Analysis of BIM maturity level among AEC firms in developing countries : a case of Nigeria

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ANALYSIS OF BIM MATURITY LEVEL AMONG AEC FIRMS IN DEVELOPING COUNTRIES: A CASE OF NIGERIA

Paper (ID#4251)

ABSTRACT

Although studies on BIM abound, but there is limited empirical study on the current level of BIM maturity among Architectural, Engineering and Construction (AEC) firms, particularly in developing countries. The purpose of this study is to assess and compare the current level of BIM maturity among AEC firms in Nigeria. The study adopted a literature review, a pilot study, and a semi-structured interview. A semi-structured interview was conducted on the selected AEC firms already using BIM. The outcome of a literature review identified four BIM maturity level namely BIM level 0, BIM level 1, BIM level 2 and BIM level 3 with their respective features for each BIM maturity level, which was used to develop a quantitative assessment tool. The quantitative assessment was used as a supporting tool for assessing the current level of BIM maturity among AEC firms and for comparison approach. The results revealed that Architectural firms were positioned on 2.00, which implies that Architectural firms are on BIM Level 2, Quantity Surveying firms were positioned on 1.02, which indicates that Quantity Surveying firms are on BIM Level 1. Structural Engineering firms were placed on 1.56, which connotes that Structural Engineering firms are on BIM Level 1, and Facility Management firms were positioned on 0.50, which signifies that Facility Management firms are on BIM Level 0 (out of four BIM maturity level). This study has both theoretical and practical implications. For instance, the quantitative assessment tool developed in this study would provide a useful guide for improvement by indicating "what" needs to be done by AEC firms to achieve higher BIM maturity levels. Also, this study could be used to benchmark similar future studies. This study has further contributed to the wider body of knowledge of process improvement in the construction industry at large.

Keywords: BIM, developing countries, consulting firms, maturity level, Nigeria.

INTRODUCTION

Over the years, the construction industry has been characterized by low productivity, fragmentation and inability to deliver optimum satisfactory projects to its clients when compared with other industries, particularly manufacturing industry (Latham, 1994; Egan, 1998). These reports anticipated for the amalgamated project procedures, suitable working environment, enhanced management and managerial skills, quality-oriented program among others. All of which are evident in Building Information Modeling (BIM). For instance, Newton and Chileshe (2012) argued that BIM adoption is vital to productivity and competitive nature of the construction industry. BIM was developed in order to provide basis for resolving the inefficiencies of the previous Computer Aided Drawing (CAD) by providing a working digital environment that incorporates all information about a building in an electronic file which can be exchange and use by the various project stakeholders (Abdullah and Ibrahim, 2016). An on-line survey on the extent to which construction professionals uses BIM in the United State of America showed that fifty-six percent of the firms

used BIM, applied it on fifty percent of their jobs, with just thirty-four percent of the respondents rarely using it (McGraw-Hill, 2010).

The government of the United Kingdom had successfully integrated BIM in the practices of their construction sector, has recorded substantial savings via the usage of BIM and has identified BIM as a relevant "instrument" in assisting the government to accomplish it aim of fifteen to twenty percent savings on project cost (UK BIM Strategy Report, 2012). However, Akerele and Etiene (2016) argued that the Nigerian construction professionals have low level of awareness on the use of BIM. This was corroborated by Alufohai (2012) that the extent of BIM implementation is relatively low in countries where there are no government policies in place to encourage BIM adoption. Although numerous studies have been conducted on BIM in Nigeria, for instance, Olugbenga (2016) evaluated BIM based project in Nigeria. The study identified the benefits of BIM implementation on the on-going Eko Atlantic City project to include geometrics development and structural systems of the city among others. Ede (2014) studied the implementation of BIM software packages on the delivery of a duplex building in Nigeria. The study showed that reasonable cost and time was saved on the project without prejudice to quality. Despite these previous studies, it is evident that there is little or no emphasis on the analysis of BIM maturity level among Architectural, Engineering, and Construction (AEC) firms in Nigeria. In order to fill this knowledge gap, this study attempt to assess the current level of BIM adoption within AEC firms with a view to identifying and comparing BIM implementation maturity level in Nigeria. This study further investigates the factors responsible for the selected AEC firm's respective current BIM maturity levels, particularly architectural firms, Quantity Surveying firms, Structural Engineering firms, and Facility Management firms.

LITERATURE REVIEW

Current state of BIM adoption in the Nigerian construction industry

Onungwa et al. (2017) argued that there is low level of awareness and technical know-how of BIM in Nigeria. This can be linked to lack of adequate BIM training for staffs and personnel(s) and inadequate exposure to BIM concept or both (Abubakar et al., 2014; Onungwa et al, 2017). According to Kori (2015) both firms that are enormous and medium in size are predominantly on the foremost in the adoption of BIM in the Nigerian construction industry whereas, firms that are relatively small in size rarely use it in their practices. Generally, the construction industry in Nigeria is fragmentized, this implies that various construction professionals usually generate project information and manage them individually (Onungwa et al., 2017). Hamma-adama et al. (2017) claimed that architectural, mechanical, electrical and plumbing designs are still prepared using 2D CAD platform with only few, especially Architects using 3D CAD platform basically for visualization or demonstration. Smith and Tardif (2009) argued that if BIM is used merely for presentation, detention of clashes and visualization, the numerous inherent capabilities it possesses may remain un-tapped. Hamma-adama et al (2017) opined that change of behaviour from the traditional method of procurement is necessary. However, change of behaviour to successfully adopt BIM is often difficult as it requires a complete transition of work processes (Hardin and McCool, 2015). Although BIM adoptions and usage in most developed nations are on the increase. However, the extent of BIM adoption in most developing countries such as Nigeria is best describe as stagnant (Ibrahim and Bishir, 2012).

BIM maturity level

Khoshgoftar and Osman (2009) stated that the different categories that comprises BIM modeling can in relation to excellence is depicted as maturity. This is affirmed by Succar (2010) who identified maturity of BIM to mean quality, duplicability and extent of excellence in the delivery of a BIM model. There is incessant growth in the evaluation of BIM maturity model in which the criterions served as the standard that construction participants and firms seek to achieve (Chen et al., 2012). Azzouz et al. (2018) identified countries with the highest maturity of BIM in an orderly manner to include Spain, Netherlands, Italy, and Germany. Since individual participant has diversified targets of performance and desired outcomes, maturity models should therefore show these targets (Dakhil, 2017). Chen et al (2012) asserted that the prevailing models for the maturity of BIM have been intended for specific firms, which comprises of contractors, designers among others while others are categorized as general model of maturity for different types of firms.

The current evaluations of models available in literature are meant to ascertain the extent of BIM maturity for firms, projects and participants (Dakhil, 2017). Azzouz et al (2018) argued that there are numerous factors responsible for the differences in the maturity of BIM across countries in Europe. These factors are institutionalized forces, individual national rules and guideline in various countries but also include socio-technological factors, traditional and social framework as well as construction participants' experiences, nature and magnitude of project, level of sophistication, revenue and building owners' requirement. Bew and Richards (2008) developed BIM maturity model, which described Computer Aided Drawing as Level 0 BIM which connotes the absence of BIM maturity. This level of BIM maturity is also refers to as infant industry (Jayasena and Weddikkara, 2012). BimTalk (2010) stated that BIM level 0 is an unmanaged Computer Aided Design (CAD), within 2D in which data can be exchange manually or electronically. The BIM level 1 is associated with the implementation of intelligence on elementary CAD usage as the entrance into BIM maturity level (Bew et al., 2008). BIM Talk (2010) stated that BIM level 1 is a managed Computer Aided Design (CAD) in either 2 dimensional or 3 dimensional format, which has collaborative tool that provide uniform data platform with a regularized approach to the structure and format of project data. Bimhub (2017) claimed that BIM level 1 features include visualizations and development of building models and it is often referred to as 'lonesome BIM' because the models generated from it cannot be share between construction project stakeholders.

The level 2 BIM also known as 'Pbim' (proprietary BIM) is a managed 3 dimensional platforms which contain project data, but they are usually models generated in isolated form by various construction professionals. However, these different models are combined to form federalized model but their identity is left intact (Bimhub, 2017). Level 2 BIM tools have a tendency to be applied on design coordination issues but are rarely utilized for construction processes (Eadie et al., 2015). Also, Bimhub (2017) reported that the remarkable attribute of this level include the incorporation of data for construction sequencing (4 Dimensional) and cost information (5 Dimensional). BSI (2013) reported that although level 2 BIM is advantageous, a remarkable transition will be experienced when Level 3 BIM is adopted. The design, formation and usage of Level 2 BIM were recognized as a significant step and response, by the United Kingdom government due to the importance of the construction industry to their economy (Ganah et al., 2014). This has been sustained and promoted via the reviewed Government Construction Scheme 2016-2020 and likewise the Construction 2025

scheme (Alwan et al., 2016). The level 3 BIM also known as iBIM (Integrated BIM) is an individual collaborative, internet-enabled, building model which comprises data for construction sequencing (4 Dimensional), cost information (5 Dimensional) and project whole life-cycle information (6 Dimensional) (Bimhub, 2017). Mason and Knott (2016) argued that level 3 BIM will enhance interconnection of electronic design of various building components and at the same time improve networking, services and project delivery.

RESEARCH METHODOLOGY

The study adopted a literature review, a pilot study, and a semi-structured interview. For instance, the outcome of a literature review identified four BIM maturity level namely BIM level 0, BIM level 1, BIM level 2 and BIM level 3 with their respective features for each BIM maturity level, which was used to develop a quantitative assessment tool presented in Table 1.

Table 1: Quantitative assessment tool

	BIM Maturity Level			
	BIM level 0	**BIM level 1**	**BIM level 2**	**BIM level 3**
Brief description of each BIM level	An unmanaged Computer Aided Design (CAD), within 2D in which data can be exchange manually or electronically	A managed Computer Aided Design (CAD) in either 2D or 3D format which has collaborative tool that provide uniform data platform with a regularized approach to the structure and format of project data	A managed 3 dimensional platforms which contain project data, but they are usually models generated in isolated form by various construction professional; however, these different models are combined to form federalized model but their identity is left intact.	An individual collaborative, internet-enabled, building model which comprises data for construction sequencing (4 Dimensional), cost information (5 Dimensional) and project whole life-cycle information (6 Dimensional)
Score	☐	☐	☐	☐
	1. No Collaboration. 2. 2D CAD drafting only is utilized. 3. Mainly production information. 4. Output via paper or electronic prints or a mixture of both 5. Distribution via paper or electronic prints or a mixture of both	1. Mixture of 3D CAD 2. 2D CAD drafting and production information. 3. CAD standards are managed 4. Electronic sharing of data from CDE. 5. No collaboration between different discipline	1. Collaborative working 2. Requires an information exchange process 3. Capable of being exported to common file format i.e. IFC or COBie 4. Enables interrogative checks 5. All parties use their own 3D CAD on different shared model	1. Full collaboration 2. Single shared project model is used 3. Enables parties to access that same model 4. Enables parties to modify that same model 5. Eliminate the final layer of risk for conflicting information
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

As indicated in Table 1, the quantitative assessment was used as a supporting tool for assessing the current level of BIM maturity among the selected AEC firms. The pilot study was conducted to identify the AEC firms adopted BIM in the study area. Prior to this, the total lists of the four selected AEC firms were obtained from their respective professional bodies in Lagos, Nigeria. Hence, the outcome of the pilot study revealed a total of 79 AEC firms already used BIM for their practices.These comprised 41 Architectural firms, 2 Facility Management firms, 25 Quantity Surveying firms, and 11 Structural Engineering firms in the study area. As indicated in Table 1, within a

particular BIM maturity level (i.e. BIM L0-L3), an identified characteristics were provided, which were used as the criteria for the rating of the interview questions with respect to each AEC firm. In this regard, a scale rating 1-5 was developed to rate the extent that selected AEC firms comprised Architectural firms, Facility management firms, Quantity surveying firms, and Structural engineering firms have gone into a particular BIM maturity level they belong. Thereafter, a semi-structured interview was conducted using the quantitative assessment tool for making a general assessment of the current level of BIM maturity of the selected AEC firms and for comparisons approach. This approach is supported by earlier researchers. For instance, Babatunde et al. (2016) quantitatively assessed the current capability maturity levels of both public and private organizations involved in PPP projects in Nigeria. Bay and Skitmore (2006) quantitatively assessed the level of project management maturity in Indonesian companies. Cooke-Davies and Arzymanow (2003) quantitatively assessed the maturity of project management in six different industries. Therefore, the authors of this paper were able to assess the current BIM maturity levels of the selected AEC firms in Nigeria. The results of average total scores for each of the selected AEC firm were presented in Figure 1.

RESULTS AND DISCUSSIONS

Table 2 reveals the background information of the selected AEC firms comprised the category of the firms, major client of the firms, and number of employee in the firms. It can be seen from Table 2 that Architectural firm has the highest percentage among the AEC firms that used BIM followed by Quantity Surveying firms (see Table 2 for more details).

Table 2: Background information of the selected AEC firms

Characteristics	Frequency	Percentage
Firm's category		
Architectural firm	41	51.9
Facility Management Firm	2	2.5
Quantity Surveying firm	25	31.6
Structural Engineering firm	11	13.9
Total	79	100.0
Firm's major client		
Private individuals	38	48.1
Corporate organizations	29	36.7
Government	12	15.2
Total	79	100.0
Firm's employee		
1 to 10	43	54.4
10 to 20	17	21.5
20-50	15	19.0
Above 50	4	5.1
Total	79	100.0

Figure 1 shows the current BIM maturity levels among the selected AEC firms. Figure 1 indicates that Architectural firms were positioned on 2.00, which implies that Architectural firms are on BIM Level 2, followed by Structural Engineering firms were placed on 1.56, which connotes that Structural Engineering firms are on BIM Level 1. Quantity Surveying firms were placed on 1.00, which signifies that Quantity Surveying firms are on BIM Level 1, and Facility Management firms were positioned on 0.50, which implies that Facility Management firms are on BIM Level 0 (out of four BIM maturity level). These study findings confirmed previous studies. For instance, Alufohai (2012) claimed that Architects have imbibe the adoption of BIM but mainly used it to improve the visual appeal of their presentation. Hamma-adama et al. (2017) asserted that the status of BIM uptake in Nigeria is the predominant usage of 2D and 3D. Olugbenga et al. (2018) found that the status of BIM adoption among construction professionals in Nigeria is at visualization phase.

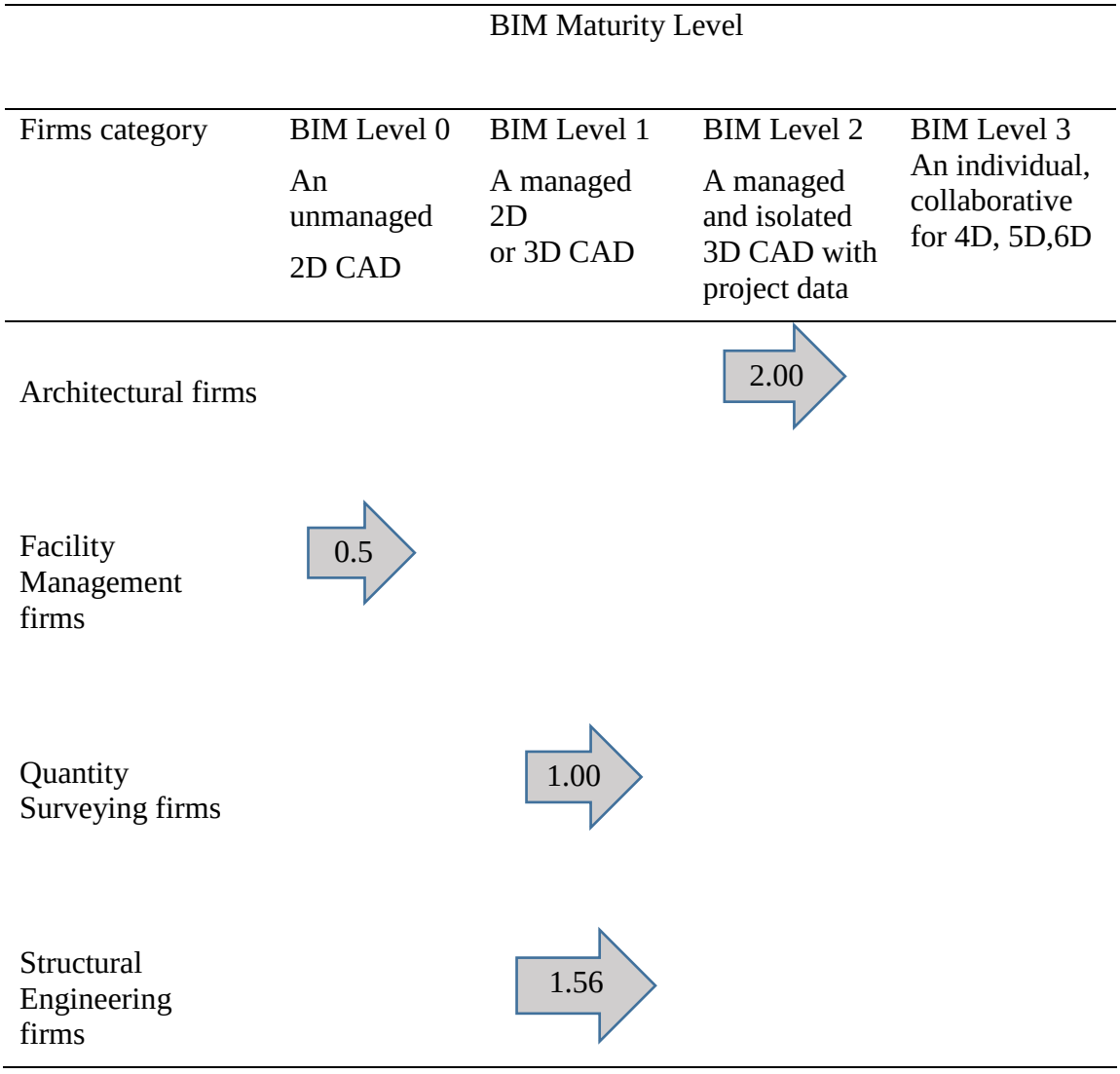

Figure 1: Current BIM maturity levels among AEC firms

Based on the findings in Figure 1, another semi-structured interview was conducted to investigate the factors responsible for the selected AEC firm's respective current BIM maturity levels as showed in Figure 1. In achieving this, 17 AEC firms were

purposively selected. These comprised 5 AEC firms each from Architectural firms, Quantity Surveying firms, and Structural Engineering firms, while 2 Facility Management firms were selected. The 17 interviewees across the selected AEC firms were at senior management levels in their respective firms. This approach was supported by Creswell (2009) that researchers could purposively select participants in qualitative research. The questions asked from the interviewees and their compilations of responses, based on each AEC firm category are as follows:

Question 1: *What do you think is responsible for your firm or profession's current level of BIM maturity*?

Architectural firms: The interviewees from the Architectural firms identified BIM awareness, speed and accuracy of doing work with BIM, experience with other consultants, and peers and colleagues deliver similar products as major factors responsible for the Architectural firms to be on BIM Level 2 in Nigeria.

Quantity surveying firms: Majority of the interviewees from quantity surveying firms agreed that low level of awareness and adoption of BIM in Nigeria, BIM involve majorly production of drawings, few stakeholders adopt the BIM, and finances are the prevalent factors responsible for QS firms to be positioned on BIM Level 1.

Structural engineering firms: There is a consensus among the interviewees that BIM awareness is relatively low and extent of usage is still low as primary factors responsible for the structural engineering firms to be placed on BIM Level 1.

Facility management firms: The interviewees identified lack of demand by clients, and low and inadequate BIM awareness as major factors responsible for facility management firms to be positioned on BIM Level 0.

Question 2: *What do you think is responsible for architectural firms to be on BIM Level 2?*

Architectural firms: The interviewees from the architectural firms agreed that pressure from clients on expected deliverables, experience and exposure, and perhaps they are the first contact with clients particularly in Design-Bid-Build projects are the factors responsible for Architectural firms to be on BIM Level 2.

Quantity surveying firms: The interviewees from the QS firms stated that most architectural firms are on BIM level 2 because they handle the design aspect of construction and majority of the BIM tools available originated for their design usage. However, the others stakeholders are yet to catch up with the architects. Also, early adoption and project initiator/or consultants that first commence the design. Hence, BIM is most useful for them (i.e. architectural firms) on daily basis; therefore they apply it in their everyday activities.

Structural engineering firms: The interviewees from the structural engineering firms agreed that architectural firms are on BIM level 2 because they are early adopters of BIM compared to other construction professionals in Nigeria. Also, it may be due to their design oriented activities and the need to improve design quality to impress their clients.

Facility management firms: Majority of the interviewees from facility management firms stated that architectural firms are on BIM level 2, due to basis of their

profession, particularly the needs to provide detailed 3D model and visualization to clients.

CONCLUSIONS

This study assessed and compared the current levels of BIM maturity among AEC firms, particularly the Architectural firms, Structural Engineering firms, Quantity Surveying firms, and Facility Management firms in Nigeria. In addition, the study investigated the factors responsible for different current BIM maturity levels exhibited by the selected AEC firms. The study found that Architectural firms were positioned on 2.00, which implies that Architectural firms are on BIM Level 2, Quantity Surveying firms were positioned on 1.02, which indicates that Quantity Surveying firms are on BIM Level 1. Structural Engineering firms were placed on 1.56, which connotes that Structural Engineering firms are on BIM Level 1, and Facility Management firms were positioned on 0.50, which signifies that Facility Management firms are on BIM Level 0 (out of four BIM maturity levels i.e. BIM Level 0 – BIM Level 3). This study established that only Architectural firms were on BIM Level 2. This finding is not surprising because the remaining selected AEC firms agreed to the fact that Architectural firms are on BIM Level 2, due the pressure from clients on expected deliverables, the need to provide detailed 3D model and visualization to clients, they handle the design aspect of construction and majority of the BIM tools available originated for their design usage, and they are early adopters of BIM compared to other construction professionals among others. This study has both theoretical and practical implications. For instance, the quantitative assessment tool developed in this study would provide a useful guide for improvement by indicating "what" needs to be done by AEC firms to achieve higher BIM maturity levels. Also, this study could be used to benchmark similar future studies. This study has further contributed to the wider body of knowledge of process improvement in the construction industry at large.

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