READINESS OF NIGERIAN BUILDING DESIGN FIRMS TO ADOPT BUILDING INFORMATION MODELLING (BIM) TECHNOLOGIES

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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 readiness of the Nigerian building design firms to adopt BIM technologies. 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 responding firms on the factors affecting BIM adoption in the Nigerian construction industry, and their level of readiness to adopt BIM technologies in their practices based on the four categories of readiness-management, people, process and technology. 42.26% response rate was achieved and used for analysis. ANOVA and DUNCAN post-hoc tests were used to establish the differences between the responses of the groups of firms, while means and standard deviations were obtained to establish the important factors affecting BIM adoption in Nigeria. The survey revealed that all the groups of Nigerian design firms are appreciably ready for the adoption of BIM technologies in their practice, with slight variations in their respective levels of readiness. '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 '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.

Keywords: Building Information Modelling, readiness, Nigerian construction industry, adoption.

1.0 INTRODUCTION

There has been a great concern over the lack of efficiency and productivity in the construction industry worldwide. This has been attributed to so many factors, among which is fragmented process of design, procurement, construction, project delivery etc. (Khalfan and Anumba, 2000). The need for continuous improvement to the conventional design and construction 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. (Kagioglou et al, 1999; Ibrahim and Price, 2006; Ibrahim, 2008)

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. His report also reiterated the need for effective processes throughout the design and construction lifecycle (Latham, 1994). The recommendations were reaffirmed by two other reports by Egan (1998, 2002), which saw the need for change in the construction processes to ensure more productivity and efficiency.

The Nigerian construction industry is not 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 produces nearly 70% of the nation's fixed capital formation yet 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, 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 in the industry for it to deliver value for money and effectively satisfy the needs of the clients.

However, there are several responses to these calls for continuous improvement in efficiency and productivity of the construction industry from different perspectives ranging from new contractual/procurement arrangements like partnering (Ibrahim and Price, 2006); 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 modelling (Isikdag and Underwood, 2010; Olatunji, *et al*, 2010).

Building information modelling (BIM), is one of such innovative processes that promises to bring about the much desired continuous improvement and 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. (Nederveen et al, 2010). 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. (Building Smart, 2010)

According to Becerik-Gerber and Rice, (2010) BIM is seen as an enabler that may 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 researches have been reported, especially those that have to do with its success stories and inherent benefits. There are numerous case studies (Eastman et al, 2011) that provide some evidence to support the fact that the use of BIM makes the building process more efficient and effective. According to Succar, (2005), BIM has now solidified its position as a promising approach towards addressing the AEC's numerous inefficiencies.

Further, evidences abound that many countries of the world like USA, UK, Australia, Netherlands, Singapore, Hong Kong Finland, Norway, Denmark, Hong Kong (Yan and Damian, 2010; Isikdag and Underwood, 2010; Nederveen et al, 2010; Wong et al, 2010; Sebastian and Berlo, 2011) and others have adopted BIM technologies at different levels and have experienced substantial improvement in construction project delivery. Some of the benefits of BIM technologies as claimed by its proponents are that 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, 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. 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.

However, despite the potentials and documented benefits of BIM technologies, not much has been reported regarding its implementation in the Nigerian construction industry. It is also not clear whether or not the industry is ready to adopt such techniligies. Therefore, for BIM to be adopted in Nigeria, there is need to identify the factors that will aid and those that will hinder its successful adoption, and the environment analysed to ensure some level of preparedness for its successful implementation. This research is aimed at evaluating the readiness of the Nigerian Building design firms to adopt Building Information Modelling (BIM) technologies with a view to suggesting ways of its adoption in the construction industry. The design firms are usually the first set of stakeholders in BIM adoption and so, they should be investigated in the first place to know whether Nigerian construction industry can have a meaningful match towards BIM adoption in its operations. In doing this, the study identified and assessed the enablers and barriers to BIM adoption in the Nigerian construction industry, to establish their level of significance. It was also found useful to compare the readiness levels between different groups of design firms for the purpose of obtaining a clear result as regards their real positions and identify the ones that need to make more efforts to achieve a reasonable level of readiness.

2.0 BUILDING INFORMATION MODELLING: AN INTRODUCTION

Building Information Modelling (BIM) has become the new international benchmark for efficiency in design, construction and maintenance of buildings. Yan and Damian (2008) described BIM as a powerful set of design management tools that has significant advantages over the entire building lifecycle, particularly design, but also construction and facility management. It is the platform that brings about collaboration between project stakeholders and improvement of project outcomes. Over the years, the issue of BIM has attained widespread popularity among all astakeholders in the construction industry the world over. Haron *et al*; (2010) observed that many design and construction organisations in different parts of the world are moving towards BIM adoption in their practices. Ayarici *et al;* (2009) reported that in a recent past, many pilots and live projects have been completed and documented in Finland, Sweden, Norway, Germany, France, Singapore, UK and Australia, which demonstrated the capability of using BIM within the construction process facilitating construction lifecycle. Though, Yan and Damian (2008) argued that not all companies are interested in its adoption, but still the future of BIM technologies in the construction industry looks bright with increasing efforts by researchers and industry stakeholders.

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 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). Therefore, the wider application of BIM poses a paradigm shift in the traditional construction processes.

2.1 Why BIM?

The need for continuous improvement to the conventional design and construction 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. (Kagioglou et al, 1999; Ibrahim and Price, 2006; Ibrahim, 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. Paper based communication was used between all project stakeholders on the construction industry with no platform for collaboration and clear visualisation of design. This has resulted to poor documentation and information management and has fuelled the fragmentation in the activities of the construction industry. It has further resulted to a lot of errors and wastes, which were considered part of the reasons for the poor performance, low productivity and inefficiency in the construction industry. A lot have been reported on the nature of complications in some forms of construction activities such as design errors, estimate deficiencies, conflicts between design and construction and fragmented platforms which limit information flow throughout project lifecycle. Olatunji *et al* (2010), BuildingSMART (2010). BIM is seen as a solution to all these problems., as it serves as a platform for effective collaboration and communication between all parties to a building project.

2.2 Benefits of BIM

Broadly speaking, BIM has led to a significant improvement in the performance of construction industry professionals especially in design, construction and facility management. Yan and Damian (2008) opined that BIM did not only improve the technology itself, but changes the process of design and build. The following are some of the benefits of BIM as reported by researchers and practitioners.

a. Simultaneous access to project database by all stakeholders.
b. Robust information.
c. Auto-quantification.
d. Quality communication
e. Multi-dimensional integration
f. Project visualisation
g. Project documentation
h. Digital facilities management
i. Clash detection
j. Time and cost reduction. Olatunji et al (2010), BuildingSMART (2010) Eastman et al (2011)

2.3 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 up 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 suggested by the writers 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 UK reported the primary barriers to the adoption of BIM by the UK construction companies a 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. Ayarici *et al*, (2009).

Similarly, another survey by RICS(2011) revealed the following as the potential barriers of 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 suggested the following as the barriers of 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. The pilot study 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.

3.0 Readiness Assessment models

So many readiness assessment models have been developed in recent times. According to Ruikar et al (2006), each tool gauges how ready a society or economy is to benefit from Information Technology (IT) and e-commerce. Vaezi and Bimar (2009) observed that the range of tools use widely varying definitions for e-readiness and different methods of measurement. Aziz and Salleh (2001) also asserted that there is no specific definition for the concept of readiness. Some tools assess the readiness of countries and economies to implement internet technologies on a global platform, while others are more focused on measuring the readiness of specific sectors to adopt the technologies.

Some of those tools include the one developed by Harvard University Center for International Development (CID 2001) called 'Networked Readiness Index' which gauges a country's ability to make use of its Information and Communication Technology (ICT) resources. It defined readiness as the degree to which a community is prepared to participate in the networked world and its potential to be part of the networked world in the future. Kirkman *et al*, (2002). Similarly, the Asia Pacific Economic Cooperation's (APEC) e-readiness assessment focused on government policies for e-commerce, while Mosaic global diffusion of the internet project's readiness assessment tool aimed at gauging and analysing the world wide growth of the internet. Ruikar *et al*, (2006). Vaezi and Bimar (2009)

On the other hand, while these tools were based on measuring the readiness of countries, governments and policies for adopting internet technologies, there are others that focused on assessing the readiness to adopt different engineering concepts and approaches. For example, SCALES (Supply Chain Assessment and Lean Evaluation System) was developed specifically for the manufacturing industry in order to assess companies' (especially SMEs) readiness for adopting Lean manufacturing techniques. Furthermore, there are several other tools that were developed for Concurrent Engineering (CE) such as RACE (Readiness Assessment for Concurrent Engineering) which was developed in the West Virginia University (United States) in the early 90s. it was conceptualised in terms of two major components: Process and technology. It is widely used in the software engineering, automotive and electronic industries. Ruikar et al (2006) According to Khalfan and Anumba (2000), RACE can be modified to be used in the construction and other industries. Similar to this one is the SPICE (Standard Process Improvement for Concurrent Engineering, which was developed in the University of Salford, United Kingdom in a form of a questionnaire. It was designed to evaluate the key construction processes within construction organisations(SPICE Questionnaire, 1998). In addition, the BEACON (Benchmarking and Readiness Assessment Model for Concurrent Engineering) was created to evaluate the construction companies' readiness level in implementing concurrent engineering with the aim of improving the project delivery process. Others include the capability Maturity Model CMM developed for software development and evaluation, and the IQ Net readiness scorecard. Khalfan and Anumba (2000), Aminali *et al*; (2009) and Ruikar *et al*; (2006)

Another readiness assessment tool that is of relevance to this research is the VERDICT (Verify End-User e-Readiness using Diagnostic Tool) developed to assess the overall readiness of end users involved in the construction industry for using e-commerce technologies. Aziz and Salleh (2011). The VERDICT model is a combination of two e-readiness assessment models-the BEACON model and the IQ Net readiness scorecard. BEACON, as mentioned earlier, assesses the readiness of construction companies to improve its practices for implementing concurrent engineering. It consists of four elements- process, people, project and technology. IQ Net readiness scorecard is web based application developed by CISCO based on a book called Net ready. Aminali et al; (2009). It assesses the readiness of IT service providers in such a way that the companies are presented with statements which fall into four categories as leadership, governance, technology and organisational competencies, for which, upon completion, they will be shown their e-readiness assessment result.

Similar methodology was adopted in developing the VERDICT model. in it, companies' e-readiness results are presented to them after responding to some statements that fall under four categories- management, process, people and technology. Ruikar et al; (2006). the developers of VERDICT argued that to successfully implement any technology, there is need to have the people with adequate skills, understanding of, and belief in the technology, then processes that enable and support the successful adoption of the technology, then the technology tools and infrastructure necessary to support the business functions and another key element to consider is the management buy-in and belief. Therefore the next is the management that believes in the technology and takes strategic measures to drive its adoption, implementation and usage in order to derive business benefits from the technology. Ruikar et al; (2006), Vaezi and Bimar, (2009). All the four elements have to work complementarily for any organisation to achieve e-readiness. The model is different from the BEACON and the IQ Net readiness scorecard in that it directly addresses the construction sector end-users in evaluating their e-readiness for using e-commerce technologies such as web based collaboration while the former two are concerned with the readiness of technology companies such as software companies or vendors.

VERDICT, as claimed by its developers, can be used to assess the e-readiness of construction companies, departments within a company, or even working groups within a department. the assessment is performed by finding an average score for each of the four categories from the judgment of the respondents on the statements of the questionnaire. According to Ruikar *et al*, (2006)

- An average score greater than or equal to zero and less than 2.5 shows a red colour which indicates that urgent attention is needed for to achieve e-readiness.

- An average score greater than or equal to 2.5 and less than 3.5 is amber colour which means that certain aspects need attention to achieve e-readiness

• An average score greater than 3.5 shows a green colour which indicates that the organisation is adequately ready and matured enough for e-commerce tools.

The choice of these boundaries was based on simple average scores computed for each of the four elements in the questionnaire.

4.0 RESEARCH METHOD

A review of literature was carried out for the purpose of articulating issues regarding the concept of Building Information Modelling (BIM) in the construction industry with particular emphasis on the Nigerian Construction Industry. The review also aimed at appreciating the different readiness assessment methods for Information Technology especially pertaining to construction companies.

The research involved the use structured questionnaire as a tool of data collection distributed to 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 sampling method because the population occurs 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 the response rate not lower than 30-40% is obtained.

The questionnaire was in three sections (Sections A, B, and C). Section A was used to obtain information regarding the profiles of the organisations which were considered to have some influence on the readiness of such organisations to adopt BIM technologies in their practices. The section B of the questionnaire was designed to obtain information on the company's perception of the factors affecting the BIM adoption 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 two tables were provided with 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.

Section C was aimed at assessing the level of readiness of the Nigerian design firms for adopting BIM technologies, based on the four key elements of readiness identified by Ruikar et al (2006). The elements are management, process, people and technology. Ayarici *et al*, (2009) further confirmed this assertion that governance, peoples' practices, business processes and technology used ultimately contribute to the organisational readiness to adopt BIM. Based on this premise, statements were provided on each of the elements considered as a subcategory of readiness for the respondents to rate their organisations on a 5 point Likert scale as in section B above. The responses obtained under this section were used to draw inferences; using the mean scores of each group of design firms, based on the intervals of measurement of the VERDICT model.

The nature of the study is exploratory and comparative. Therefore, the grouping became relevant because design activities among the groups vary in relation to the nature of specialisation of each group. Hence, the groups were treated as independent. This provided the basis for comparison of readiness among the groups of firms.

5.0 DATA ANALYSIS TECHNIQUES

The analyses of data and discussion of results were based on the categories of data. Section A of the questionnaire entailed observations on the distribution of the respondents regarding organisational profiles. Sections B and C were analysed as discussed in the following subsections.

Analysis of sections B and C of the questionnaire was done using descriptive statistics such as means and standard deviation, a parametric one-way Analysis of Variance (ANOVA), and a follow up test DUNCAN multiple range test.

The choice of one-way ANOVA was due to the fact that the data involves interval measurement and there is need to compare the means of the different groups of firms. The DUNCAN multiple range tests is a follow up test conducted to further analyse the extent of variation in means of different groups after conducting ANOVA test to make the results clearer and enable the ranking of the groups' means. However, the data set could not satisfy the assumtions of using one-way ANOVA, therefore, a non-parametric alternative-Kruskal-wallis test was then used, the result of which was found to be similar to the ANOVA result. For this reason, the DUNCAN test was still considered valid ie exploring the extent of variations between the groups of design firms.

Statistical Package for Social Sciences (SPSS) computer package was used in conducting the analysis.

Table 5.1 gives the breakdown of the administered questionnaires based on the number of responses obtained.

Table 5.1: **Breakdown of administered questionnaires**

No. distributed	108
No. properly filled and returned	46
Percentage response	42.26%

Source: Field survey 2012

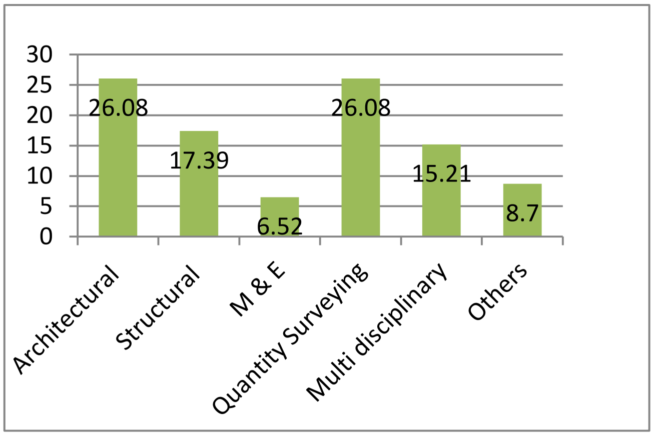
From table 5.1, it can be depicted that out of 108 questionnaires distributed, 46; which amount to 42.26% were properly filled and returned. Based on the assertion of Moser and Kalton (1971), the result of a survey could be considered significant if the response rate not lower than 30-40%. Therefore, the percentage of the returned questionnaires is adequate for analysis.

Section A of the questionnaire considered the profiles of the companies in terms of their expertise, years of experience, and size of projects they handle. These were considered relevant for the research because they can be related to the firms' ability to adopt any innovative practice like the use of

Building Information Modeling tools in building design and construction

5.1 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:



From the chart, it can be seen that architectural and quantity surveying firms formed the largest groups of the respondents; having 26. 08% 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%.

5.2 Readiness of the groups of Nigerian Design Firms to Adopt BIM technologies

The result of the questionnaires did not indicate any significant difference between the readiness levels of the various groups of design firms with respect to the adoption of BIM technologies in their practices. However, there are some levels of differences exposed by the DUNCAN multiple range test (table 4.4) which shows the 'others' group as having the highest mean score 4.04, followed by mechanical and electrical engineering firms with 3.81, then 3.55 for structural engineering firms and 3.52, 3.38 and 3.13 for architectural, multidisciplinary firms and quantity surveying firms respectively.

Table 4.4 DUNCAN Test Result showing the variations between the groups of design of firms in their levels of readiness to adopt BIM technologies.

GROUPS	N	Mean
Quantity Surveying Consultancy	12	3.1365
Multi-disciplinaryl Consultancy	7	3.3834
Architectural Consultancy	12	3.5266
Structural Engineering Consultancy	8	3.5508
Mechanical and Electrica Engineering Consultancy	3	3.8129
Others	4	4.0463

To further explore the variations among the groups, the four categories of readiness as classified by Ruikar et al (2006), which are management readiness, process readiness, people readiness and technology readiness were examined separately to see the stands of the individual groups of design firms. The result is presented in appendix B. For management readiness, the 'Others' group is the highest with a mean score of 3.80, followed by 3.46 for architectural firms, then mechanical and electrical design firms, and followed by structural engineering firms, and then multi disciplinary and quantity surveying firms having the mean score of 3.12 and 2.76 respectively.

In the process readiness, the others group recorded the highest mean score of 3.94, then mechanical and electrical engineering

6.0 CONCLUSION

The survey revealed that the groups of Nigerian building design firms do not differ significantly in their perception on the existence of drivers/facilitators of BIM adoption in the Nigerian construction industry. All the groups of respondents responded positively to the existence 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 significant drivers of BIM adoption in Nigeria 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 of BIM adoption in the Nigerian construction industry, all the groups of firms agreed that those barriers 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 significant with mean scores of 3.67 and 3.60 respectively. Others are the lack of trained professionals and frequent power failure. This is in line with the findings of 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).

On the issue of readiness of the firms to adopt BIM technologies in their practices, the results revealed that all the groups seem to be ready for the adoption, with slight variations in their levels of readiness. ‘Others’ group (which consists of companies with in-house design and construction professionals) has the highest mean score of 4.04. and while M & E firms have 3.81, followed by structural engineering and architectural firms with 3.55 and 3.52 respectively. Then multi-disciplinary firms and quantity surveying firms having 3.38 and 3.13 respectively.

This shows that, so far the enablers of BIM adoption in Nigeria will be improved and the hindrances or barriers of the adoption are removed or significantly lowered, the Nigerian design firms are ready to harness the potentials of Building Information Modelling technologies in their services.

The four categories of readiness examined also show slight variations among the groups of firms in their levels of readiness for the BIM adoption. However, there is no statistical evidence to show that the variations among the groups are significant. In management readiness, ‘others’ group has the highest mean score of 3.80, followed by architectural, M & E and structural engineering firms with respective mean scores of 3.46, 3.37, and 3.27. while multi-disciplinary and quantity surveying firms have 3.12 and 2.76 respectively.
Similar results were obtained in the other three categories i.e. process, people and technology readiness.

7.0 RECOMMENDATIONS

Based on the findings of this study, the following recommendations were made with a view to ensuring a successful adoption of BIM technologies 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 therefore recommends that BIM training programs should be provided by the academic institutions and other stakeholders in the construction industry to make our professional design consultants well acquainted with BIM processes to ensure successful take up of the technology. BIM shouldalso be incorporated in the curriculum of all tertiary institutions taking construction related courses, in order to tackle the dearth of well trained professionals to handle BIM tools in the design consultancy firms.

It is recommended that Nigerian construction stakeholders including the government and professional regulatory bodies should work hand-in-hand in ensuring that the enablers of BIM adoption such as the provision of regulations and industry standards guiding the implementation are provided and strengthened to make the industry ripe enough for BIM adoption.

Consultancy companies should further assess their capabilities and address all the issues highlighted in the different categories of readiness to create an enabling environment for them to fully adopt BIM in their practices.

Further research should be conducted to establish the readiness levels of all other sectors of the Nigerian construction industry for the adoption of BIM technologies. This is because the adoption cannot just be achieved by one segment of the industry, but is a collaboration issue which needs all the segments of the industry such as contractors, clients, suppliers, manufacturers and government to have a fair level of readiness if the industry is to benefit from the adoption of the technology.

A framework should also be developed for the full adoption of BIM in the Nigerian construction industry.

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