TOWARD ADOPTION OF BIM IN THE NIGERIAN AEC INDUSTRY; CONTEXT FRAMING, DATA COLLECTING AND PARADIGM FOR INTERPRETATION

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ABSTRACT

In an effort toward aligning the Nigerian Architecture, Engineering and Construction (AEC) sector to the international benchmark of practice in adoption of Building Information Modelling (BIM), this research aimed to understand the Nigerian AEC context assessing the current state of art in the Architectural firms. The research consisted of: creating a survey to collect data on distance mode; adapting different researches and methods in this field to the local context using European and North American protocols as the basis; helping to inform the discussion on future directions and serve as a basis for developments, based on an assessment model specifically defined for a developing Country and the interpretation of the collected data. Part of the research was a review of literature and case studies to appreciate BIM and its potential to the Nigeria AEC sector. It has been realized that BIM among other means has potential to minimize curb corruption in the construction industry which is a worrisome ongoing issue and a slackening factor for the economic growth. As one of the objectives, a conceptual framework was developed based on the Succar's (2009) BIM maturity matrix: this was considered as the basis for the development of the online questionnaire. It involved assessment of technology, processes, policy and functional targets. The assessment conducted through the survey was explanatory and descriptive by itself. It involved 101 architectural firm registered in Nigeria distributed across selected four cities of Lagos, Abuja, Kaduna and Kano where more than 60% of the firms in the country are located. An online questionnaire survey - based on FluidSurveys™ tool – was used to administer the survey. The study opted for a three steps analysis: (i) to classify the firms into a 3 level scale based on staff employed; (ii) to assess data by analysing the responses in each category against the BIM maturity models using cross tabulation; (iii) to define the level of each category in its prospect to the BIM adoption using a descriptive analysis. It was found that most of the medium and larger scale firms are significantly catching up toward the BIM practice, but the small scale firms are having setbacks especially in the aspect of process and policy adherence. However, among all the groups, the level of technological workforce toward BIM and digital technology at large was found appreciable.

Keywords: BIM, Nigeria, AEC, BIM maturity matrix, adoption.

1. INTRODUCTION

In the wake of the information and digital revolution, the Architecture, Engineering and Construction (AEC) industry is facing a paradigm shift in the use of Building Information Modelling (BIM) and Integrated Design and Delivery Solutions (IDDS) (Owen et al., 2009) aiming to increase productivity, efficiency, value, quality and sustainability, and to reduce lifecycle costs (Arayici et al., 2011). Making these gains needs a corresponding shift in focus and processes. Such a change cannot be ensured by a single unit; it is rather a transition that requires participation from the building clients, designers , builders and product manufacturers. BIM is seen as an enabler that may help the building industry to improve its productivity by ensuring an effective communication and collaboration between all project stakeholders from inception to completion of building projects (Becerik-Gerber and Rice, 2010). 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 effective have been reported. According to Succar (2012) BIM has now solidified its position as a promising approach towards addressing the AEC sector's numerous inefficiencies.

Countries like Finland, USA, UK, Australia, Netherlands, Singapore, Hong Kong Norway, Denmark among others have adopted BIM technologies and have experienced significant benefits in construction project delivery (Yan and Damian, 2008; Isikdag and Underwood, 2010; Nederveen et al, 2010; Wong and Lee, 2010; Sebastian and Berlo, 2010). Some of the benefits of BIM technologies as claimed by its proponents are the provision of an efficient communication and data exchange system (Nederveen et al, 2010), auto quantification, improved collaboration, coordination of construction documents, improved visualisation of design (Olatunji, et al, 2010; Sacks et al, 2010), clash detection and cost reduction (Eastman et al; 2011) among others. In view of 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 AEC 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 attributed to it (Kolo and Ibrahim, 2010; Mohammed, 2012) to exploit the widely acclaimed benefits of BIM and achieving continuous improvement needed by its core players. However, despite the potentials and documented benefits, not much has been reported regarding its implementation in the Nigerian AEC industry. It requires examining the prospect of the AEC industry market through its state of art and openness to the information and digital technology. In light of that, this research upon taking to the task, focused generally on survey of the prospect of BIM adoption in the state of art of the Nigeria AEC industry practice, but focusing primarily on the Architectural practice to help with developments within this particular sector.

Aim and Objectives of the Research

The aim of the research was to examine the prospect of the Nigerian Architectural firms' market on its state of art and the openness of the firms to the information and digital technology toward adoption of BIM. To achieved that, a review of literature was vital, and was done focusing on the understanding of the BIM, some case studies using BIM. Thereafter, the study opted for a three steps analysis: (i) to classify the firms into a 3 level scale based on staff employed; (ii) to assess data by analysing the responses of each category against the BIM maturity models using cross tabulation; (iii) to define the level of the willingness and implementation in each category in its prospect to the BIM adoption using a descriptive analysis.

Although several earlier researches were done surveying the impact of the information technology in the Nigerian AEC industries, they mostly focus on either its impact on education (Ogunsote et al., 2008), or towards integrating it to the architectural curricular (Ajufoh et al., 2012). Only few have focused on practical aspects, like Fasheun-Motesho (2002) who studied the adoption and growth of Information Technology in Nigerian Architectural Firms. However, even this study ran short of relating his findings to the current challenges facing the AEC industry, like BIM, and identifying the state of the art in the firms. However, state of art studies of IT issues in any context will become obsolete in the rapidly changing technology environment . As a suggestion for further scholarship, Fasheun-Motesho (2002) has advocated for more studies investigating the prospect of information technology in enhancing the new practices in the industry.

2. BUILDING INFORMATION MODELLING AND THE NIGERIA CONTEXT

Case studies of BIM introduction in different markets

The adoption of BIM has not been absolute or as swift as wished, because of the AEC industry's conservativeness to their practice (Khemlani, 2006). Thus, most of it success stories exist as a result of some external issues, like market competition (Liu et al., 2010) or as a result of Government enforcement, like in USA where the General Services Administration (GSA) mandated the use of BIM for any public and significantly funded project in 2007. Similar demands have implemented also, for example, in Northern Europe and in Singapore. Until recently BIM adoption was slow in the United Kingdom, but after the UK Government stated in 2010 that the use of BIM will become mandatory in all Governmental projects in 2016 the development has been very fast. However, Liu, Issa and Olbina (2010) identified that the internal readiness which involved the management willingness and equip-

ment are among the major factors affecting the adoption of BIM. Based on this view, this research made a survey study of the environment in Nigeria to see what was the prospect within the internal readiness.

Nigerian AEC market and how practices are using IT and digital tools.

Generally speaking, just as being categorised of being a developing country, also Nigeria's level of ICT is developing. There has been efforts by researchers and practitioners in the industry to make the best out of the emerging technology to better enhancing practice. While, the industry itself was increasing awareness and applications in its practice, researchers like Oyediran & Odusami (2005) studied the extent of use of the computers particularly among Nigerian quantity surveyors, and found that about 90% of them use computer for project cost management services (PCMS). Oladapo (2006) studied the influence of Information and Communication Technology (ICT) on professional practice in general and his study revealed significant acceptance rate in the industry. Later (2007), he reinvestigated the impediments to the use of ICT in typical Nigerian construction industry settings and identified the cultural issues as a main factors affecting it.

BIM prospect evaluation model

An important part of the research was to reflect from existing maturity models/indices by analysing, testing and then adopting some of the widely-used maturity models. The considered models for these study include; Control Objects for Information and related Technology, CMMI (Capability Maturity Model Integration), CSCMM (Construction Supply Chain Maturity Model), I-CMM (Interactive Capability Maturity Model), Knowledge Retention Maturity Levels, LESAT (Lean Enterprise Self-Assessment Tool), P3M3 (Portfolio, Programme and Project Management Maturity Model), P-CMM® (People Capability Maturity Model), $(PM)^2$ (Project Management Process Maturity Model), SPICE (Standardised Process Improvement for Construction Enterprises), Supply Chain Management Process Maturity Model, and BPO (Business Process Orientation Maturity Model). These models conceptualise the relation between process maturity and supply chain operations based on the Supply-chain Operations Reference Model (Stephens, 2001) ; Succar, 2009) in analysing their suitability for the development of a BIM-specific maturity index suggest that most were broad in approach and could collectively form a basis for a range of BIM processes, technologies and policies. However, there are not enough differentiation between the notion of capability and that of maturity. Therefore, finally the Succar's model was considered to form the best basis for the study and after modifications to suit the situation in the context of this research.

3. RESEARCH METHOD

A literature review was carried out for the purpose of articulating issues regarding the concept of BIM in the AEC industry with particular emphasis on the context of Nigeria. The review also aimed at appreciating the different BIM readiness and implementation framework models. BIM matrix by Succar (2009) was adopted and then a conceptual framework was designed for evaluating factors against the firms' state of art. This framework served as the basis of the questionnaire.

The study involved an online survey questionnaire using an online application FluidSurveys™ as the tool for data collection. The link to the survey was distributed via email to Architectural consultancy firms within four selected cities, Lagos, Abuja, Kano and Kaduna. 100 surveys were administered using emails and 40 surveys (40%) were retrieved and used for analysis. This was adequate based on the assertion of Moser and Kalton (1971) that the result of a survey can be considered significant if the response rate is not lower than 30-40%.

Classification of the firms

As stated earlier, the firms were classified to ease the level definition of each scale. Previous researches in the similar context were done by Oluwatayo (2009) who ended up classifying most firms in the medium scale. In this study the classification was based on the number of staff: (i) between 1 to 10 employees was classified into Small Architectural firm, (ii) between 11 to 20 into Medium Architectural firm, and (iii) beyond 20 into Large Architectural firm.

Furthermore, in addition to examining the number of staff, a study of how that was related to technological workforce of digital design technology was done. A chi-square test was used to achieve this.

4. ANALYSIS

Analysing the sizes and scales of the Firms

Table 1 shows how the number of digital design workforce (staff) correlates to the respective size of the firms used for classification, further analysis using Chi-square test of independence was used to validate the relation. This was done to ascertain the relevance of the classification for the study.

This classification allows equal participation of the firms in the study. Because the number of technological workforce, computer literacy and digital design skilled staff is depending on the number of the entire staff, the classification based on the size of the firm can play a vital role in a group study of the firms.

Table 1: Cross tabulation of size of firms by digital design staffs in the firms

Size of firm * Number of Digital design workforce cross tabulation						
			Number of digital design workforce			Total
			1 to 10	11 to 20	Beyond 20	
SIZE OF FIRMS	Small firms	% within size of the firm	100.0%			100.0%
		% within digital design workforce	45.8%			45.8%
	Medium firms	% within size of the firms	71.4%	28.6%		100.0%
		% within digital design workforce	41.7%	57.1%		98.8%
	Large firms	% within size of the firms	20.0%	20.0%	60.0%	100.0%
		% within digital design workforce	12.5%	42.9%	37.5%	100.0%

The Assessment

In this section the primary research question was answered identifying and assessing the current state of the art of the architectural firms based on the designed conceptual framework. Also the questions on the questionnaires were set based on the designed conceptual framework. The findings in this section would be mainly descriptive as it relates to the level definition. As planned the study was based on the classification of the firms, and the analysis cross tabulation was done based on the size of the firms followed by a descriptive analysis in each case.

Small Firms

Table 2 reveals the state of use of the BIM in the small firms and the questionnaires indicated that digital tools were mainly used for sketching, modelling and usually only printed copies were shared for visualisation and presentation which made the use of BIM almost obsolete. BIM was regarded as a technology stream without much consideration to the business process and its implementation lacked performance and improvement strategy with lack of leadership and motivation. Also, less regard is given to the product and service potential of the tools in producing a more comprehensive information rich model. There was lack of any policies, rules, guidelines or standards in use of the digital tools as the perception lay basically on technology and less, or no focus was given to the contractual and regulatory aspects.

Table 2: The summary table of the assessment in the small architectural firms

BIM Maturity Matrix Competency set		0 points	10 points Initial	20 points Defined	30 points Managed	40 points Integrated	50 points Optimised
Technology	Software	0	100	0	0	0	0
	Hardware % Network 1	0	18.2	63.6	18.2	0	0
	Hardware & Network 2	9.1	45.5	36.4	9.1	0	0
Process	Leadership	36.4	9.1	9.1	9.1	27.3	9.1
	Human Resources	45.5	9.1	27.3	9.1	9.1	0
	Product and services	0	100	0	0	0	0
	Contractual	36.4	9.1	9.1	9.1	27.3	9.1
Policy	Regulatory	45.5	9.1	18.2	9.1	0	18.2
	Preparatory	9.1	0	18.2	0	36.4	36.4
	Sub total	182	300.1	181.9	63.7	100.1	72.8
	Percentage	**20.2%**	**33.3%**	**20.2%**	**7.0%**	**11.1%**	**8.0%**
BIM Capability Stage		**Pre BIM**	**Object based Modelling**		**Model based Collaboration**		**Integration**

Medium firms

Table 3 illustrates that there is significant intra-disciplinary collaboration using digital models within the medium size firms and tools are mainly used for modelling and visualizations while printed copies still remain the main media for the interdisciplinary collaboration. Apparently BIM in this category was still mainly regarded as a technology stream but with some ideas about the process although reluctantly adhered to with less motivation and lack of leadership. In the aspect of detailed integration of models, there is significant potential to improve collaboration on a digital platform but it is not used by the firms. Rules, guidelines or standards for use of BIM were not regarded but basically lay on individual championship and what was readily available.

Table 3: The summary table of the assessment in the medium size architectural firms

BIM Maturity Matrix Competency set		0 points	10 points Initial	20 points Defined	30 points Managed	40 points Integrated	50 points Optimised
Technology	Software	0	0	0	100	0	0
	Hardware % Network 1	0	0	50	35.7	7.1	7.1
	Hardware & Network 2	7.1	35.7	28.6	7.1	14.3	7.1
Process	Leadership	21.4	14.3	0	42.9	14.3	7.1
	Human Resources	21.5	0	14.3	14.3	14.3	35.7
	Product and services	0	0	0	100	0	0
	Contractual	21.4	14.3	0	35.7	21.4	7.1
Policy	Regulatory	21.4	14.3	0	42.9	14.3	7.1
	Preparatory	7.1	0	0	0	50	42.9
	Sub total	99.9	78.6	92.9	378.6	135.7	114.1
	Percentage	**11.1%**	**8.0%**	**10%**	**42%**	**15%**	**12%**
BIM Capability Stage		**Pre BIM**	**Object based Modelling**		**Model based Collaboration**		**Integration**

Large Firms

Table 4 indicates that the use of digital tools in the large firms was relatively consistent with regards to collaboration i.e. Model based collaboration. While still significantly adhering to a set process, there was lack of effective leadership and facilities to support the process. This in turns affected the effective implementation of the available policy elements such as guidelines, contracts and effective training.

Table 4: The summary table of the assessment in the large architectural firms

BIM Maturity Matrix Competency set		0 points	10 points Initial	20 points Defined	30 points Managed	40 points Integrated	50 points Optimised
Technology	Software	0	0	0	100	0	0
	Hardware % Network 1	0	20	26.7	6.7	33.3	13.3
	Hardware & Network 2	6.7	40	6.7	6.7	13.3	26.7
Process	Leadership	13.4	6.7	0	13.3	33.3	33.3
	Human Resources	6.7	6.7	53.3	0	26.7	6.7
	Product and services	0	0	0	100	0	0
	Contractual	13.4	6.7	6.7	0	46.7	26.7
Policy	Regulatory	13.4	6.7	0	13.3	33.3	33.3
	Preparatory	0	0	0	6.7	40	53.3
	Sub total	53.6	86.8	93.4	246.7	226.6	193.3
	Percentage	**6.0%**	**10.0%**	**10.0%**	**27.0%**	**25.0%**	**21.0%**
BIM Capability Stage		**Pre BIM**	**Object based Modelling**		**Model based Collaboration**		**Integration**

5. CONCLUSION

BIM has the potential to play a vital role in the Nigerian AEC sector. Due to its clarity and transparency benefits, it could help standardisation across the industry which has been a worrisome issue in the Country. Adoption of BIM in the industry is an entire shift in the practice. Generally the cultural transformation has always been a greater challenge than technological transformation, however, the medium and the large firms in the Nigeria AEC industry could easily curb with the known challenges of the BIM adoption if the identified process issues could be recognised as an important issue in the industry. This would improve the buildings and adherence to the policy issues. However, the issues in the small firms were relatively major problems as there is lack of understanding of the process itself or even less of the policies,. The small firms regarded the whole shift just as a technological stream and disregarded its accompanying effects on their business settings. However, all the firms affirmed an enthusiasm for a technological innovation with some resistance to changing their practice.

RECOMMENDATIONS

Acknowledging that the shift in BIM is accompanied by cultural and business transformation in the practice is vital to the adoption in the industry. The government and professional institutes can take the lead in the process. However, education and training have also been identified as important parts of BIM adoption and implementation.(Arayici et al., 2009). The software vendors, professional institutes and firms should encourage dissemination through workshops on regular basis to increase knowledge about the BIM, and at large integrating BIM into the core curricula may improve understanding in the AEC industry.

Further research is recommended to understand how the BIM adoption does change the practice in the industry, what approach to adopt, and other topics to reconcile the issues arising.

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