
Frequent power failures	2	2	2	8	2	3.38	4	0.94	Low
Lack of contractual documents for BIM	1	3	3	7	2	3.38	4	0.94	Low
Fear of change	-	4	6	3	3	3.31	5	0.92	Low
Pooled						3.58		1.00	

Key: For no impact (1), for little critical impact (2), for fairly critical impact (3), critical impact (4), for extremely critical impact (5)
(Source: Field survey, 2015)

Research Question 4: What are solutions to the challenges and barriers encountered?

Table 6. Analysis of solutions to challenges and barriers to adoption of BIM

Items	Frequency	Percent	Cumulative Percent
None	10	62.5	62.5
Policy maker should promote the use through result of reserches done in the institute.	1	6.3	68.8
Schools should provide necessary equipment and enforce learning to all students.	1	6.3	75.0
Seminars, lectures, demonstrations on use of bim.	1	6.3	81.3
The provision of basic infrastructure that will promote the use of bim.	1	6.3	87.5
Training and awareness.	1	6.3	93.8
Trainings, adaption to changes.	1	6.3	100.0
Total	16	100.0	

5 Conclusion and Further Research

This research was conducted to find the barriers to adoption of BIM in Nigeria and the solution to barriers. The barriers with most impact were lack of skilled personnel, lack of internet connectivity, Reluctance of other stakeholders to adopt BIM and lack of awareness of technology. From the study, the identified solutions to challenges are: Policy makers should promote the use of BIM through result of researches done; Schools should provide necessary equipment and enforce learning to all students, Seminars, Lectures and Training on the use of BIM should be conducted to professionals in the field, Infrastructure that will promote the use of BIM should be put in place. This includes constant electricity and internet connectivity.

Further research will be done on standards of BIM in the country and provision of BIM object libraries. This research will benefit Architects, the Government, Engineers, Contractors and all companies involved in construction in Nigeria.

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