BARRIERS AND DRIVERS OF BUILDING INFORMATION MODELLING (BIM) TECHNOLOGIES ADOPTION IN THE NIGERIAN CONSTRUCTION INDUSTRY

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Abstract

Building Information Modelling (BIM) has become the new international benchmark for efficiency in design, construction and maintenance of buildings. It is the platform that brings about collaboration between project stakeholders and improvement of project outcomes. With all its potentials, not much of the impact of BIM technologies has been felt in the Nigerian construction industry. This research aimed at assessing the perception of the Nigerian building design firms on the potential barriers and drivers of BIM adoption in the Nigerian construction industry. The research was exploratory in nature. A field survey was conducted with the use of structured questionnaire, self administered to a sample of building design consultancy firms (architectural, structural, M&E, quantity surveying, and multi-disciplinary design firms) within Abuja and Kaduna. The questionnaire sought the perception of the firms on the factors affecting BIM adoption in the Nigerian construction industry, 42.26% response rate was achieved, The results indicates that 'Lack of

awareness of BIM technology among professionals' and clients and 'lack of knowledgeable and experienced partners' were identified as the most important barriers of BIM adoption in Nigeria; while the most significant drivers are the 'availability of well-trained professionals' and 'cooperation and commitment of professional bodies to the adoption'. Education and training of building design professionals and cooperation of all stakeholders in the design and construction supply chain were recommended as part of measures to ensure successful adoption of BIM in the Nigerian construction industry. The limitation of the findings is that the research considered Abuja, and Kaduna state only which may not be a full representation of Nigeria.

Keywords: Barriers, Building Information Modelling, Drivers, Nigerian Construction Industry.

Introduction

The inefficiency and lack of productivity of the construction industry have raised serious concern all over the world. These have been attributed to so many factors, among which, are the fragmented processes of design, procurement, construction, and project delivery. (Khalfan and Anumba, 2000). The need for continuous improvement to the conventional design and construction method in the industry has been well documented in the literature. Several studies and government reports have enunciated the desire for the construction industry to improve and change the way it performs its primary activities. (Kagiglou*et al,* 1999)

Latham (1994) considered the fragmented nature of the construction industry as one of the factors responsible for poor communication between parties working on a construction project which leads to inefficiency and lack of productivity in the construction project delivery. The report also reiterated the need for effective processes throughout the design and construction lifecycle (Latham, 1994). recommendations were reaffirmed by two other reports by Egan (1998, 2002) Khalfan and Anumba, (2000) reiterated the need for change in the construction processes to ensure more productivity and efficiency.

The Nigerian construction industry is not also free from such problems and even more. It has severally been characterized as inefficient with low productivity and lack of capacity to deliver and satisfy its clients. Oyewobi*et al.*, (2011) attributed the drop in the Nigerian construction industry's contribution to GDP between 1980 and 2007 to poor performance and low productivity. Similarly, Idrus and Sodangi (2007) asserted that the Nigerian construction industry, despite producing nearly 70% of the nation's fixed capital formation, its performance within the economy has been, and continues to be, very poor. Among other criticisms facing the industry are time and cost overruns (Kuroshi and Okoli, 2010; Ameh and Osegbo, 2011; Ogwueleka 2011), inadequate planning and budgetary provisions, contract sums inflation, inefficient and poor service delivery (Kolo and Ibrahim, 2010; Mohammed, 2012). Hence Aibinu and Jagboro (2002) and Oyewobi*et al.*, (2011) emphasised the need for improved performance and efficiency, if the industry is to deliver value for money and effectively satisfy the needs of its clients.

However, there are several responses to these calls for continuous improvement in efficiency and productivity of the Nigerian and the global construction industry from different perspectives. These range from new contractual/procurement arrangements like partnering, concurrent engineering (Malik et al, 2000), integrated project delivery, (Kim and Dossic, 2011) to technological innovations in design and construction processes such as 3D CAD and modeling (Isikdag and Underwood, 2010; Olatunji, et al, 2010).

Building information modeling (BIM) is one of such innovative processes that promises to bring about the much needed continuous improvement and desired change in the construction industry. 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 (Nederveenet al, 2010).

BIM has also been defined as the digital representation of the physical and functional characteristics of a facility, which serves as a shared knowledge resource for information about a facility, forming a reliable basis for decisions during its life-cycle from inception onward (Building Smart, 2010).

According to Becerik-Gerber and Rice (2010), BIM is seen as an enabler that can help the building industry to improve its productivity by ensuring effective communication and collaboration between all project stakeholders from inception to completion of building projects. Several BIM-related studies have been reported, especially those that have to do with its success stories and inherent benefits. There are numerous case studies (Khanzode et al, 2008; Eastman et al, 2011) that provide evidences to support the fact that the use of BIM makes the building process more efficient and effective. According to Succar (2005), BIM has solidified its position as a promising approach towards addressing the construction industry's numerous inefficiencies.

Studies reported that many countries of the world like USA, UK, Australia, Netherlands, Singapore, Hong Kong, Finland, Norway, Denmark and so on, have adopted BIM technologies at different levels and have experienced substantial improvement in construction project delivery (Yan and Damian, 2010;Nederveen et al, 2010; Isikdag and Underwood, 2010; Wong et al, 2010; Sebastian and Berlo, 2011). Some of the benefits of BIM technologies as claimed by its proponents are that it provides for efficient communication and data exchange (Nederveenet al, 2010), auto quantification, improved collaboration, coordination of construction documents, and improved visualization of design (Olatunji, et al, 2010; Sacks et al, 2010), clash detection, and cost reduction (Eastman et al; 2011) among others.

Considering the documented benefits of BIM, Olatunji, et al; (2010) stressed the need for its full adoption across all disciplines and geographical boundaries. However, despite the potentials and documented benefits of BIM technologies, not much has been reported regarding its implementation in the Nigerian construction industry.

Consequently, it becomes imperative for the Nigerian construction industry, which has been described as a 'sleeping giant' and having no capacity to deliver due to inefficiency and poor service delivery among other problems (Kolo and Ibrahim, 2010; Mohammed, 2012), to exploit the widely acclaimed benefits of BIM technologies in order to practice in line with the global best practices and achieve the continuous improvement needed by its players. This necessitated the current investigation into the state of the industry with a view to identifying the issues that need to be addressed in order to have the technology implemented.

Moreover, adoption of innovations such as BIM usually brings about changes in the business processes and operational procedures of an industry or an organisation. It may also be faced with some risks and challenges that may hinder its successful take-off. It is therefore important to identify and evaluate the enablers and impediments of adopting BIM technologies in construction organisations or the entire construction industry.

BIM and its impact on construction Operation and Productivity

The construction industry have for centuries been used to symbols on paper (drawings and specifications)as the primary means of representing and communicating design intent for client approval, bidding, procurement, fabrication, construction and installation. These have resulted to a number of inefficiencies in information management and coordination of project stakeholders, difficulty in information exchange, unnecessary delays, and cost overruns.Eastman et al. (2011). The 2D paper drawings also bring about serious misunderstandings between project parties and have been identified by Kymmel (2008) as an imperfect method of planning and building complex projects.

Building Information Modelling is seen as a solution to most or all of these problems. It has avail the construction industry with a lot of promises of improved productivity by serving as a platform for effective collaboration and communication between all parties to a building project. BIM has the capability of bringing sanity in the design and construction processes

thereby improving the general performance of the construction industry. A BIM model is an information resource that is used as a digital simulation of a building facility for its design, construction and management. The model integrates 3D drawings and 4D animations to improve the communication, coordination, and planning of construction projects, while reducing risks, errors and costs. Kymmel (2008).

Several benefits of BIM were claimed by its proponents to include changing the process of design and build to better, integration of building plans, sections, graphics and details in ways not possible in 2D CAD, providing concurrent information on performance and economic aspects of construction among others. This new technology that was introduced in the early 80s has now proves its potentials in sanitising the construction industry from its traditional and fragmented ways of operation with improved efficiencies and collaboration capabilities. Aranda-mena et al, (2008).

The tools improve consistency of all working drawings to the design intent and allow for automatic corrections when changes are made in the design process. Yan and Damian (2008), Olatunji et al (2010), Eastman et al (2011). Furthermore, BIM can be used to extract an accurate bill of quantities and spaces that can be used for cost estimation, which can be generated at any stage of design. Olatunji et al (2010), Eastman et al (2011).

At the construction stage Building Models provide an accurate design model containing information on the material requirements of each segment of the work. Eastman et al; (2011) This serves as a basis for improved planning and scheduling of work and allows for better collaboration of all stakeholders on the job site, in addition to the reduction of construction cost and time. Conflicts and constructability problems are also easily identified before they are detected on site. Coordination among participating designers and contractors is enhanced. This speeds the construction process, reduces costs, minimizes the likelihood of legal disputes, and provides a smoother process for the entire project team.

Eastman et al (2011) argued that a building information model that has been updated with changes made during construction provides accurate information about the as-built spaces and systems of a building, and provide a starting point for its operation and management. Building models are used as rich handing over tools, since they can be used by mechanical and electrical services contractors to link all the information collected from manufactures of equipment and systems installed in the building about the maintenance and management of the facilities. Building Information Modelling provides interactive platforms for streamlined information management from design to the entire facility lifecycle.

Barriers and drivers of BIM adoption

The introduction and adoption of any new technology such as BIM usually requires that the factors that may positively or negatively affect the adoption by the relevant stakeholders be identified and addressed for the successful take off of the innovations and subsequent benefits to be derived. Numerous potential barriers and drivers for BIM adoption were documented in the literature. These barriers are of different categories as defined by different experts. Fox and Hietanen (2006) put it that some of these barriers are specific to building information modelling, while others are general to the diffusion of innovation. Eastman et al; (2011) posited that the barriers to BIM adoption fall into two categories: process barriers to the business including legal and organisational issues that prevent the adoption; and technology barriers related to readiness and implementation. Autodesk (2004) on the other hand view the barriers to BIM adoption in three aspects as transactional business process evolution, computability of digital information, and meaningful data interoperability. On critical observation, it can be seen that all the aspects of barriers can conveniently fit into the first categorisation by Eastman et al, (2011) i.e. the process and the technology barriers.

Some of them include the lack of highly skilled cross trained staff with both construction and IT skills which could hinder the realisation of BIM benefits, (Fox and Hietanen 2006). A survey conducted in UK reported the primary barriers to the adoption of

BIM by the UK construction companies to include the unfamiliarity of firms with the use of BIM, reluctance to train staff or initiate new work flows, lack of opportunities to implement, and lack of proof for tangible benefits of BIM. The same survey also revealed that lack of training; cost of training and high cost of software are the barriers to BIM adoption by other respondents. Ayariciet al, (2009).

Similarly, another survey by RICS (2011) revealed the following as the potential barriers to BIM adoption amongst quantity surveyors, building surveyors, and project managers in UK: lack of clients demand for BIM in their projects, lack of standards to guide implementation, lack of government lead/direction, lack of IT infrastructure, lack of new or amended conditions of contract; and lack of education and training.

Further, a survey by some professional groups in Texas identified the following as the barriers to adopting BIM by construction stakeholders: lack of knowledgeable and experienced partners; legal and contractual constraints; lack of industry standards; it takes too much time to learn; and high cost of implementation (TCUF 2009). The pilot study for this research also identified the frequent power failure and poor internet connectivity as barriers in the case of Nigeria.

On the other hand, the drivers of BIM adoption in the construction industry were identified as government support through legislation, clients' interest, software availability, cooperation and commitment of professional bodies, and collaborative procurement methods. All these have to be in place to enable successful transition of the industry to BIM working.

Research methods

Questionnaire was used for data collection. This was administered on building design firms (Architectural; Structural; Mechanical and Electrical Services design firms; Quantity Surveying Firms; and Multi-disciplinary Design Firms) within Abuja and Kaduna. The firms were selected through stratified random sampling method because the population occur in distinct strata, as suggested by Fellows and Liu (2003). 108 questionnaires were self-administered by the researchers and

46; which amount to 42.26% were retrieved and used for analysis, based on the assertion of Moser and Kalton (1971), that the result of a survey could be considered significant if a response rate not lower than 30-40% is obtained.

The questionnaire was meant to obtain information on organisations' perception of the factors affecting the adoption of BIM in the Nigerian construction industry. The factors identified from literature were of two categories: drivers/facilitators of the adoption and the barriers to the adoption which was also divided into two subcategories by Eastman et al (2011) as process barriers and technology barriers. The survey instrument contained statements on the two categories to be assessed by the respondents on a five point Likert scale, where 1 = strongly disagree, 2 = disagree, 3 = somewhat agree, 4 = agree and 5 = strongly agree.

Analysis of the questionnaire was done using descriptive statistics.

Results and discussion

Distribution of design firms according to groups.

From the responses obtained, the distribution of the various groups of design consultancy firms is presented in the figure below:

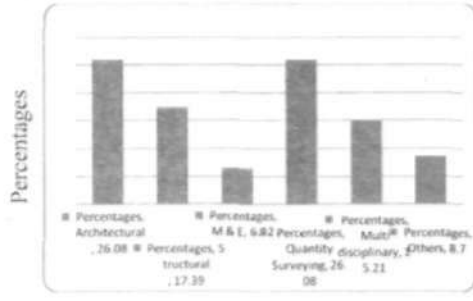


Fig. 1 Distribution of design firms according to groups

From the chart, it can be seen that architectural and quantity surveying firms formed the largest groups of the respondents; having 26% each, followed by structural engineering firms with 17.39%, then multi-disciplinary design firms with 15.21% followed by the 'others' group (comprising of property development firms with in-house design teams, and construction firms with both design and construction teams) having 8.70% and lastly M&E firms with 6.52%.

Factors Affecting the Implementation of BIM in the Nigerian Construction Industry

The questionnaire sought the opinion of the respondents as regards the significance of factors that affect the implementation of BIM in the Nigerian construction Industry. The factors identified from literature were of two categories; those that facilitate the adoption called the drivers and others that hinder the adoption called barriers. The responses are as follows:

Drivers/Facilitators of BIM Adoption in the Nigerian Construction Industry.

The ANOVA result for the test of significant difference between the groups of design firms on the existence of drivers/facilitators of BIM adoption in the Nigerian construction industry is presented in Table 1

Table 1: Drivers of BIM adoption in the Nigerian construction industry.

Sources of variation	d.f	Sum of squares	Mean square	F	P-value
Treatments (Groups)	5	3.587	0.717	1.805	0.134
Error	40	15.895	0.397		
Total	45	19.483			

α=0.05

The overall results indicated no significant difference between all groups of design firms in terms of agreement with the existence of drivers/facilitators of BIM adoption in the Nigerian construction industry. However, this is not to say that they are all at the same level of agreement, some variations still exist, but they are not statistically significant. This necessitate the use of a post-hoc DUNCAN multiple range test to further explore the extent of differences that exist between them.

Table 2: DUNCAN result on the Drivers/Facilitators of BIM adoption

GROUPS	N	Mean
Multi-disciplinary design Consultancy	7	3.3700
Architectural Consultancy	12	3.5467
Others	4	3.8550
Mechanical and Electrical Engineering Consultancy	3	3.9033
Quantity Surveying Consultancy	12	4.0592
Structural Engineering Consultancy	8	4.0900

The follow up test revealed the highest level of agreement coming from the structural engineering firms with a mean score of 4.09, followed by quantity surveying consultancy firms with a mean score of 4.05, then mechanical and electrical design firms with a mean of 3.90, then 'others' (comprising of property development firms with in-house design teams, and construction firms with both design and construction teams); 3.85, followed by architectural design firms with 3.54 and the least is multi disciplinary design firms with mean score of 3.37.

The result therefore shows that all the groups of respondents agreed with the existence of drivers or facilitators of BIM adoption in the Nigerian Construction Industry.

Moreover, considering the drivers individually, from the table of descriptive statistics results (Table 3), 'availability of well trained professionals to handle BIM tools' and 'cooperation and commitment of professional bodies to its implementation' top the list of most important drivers of BIM adoption in the Nigerian construction industry with mean scores of 4.06 and 4.00 respectively.

Table 3: Descriptive Statistics Results for the Drivers of BIM Adoption

Drivers of BIM Adoption	N	Ranking	Mean	Std. Deviation
	Statistic		Statistic	Statistic
Government support through legislation	46	5	3.6739	1.30050
—	46	3	3.8913	.94817
Software availability	46	3	3.8913	1.17810
Availablility of well trained professional to handle the tools	46	1	4.0652	1.04141
Cooperation and commitment of professional bodies to its implementation	46	2	4.0000	1.03280
Procurement methods	46	6	3.6087	1.14462

The second important category of drivers as indicated by the respondents are 'clients' interest in the adoption' and software availability with mean scores of 3.89 each, then government support through legislation and collaborative procurement methods as the least with mean scores of 3.67 and 3.60 respectively. It can be concluded here that the issues of trained professionals to handle BIM tools and commitment and cooperation of all professional bodies towards the implementation of BIM are the most significant drivers of BIM adoption as opined by the respondents. This is in line with the findings of a survey by Texas College and University Facilities Conference (TCUF) 2009 on the state wide BIM adoption. It also reflects the idea propagated in the Rethinking Construction document of the United Kingdom in 2008 about education and training for the transformation of the UK construction industry. Moreover, the clients' interest in the adoption is another major facilitator since the clients are the initiators of construction projects and their support for any innovation in the construction process has a far reaching effect to the successful implementation of such innovation. The government as the regulator of affairs has a vital role also to play by enacting legislations that mandate or govern the implementation of initiatives such as the use of BIM in construction. Part of the efforts expected of government in this regard is the introduction of new collaborative procurement methods that will support the adoption of BIM technologies in construction projects.

Barriers to BIM Adoption in the Nigerian Construction Industry

The barriers to the adoption of BIM technologies in the Nigerian construction industry are considered under two headings as classified by Eastman *et al*; (2011) i.e. process and technology barriers.

Table 4: Process barriers to the adoption of BIM in the Nigerian construction industry.

Sources of variation	d.f	Sum of squares	Mean square	F	P-value
Treatments (Groups)	5	4.119	0.824	1.156	0.347
Error	40	28.506	0.713		
Total	45	32.625			

α=0.05

Table 5: Technology barriers to BIM adoption in the Nigerian construction industry.

Sources of variation	d.f	Sum of squares	Mean square	F	P-value
Treatments (Groups)	5	4.783	0.957	1.192	0.330
Error	40	32.090	0.802		
Total	45	36.873			

α=0.05

The results shows that all the groups of respondents are in agreement with the existence of most barriers to the adoption of BIM in in the Nigerian construction industry. However, the slight variations among them as explored by the DUNCAN test shows architectural firms with the highest mean score of 3.65 followed by structural engineering firms with 3.48, then quantity surveying, 3.47 and multi disciplinary design firms with 3.40. 'Others have a mean of 3.02 then mechanical and electrical design firms with the least mean of 2.87.

Table 6: Descriptive Statistics Results for the Barriers of BIM Adoption

Barriers of BIM Adoption	N	Ranking	Mean	Std. Deviation
	Statistic		Statistic	Statistic
PROCESS BARRIERS				
Lack of awareness of the technollogy among professionals and clients	46	1	3.8696	1.24023
Lack of knowledgeable and experienced partners	46	2	3.8043	1.02458
High cost of training	46	5	3.3696	1.19923
Lack of enabling enviroment (Government policies) to guide implementation	46	5	3.2609	1.38940
Legal and contratual constraints	46	5	3.2609	1.10423
Lack o f trained professionals to handle the tools	46	3	3.4565	1.18709
Social and habitual resistance to change	46	4	3.2826	1.20486
No proof of financial benefits	46	6	2.7174	1.16739
Lack o f clients demand of BIM use in their projects	46	4	3.2826	1.12868
TECHNOLOGY BARRIERS				
High cost of integrated software/models for all professionals	46	2	3.6304	1.01890
Lack of standards to guide implementation	46	1	3.6739	.99005
Poor internet connectivity	46	4	3.2174	1.28085
Frequent power failure	46	3	3.4783	1.36201

Furthermore, the descriptive statistics result (Table 6) shows that, in the process barriers, lack of awareness of BIM technologies among professionals in the construction industry and lack of knowledgeable and experienced partners were identified by the respondents as the most important process barriers to the adoption of BIM technologies in the Nigerian construction industry with mean scores of 3.86 and 3.80 respectively. These were followed by lack of trained professionals to handle the tools with a mean score of 3.45, while the least important barrier as reported by the respondents is the lack of proof of financial benefits, which is seen not as much a barrier by the groups of Nigerian design firms.

On the other hand, lack of standards to guide implementation of BIM and high cost of integrated software were

seen as the most significant technology barriers to BIM adoption in the Nigerian construction industry with mean scores of 3.67 and 3.63 respectively. These were followed by frequent power failure, while poor internet connectivity was seen as the least important barrier to BIM adoption in the Nigerian construction industry. These findings agreed with the previous studies such as Fox and Hietanen (2006) Ayarici*et al,* (2009) and the TCUF (2009) survey. The slight difference is on the issue of clients' demand of BIM use in their projects which seems to be least significant in this research, and this may be due to low level of BIM usage in the country or the lack of awareness of the technology among the professionals in the Nigerian construction industry.

Conclusion

The survey revealed that the groups of Nigerian building design firms do not differ significantly in their perception on the significance of drivers/facilitators of BIM adoption in the construction industry. All the groups of respondents affirmed to the importance of drivers or facilitators of BIM adoption in the Nigerian Construction Industry.

Furthermore, the respondents rated 'availability of well trained professionals' and 'cooperation and commitment of professional bodies' as the most important drivers of BIM adoption with mean scores of 4.06 and 4.0 respectively. These were followed by 'software availability and clients' interest' with mean scores of 3.89 each.

On the barriers to BIM adoption in the Nigerian construction industry, all the groups of firms agreed that those barriers significantly exist in the industry. Moreover, the most important barriers according to the respondents are the lack of awareness of the technology among professionals and clients, and lack of knowledgeable and experienced partners with mean scores of 3.86 and 3.80 respectively. However, these are among the process barriers. In the technology barriers, lack of standards to guide implementation of BIM in Nigeria and high cost of integrated software for use of all professionals were seen as the most prevalent with mean scores of 3.67 and 3.60 respectively. Others are the lack of trained professionals and frequent

power failure. These findings are in line with those of Kigbu (2012) on BIM awareness in the Nigerian construction industry, another survey on state-wide BIM adoption (2009) in Texas by the groups of professionals, and another one in Finland as reported in Fox and Haetanen (2006).

Recommendations

The study has set a scene for further research and development in the area of BIM adoption in the Nigerian construction industry. It therefore recommends that further studies should focus on developing a framework for the full adoption of BIM in the Nigerian construction industry.

Education and training were identified as important parts of BIM implementation due to the process and technological changes it brings in an organisation. Ayarici et al; (2009). This research also recommends that further studies be cantered on providing ways of incorporating BIM training in the curriculum of tertiary institutions offering any built environment related programmes. This is to address the BIM skills and training issues identified by this and similar studies.

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