

Evaluation of usage level of BIM tools for project delivery by architecture, engineering and construction (AEC) firms in Southwestern Nigeria

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Abstract:

Building Information Modelling (BIMTools) is a revolutionary technology and process that has transformed the buildings designed, analysed, construction, and management. The construction industry has witnessed low productivity compared to other industries, no thanks to medieval approaches that are error-prone, cost-inefficient, time-consuming, and deficient in meeting the rising trends. Therefore, this study aims to evaluate the awareness level and the level of BIM Tools usage for project delivery in AEC firms in southwest Nigeria. Data were collected through a questionnaire survey from 246 AEC firms in southwest Nigeria. Descriptive analysis was employed to analyse the data. The AEC construction firm observed a high awareness level of Building information modelling (BIMTools) for project delivery. The study further revealed that the maturity usage of BIMTools for project delivery is level 1 (2D and 3D) in the AEC firm in southwest Nigeria. This study established that AEC construction firms are fully aware of BIMTools for project delivery and further indicates that AEC firms are currently using 2D and 3D for project delivery. BIMTools has progressed beyond 2D and 3D, and the study firms to invest in BIMTOOLS to improve their long-term efficiency. The study contributes to the body of knowledge by providing insight into the usage level of BIMTool applications in ACE firms for project delivery.

Keywords:

AEC firm, BIM tools, construction, project delivery, Nigeria

1 Introduction

The construction industry has witnessed low productivity (Moswane et al. 2018) when compared to other industries, no thanks to medieval approaches, which are error-prone, cost-inefficient, time-consuming, and deficient in meeting the rising trends, demands, and complexities of timely, cost-efficient, quality, and sustainable project deliveries (Douglas 2010; Abioye et al. 2021). Nonetheless, advancements in technology and digitisation have birthed paradigm shifts that transform the building sector through improvements in construction works' efficiency, productivity, and management throughout the building lifecycle (Eastman et al., 2011; Toyin and Mewomo 2021a). Meanwhile, Ahuja et al. (2009)

and Shehzad et al. (2021) affirmed that information and communication technology (ICT) has proven effective by playing vital roles in information management and transmission among Architecture, Engineering, and Construction (AEC) firms which enables active communication and nexus among the built-environment professionals. Saka, Chan, and Olawumi (2019) revealed that such technologies as Building Automation, Lean Construction, Building Information Modelling, and Digital Twin Technology have emerged and continually augmented to tackle numerous issues, improve outputs and achieve monetary value in the building industry.

Building Information Modelling (BIM) is now a dominant tool used throughout the lifecycle of new projects and existing buildings and has fostered collaboration and integration among stakeholders in the AEC industry (Ezeabasili et al., 2015). Succar (2009) described BIM as widespread interacting policies, processes, and technologies. Furthermore, Eastman et al. (2011) termed BIM as the creation of a digital parametric model representing a building's physical and functional characteristics. Notably, numerous works of literature have fruitfully identified the various paradigms within the BIM subject, viz: Awareness (Akerlele & Etienne, 2016), Adoption (Ayinla & Adamu, 2018; Succar & Kassem, 2015; Vidalakis et al., 2019), Impacts (Toyin and Mewomo 2021a), Drivers (Liao and Teo 2019; Saka, Chan, and Siu 2020), Challenges (Abubakar et al., 2014). Critical Success Factors (CSFs) (Olawumi & Chan, 2018a), Benefits (Olawumi & Chan, 2018b), and Barriers (Chan et al., 2019), among others. These BIM paradigms have gained ground among the first world economies such as Singapore, the United Kingdom, the United States, the Netherlands, Canada, Hong Kong, and Australia (Saka et al., 2019; Toyin and Mewomo, 2021b). On the downside, they have not been deep-rooted in most developing countries, especially sub-Saharan Africa (SSA). For instance, Nigeria, currently undergoing rapid urbanisation with a boatload of construction industries, is still beclouded with low BIM awareness and expertise levels (Onungwa, Uduma-Olugu, And Igwe 2017) and somewhat far from utilizing this promising technology in construction project delivery. Investigations on usage level of BIM tools in Nigeria are still insufficient (Saka et al., 2019). Hence, this study investigated the awareness level of BIM tools and examined the utilisation level of BIM tools maturity for construction project delivery amidst AEC firms in southwestern Nigeria.

2 BIM Tools

BIM tools have launched innovative construction and project delivery methods (Alhamami et al., 2020) via revolutionary technology and process that transforms how buildings are designed, analysed, constructed, and managed (Hardin & McCool, 2015). According to Eastman et al. (2011), BIM Tools are applications that produce a specific task outcome. These tools are used for such functions as drawing production, model generation, specification detailing, cost estimation, clash and error detection, energy analysis, rendering, scheduling, and visualisation (Khajavi et al., 2019; Toyin and Mewomo, 2021a). These tools are specific in reports and drawings, sometimes transferred to other software packages to forward work, such as quantity take-offs for cost assessment and structural reactions input into a connection-detailing program (Wijayakumar & Jayasena, 2013).

Understanding the usage of Bimtool is vital to assess the awareness level among AEC firms. Several studies have examined the awareness of BIMTool; for instance, Akerele & Etiene (2016), which the study identified a low level of awareness among the AEC firms. Onungwa et al. (2017) revealed low awareness of BIMTool usage as one of the barriers to construction management use. Furthermore, Hamma-adama et al. (2018) demonstrate a reasonable awareness of BIM technology, yet many are aware of the tools without knowing it as BIM; as a result, industry experts lack a clear comprehension of BIM. The vital function of time control, waste, and the cost are essential to the productivity of all parties involved in a construction project (Arayici & Aouad, 2011; Mewomo & Ejidike, 2021). Many problems relating to issues of control result from the inadequate communication of information within contracting firms or amongst design firms (Al Nahyan et al., 2019). Harris (2013) pointed out that BIM tools are reliable digital, three-dimensional, and virtual representations of the built project.

Furthermore, these auspicious tools function for design decision-making, planning, cost estimates, construction scheduling, and maintenance of construction projects to improve the delivery of the project. However, according to Alufohai (2012), AEC firms that use BIM for the building process still use the traditional design-bid-build method. The ability to use BIM Tools to construct a project before it is built virtually gives a crucial means of checking its constructability and maintainability in the real world and resolving any doubts that may arise during the process, making the Tools more advantageous than the traditional method of construction (Bynum et al., 2013).

2.1 Level of BIM tools usages maturity

According to Gledson, Bleanch, and Henry (2012), Levels of BIM Tool's usage maturity is developed for the UK BIM strategy, but other countries have adopted the model. Construction firms' ability to operate, exchange information, and deliver projects is described by the maturity levels of BIM tools. According to Smith (2014), the usage maturity levels of BIM Tools define the level of information (dimension) required for modelling, cost estimating, scheduling, and delivery of the project. Ibem et al. (2018) revealed that the usage of BIMTool is still moderately low among firms. Furthermore, Abdulmumin et al. (2020) pointed out that the level of BIM Tool usage is still low among the AEC firm, attributed to a low level of awareness.

The BIM project strategy team is intended to use BIM Tools to prioritise the development of the BIM infrastructure by supporting infrastructure, collaboration, and integration at each level of capability. Four levels of BIM maturity exist amongst most AEC firms (as shown in Figure 1). viz: level 0, level 1, level 2, and level 3 BIM (Bew and Richards 2008; Succar 2009)



Figure 1: The Bilal-Succar Model of BIM maturity levels source (Succar, 2009)

2.1.1 *Level 0 BIM*

Traditionally, the Construction Industry has developed building information via drawings and notes. Furthermore, specifications before adopting ICT technologies, the automation of the traditional method of developing building information is called Level 0 BIM (Blanco & Chen, 2014). Level 0 BIM is document-oriented and entails 2D CAD software drawings, Excel calculations, and information processing with Microsoft Word. The level denotes an absent or no BIM maturity, unmanaged 2D or 3D Computer-Aided Design (CAD) (Bew and Richards 2008; Babatunde, Ekundayo, and Adekunle 2019). It is mainly adopted by AEC firms of developing economies at the nascent stage of development.

2.1.2 *Level 1 BIM*

Modelling in Level 1 BIM is object-oriented where 2D or 3D CAD objects, BIM Tools are designed in software used to construct a building in a virtual environment. These 2D or 3D objects typically feature geometric descriptions that can be related to intelligence (Eadie et al., 2014). However, level 1 BIM does not integrate discipline-specific models but can create a federated building information model (Borrmann et al., 2018). Eadie et al. (2014) recommend that level 1 BIM review discipline-specific information models to eliminate errors and defective works. According to Succar (2009), this BIM stage is initiated by deploying an 'object-based 3D parametric software tools. However, the models generated from this stage cannot be shared between construction project stakeholders (BIMhub., 2017).

2.1.3 *Level 2 BIM*

Collaboration among team members necessitates the coexistence or integration of discipline-specific information models to develop a model, and coordinated information models can also be referred to as '*iBIM*' because they serve as a database for the project (RIBA, 2012). Level 2 BIM is collaboration-oriented; BIM tools are commonly used to solve design coordination challenges by creating a model that depicts the operations and performance of building systems and components (Nagalingam et al., 2013). Babatunde, Ekundayo, and Adekunle (2019) opined that most architectural firms in developing countries such as Nigeria are at this stage since they are early adopters of BIM tools, leverage on the design aspect of buildings, and are poised with the need to provide their clients detailed 3D model and visualisation. However, these tools are rarely utilised for construction processes (BIMhub., 2017).

2.1.4 *Level 3 BIM*

Meanwhile, the difference between level 2 and 3 BIM is the integration of the discipline-specific information models to evolve into a single master model, which can only be achieved under the Interoperable BIM standards such as COBie, and IFC. Building Information Council (2014) noticed that level 3 BIM is all about integration and lifecycle management.

3 Research Methodology

The general approach to conducting research design includes theoretical phases that enable data collecting and analysis (Chun Tie et al., 2019). This study employed a quantitative research approach to achieve the aim of the study. The principal data source was empirical questionnaires, whereas the secondary data source was a literature review. A comprehensive literature review is performed to determine the maturity of BIM tool usage, based on a

questionnaire prepared to determine the level of awareness of BIM tool usage for project delivery and the utilisation rate in southwest Nigeria. A good structure questionnaire was developed and administered to practising AEC firms in Victoria Island, Lagos State, Akure, Ondo State, and Ibadan Oyo State. Since the exact population of AEC firms for the sample size is difficult to calculate, the Cochran equation for the unknown population was utilised, which has previously been used by (Ghansah et al., 2020).

$$N_0 = \frac{Z^2 pq}{e^2}$$

N_0 =sample size, z^2 = the abscissa of the normal curve that cuts off an area at the tail, e = the desired level of precision, p = the estimated proportion of an attribute that is present in the population, (small: 0.2-0.3, medium: 0.5, and high: 0.8) $q = 1 - p$

$$N_0 = \frac{(1.962^2 \times 0.2 \times 1 - 0.2)}{0.05^2} = 245.8624$$

Approximately 246 AEC firms; hence, 82 questionnaires were shared in each state. Descriptive analysis was used on the retrieved data. The mean item score was used to analyse the data retrieved.

4 Findings and Discussion

4.1 Breakdown of respondents

The questionnaires were distributed in a total of 246 copies. However, 82 questionnaires were shared in each of the three states. Altogether, 180 copies of the questionnaires were retrieved, representing approximately a 73.2% response rate.

Table 1: Breakdown of respondents

Location	Quantity Distributed (Q_d)	Number Completed and Retrieved (Q_r)	Number not Completed	Response rate (%) $\frac{Q_r}{246} \times 100$
Akure-South LG, Ondo State	82	45	37	18.3
Ibadan, Oyo State	82	65	17	26.4
Victoria Island, Lagos State	82	70	12	28.5
Total	246	180	66	73.2

(Source: Authors' Field Survey, 2022)

4.2 Type of AEC firms

Figure 1 shows that Akure has a 48.89% Architectural firm, 26.67% Quantity surveyor, 15.56% Building construction firm, and 8.89% Engineering firm. Meanwhile, Ibadan, Oyo State has 40% Architectural firm, 30.77% Quantity Surveyor firm, 15.38% Engineering firm, and 13.85% Building Construction firm, whereas Victoria Island, Lagos State has 41.43%

Architectural firm, 21.43% Quantity Surveyor firm, 20% Engineering firm, and 17.14% Building Construction firms.

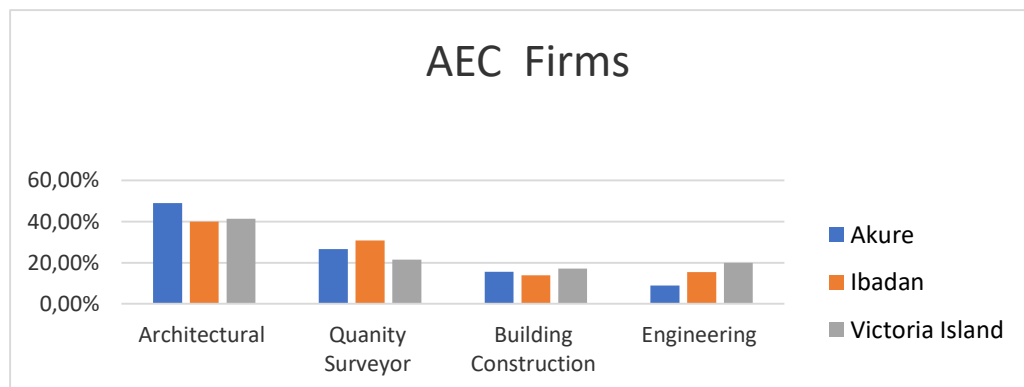


Figure: 1 Type of AEC firms

4.3 The level of awareness of BIM tools for project delivery in their firm

Figure 2 shows that Akure has an awareness level of 51.11%, which is high Ibadan has an awareness level of 32.31%, which is high, and Victoria Island has an awareness of 50%, which is high.

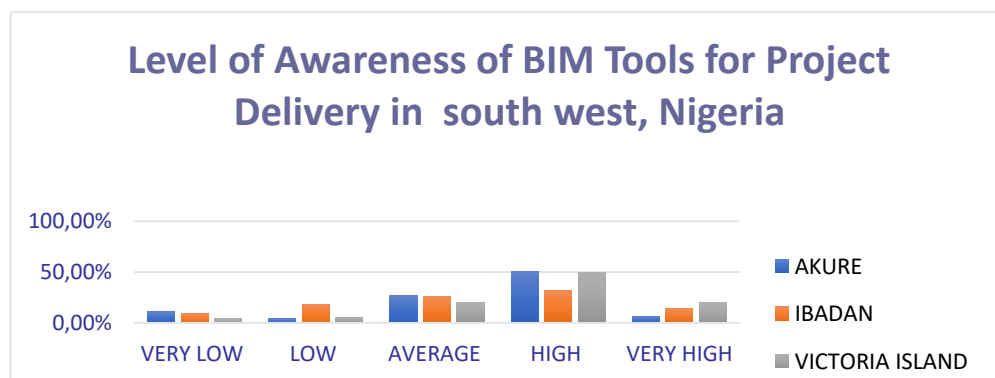


Figure 2: Level of awareness of BIM tools for project delivery in their firm

4.4 Levels of BIM tools maturity usage

Figure 3 shows that Akure has 82.22% of respondents on level 1 (2D and 3D), and 17.78% are on level 2 (4D and 5D). Ibadan show that 80% are on level 1 (2D and 3D), 18.29% are on level 2 (4D and 5D), 1.54% are on level 3 (6D and 7D). Also, Victoria Island indicates that 75.71% of respondents are on level 1 (2D and 3D), and 24.29% are on level 2 (3D and 4D).

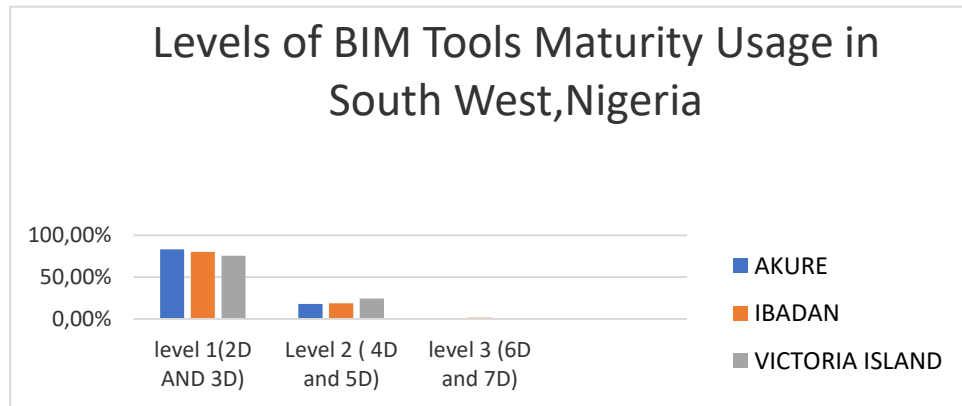


Figure: 3 Level of BIM Tools Maturity Usage on Victoria Island

4.5 Rate of usage of BIM tools for project delivery

Figure 4 presents the respondents' rating for using BIM Tools for project delivery. Akure indicates 48.89% of average rate and 26.67% of very high, 15.56% of high, and 8.89% of low rate. Ibadan indicates 67.69% of average, 13.85% very high, 10.77% high, and 7.69% low; Victoria Island indicates 62.80% average, 20% high, 12.86% very high, 4.29% low.

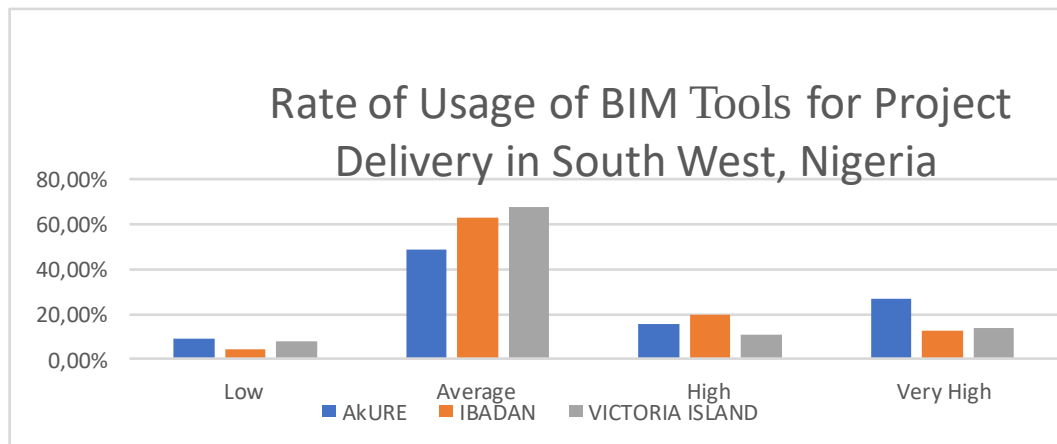


Figure 4: Rate of Usage of BIM Tools for project delivery in South West, Nigeria

5 Discussion

The results obtained from the data collected through the medium of the questionnaire and analysed shall be discussed concerning the objectives of this research work previously listed. The level of BIM Tools Awareness in AEC firms in southwest Nigeria. The respondents were first asked to rate themselves on a scale of 1-5 regarding their level of awareness of BIM Tools for project delivery in their firm; the three-state showed a high level of awareness for BIM Tool for project delivery, which is a very good bringing for the use of BIM Tools. Since awareness is the initial stage of usage and adoption of BIMTools as postulated by Rogers Everett (1995) and Ibem et al. (2018), The study implied that all three states examined are aware of BIMTool for project delivery in Southwest Nigeria. The paper shows an

improvement to the study of Akerele and Etiene (2016) and Onungwa et al. (2017) reported that construction firms are generally low and moderate on the awareness level of BIM Tools for project delivery.

On the usage level, the study discovered that AEC firms are in level 1 (2D and 3D) of the usage of BIM Tools for project delivery than level 2 (4D And 5D). This finding is in line with the study of Olugboyega & Aina (2016) and Ibem et al. (2018), which revealed that level 1 (2D and 3D) BIM models were very high among the AEC firms for project delivery in southwest Nigeria, which can be attributed to the 2D-architectural drawings such as plans sections and elevations and 3D visualisation of Architectural detailing scheduling and modelling. It indicates that there is much opportunity to improve the quality of project delivery in southwest Nigeria. Finally, the study indicates that the AEC firm's BIM Tools usage project delivery rate in southwest Nigeria is average. The frequency of usage to optimise and track the project's development in the industry is improving from paper time to more digitisation visualisation presentation.

6 Conclusion and Further Research

The study examined the evaluation of the usage level of BIM Tools for project delivery by AEC firms in Southwest Nigeria. The study employed a quantitative research approach to analyse the data retrieved from the AEC firms. The study concludes that AEC firms are fully aware of BIM for project delivery. It is on this basis to ensure the usage of BIM Tools for project delivery, for effective building planning, construction, and maintenance during the whole building life cycle. The objective of this study sought to investigate the level of BIM Tools usage in AEC firms in Southwest Nigeria. The study discovered that the AEC firm is current in average levels of BIMTool usage. That is, the performance level of BIM tools is average level. BIM has revolutionised the AEC firms, but unfortunately, the usage rate is average in design, analysis, construction, and management. Therefore, this research recommends that AEC firms encourage their employees toward BIM practices by organizing an in-house workshop and seminar to boost their understanding and familiarity with BIM Tools. This study contributes to the body of knowledge on the usage level of BIMTool and contributes to existing literature that enlightens the AEC firms for project delivery by AEC firms. This study is limited to three states in Southwest Nigeria: Lagos state, Oyo state, and Ondo state. Research can be further extended to other regions in Nigeria to determine the region's usage and awareness.

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