). A Systematic Literature Review of Building Information Modelling in the Nigerian Architecture, Engineering, and Construction (AEC) Industry – The Case of Nigeria.

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Abstract

Over the years, Building Information Modelling (BIM) has been transforming the Architecture, Engineering, and Construction (AEC) Industries across the globe. Many benefits have been reported by the early adopters of BIM from inception to decommissioning stage of the project cycle. Despite these benefits, many countries are still lagging in the adoption and implementation in their construction industry. The Nigerian construction industry which is bedevilled by myriads of challenges such as cost overrun, time overrun, project abandonment and disputes among others stand to gain a lot with BIM. However, there is slow BIM intake and there is a dearth of studies on BIM in the Nigerian construction Industry. The BIM research in Nigeria is in its nascent stages and there is a need to understand the current situation of BIM in Nigeria. Extant studies have embarked on various research to study the awareness, adoption, implementation, and challenges both from the industry perspective and academia perspective. Hitherto, there has been no systematic review of the adoption and implementation of BIM in the Nigerian construction industry. This research adopted an interpretivist epistemology approach with a light touch of metanalysis to conduct a systematic review of the BIM studies in Nigeria. A total of 46 papers were used for the analysis and the status of BIM adoption and implementation, challenges, benefits and drivers in the Nigeria AEC was presented. This study provides its readers with the status quo of BIM and set the scene for further studies on BIM in the Nigerian AEC industry.

Keywords: Building Information Modelling (BIM), future directions, Nigerian construction industry, status quo, systematic review.

1.0 BACKGROUND

The Architecture, Engineering and Construction (AEC) industry is a complex industry with low productivity when compared to other industries (e.g manufacturing industry). (Latham, 1994) asserted that this low productivity is due to the fragmentation of the industry and this was corroborated by (Egan, 1998). Consequently, there has been emerging paradigm and technologies (e.g lean construction, Building Information Modelling, Automation, Artificial Intelligence, etc) over the years aimed at combating the myriad challenges of the industry and thereby improving the output and achieving value for money.

The Building Information Modelling (BIM) is an interrelating policies, processes and technology (Succar, 2009). It is an IT-enabled process for the representation of building in digital format and interaction with it by the various stakeholders during the lifecycle of the project. Various benefits have been reported by the implementation of BIM at the project level, organisation level and industry level. Benefits such as improves design process, improves collaboration, time-saving, cost saving, improves efficiency and productivity have been documented in extant studies. These benefits and many more have prompted governments/institutions to embark on BIM crusades in their construction Industry (M. Abubakar et al., 2014).

The United Kingdom (UK) government mandated the use of BIM on all public procured projects with 2016 as the deadline in a bid towards reduction of the industry cost by 20%

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(Munir & Jeffrey, 2013); the move towards 33% reduction in cost, 50% reduction in time, 50% reduction in greenhouse emission, 50% reduction in trade gap has been set for the construction industry towards 2025. The mandate has dramatically impacted the UK construction industry BIM adoption. In the United States of America (USA), the US General Services Administration has pioneered the implementation of BIM on public projects leading to a proliferation of BIM adoption in the country. The Building and Construction Authority in Singapore implemented the BIM Roadmap in 2010 with the aim that 80% of the construction industry will be using BIM by 2015 towards the bid of increasing the industry productivity by 25% (Smith, 2014). South Korea also mandated the use of BIM on projects over S$50 million for all public projects. Similarly, countries such as Malaysia, Hong Kong, Canada, Australia and China have embarked on various strategies towards the proper implementation of Building Information Modelling in their construction industry. However, most developing countries with exception of China and Malaysia have been reported to be slow with adoption and implementation of BIM (Olawumi & Chan, 2019).

The Nigerian construction Industry is one of the contributors to the GDP of the country and produces a large portion of the nation's fixed capital formation. The industry is also bedevilled with myriads of problems such as cost overrun, time overrun, project abandonment, inefficiency, low productivity and other problems. Consequently, tagged as a 'sleeping giant' and there has been a continuous call for the need for improvement in the industry. Despite the benefits that have been reported and the potential BIM holds for AEC such as the Nigerian construction industry; not much has been reported and the implementation is slow. (S. A. Kori & Kiviniemi, 2015) have it that the BIM has a great potential in the Nigeria construction industry and this was corroborated by (Hamma-adama & Kouider, 2018b).

The BIM research in Nigeria is in its nascent stages and there is a need to understand the current situation of BIM in Nigeria. Extant studies have embarked on various research to study the awareness, adoption, implementation, and challenges both from the industry perspective and academia perspective. Hitherto, there has been no systematic review of the adoption and implementation of BIM in the Nigerian construction industry. Thus, this paper is a comprehensive systematic review of the BIM studies in Nigeria with a view of presenting the status (awareness, adoption and implementation), challenges, benefits, and barriers of BIM. Also, the future direction of the BIM study is presented, and strategies were suggested for the proliferation of BIM in the Nigerian Construction Industry.

This paper is divided into four parts. The first part presents the background of the study, the second part discusses the research methodology adopted and the data collected, the third part presents the main discussion from the papers, and the last part discusses the inferences from the review and recommendations.

2.0 RESEARCH METHODOLOGY

This research adopted an interpretivist epistemology approach with a light touch of metanalysis to conduct a comprehensive systematic review of the BIM studies in Nigeria. Search engines such as Google scholar, Scopus, Web of Science (WOS), and Google were searched for BIM studies in Nigeria. Citation tracking was also adopted to ensure that a large percentage of the studies under consideration were considered. The search yielded 46 papers at the point of 'critical saturation' (i.e the point at which no new papers were found using the search engines and citation tracking) as shown in Table 1 in reverse chronological order.

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Table 1: List of Published BIM Papers in Nigeria

ID	Source	Approach	Respondents	Focus
01	Kori et al. (2019)	Survey	Architecture firms	Adoption
02	Hamma-adama and Kouider (2018b)	Literature Review	-	Awareness
03	Olabode and Umeh (2018)	Survey	AEC firms	Adoption
04	Babatunde et al. (2018)	Survey	Academia	Awareness
05	J. J. Maina (2018)	Survey	Academia	Awareness
06	Ganiyu et al. (2018)	Survey	AEC firms	Awareness
07	Ibem et al. (2018)	Survey	Architecture firms	Awareness
08	Mansur Hamma-adama et al. (2018)	Survey	Academia	Awareness
09	Ganiyu (2018)	Survey	AEC firms	Adoption
10	Ruya et al. (2018)	Survey	AEC Professionals	Adoption
11	Kori and Makarfi (2018)	Survey	Architecture firms	Adoption
12	Maina (2018)	Survey	Academia	Awareness
13	Mansur Hamma-adama et al. (2018)	Qualitative	AEC Professionals	Awareness
14	Hamma-adama and Kouider (2018a)	Survey	Academia	Awareness
15	Olapade and Ekemode (2018)	Survey	FM firms	Awareness
16	Oyewole and Dada (2018)	Survey	AEC Professionals	Adoption
17	Olugboyega and Aina (2018)	Survey	AEC Clients	Adoption
18	Amade et al. (2018)	Survey	AEC Professionals	Awareness
19	Anifowose et al. (2018)	Survey	AEC Professionals	Awareness
20	Ebiloma et al. (2017)	Survey	AEC Professionals	Adoption
21	A. Y. Ganiyu et al. (2017)	Survey	AEC Professionals	Adoption
22	Onungwa et al. (2017)	Survey	AEC firms	Adoption
23	S. Ganiyu et al. (2017)	Survey	AEC Professionals	Adoption
24	Joseph et al. (2017)	Survey	Academia	Awareness
25	Ede et al. (2017)	Case Study	A complex staircase	Implementation
26	Y. S. Abubakar et al. (2017)	Survey	AEC firms	Adoption
27	Olaleye et al. (2017)	Survey	AEC Professionals	Adoption
28	Ogunde et al. (2017)	Survey	AEC Professionals	Awareness
29	Olugboyega (2016)	Case Study	Eko Atlantic City	Implementation
30	Ezeokoli et al. (2016)	Survey	AEC Professionals	Awareness
31	Ikediashi and Joseph (2016)	Survey	FM Professionals	Adoption
32	Akerele and Etiene (2016)	Survey	AEC Professionals	Awareness
33	Olugboyega and Aina (2016)	Survey	AEC Professionals	Adoption
34	Odeyale et al. (2016)	Survey	Architecture firms	Adoption
35	Usman et al. (2016)	Survey	AEC Professionals	Adoption
36	Wang et al. (2015)	Survey	MEP Consultants	Awareness
37	Dim et al. (2015)	Literature Review		Adoption
38	Ugochukwu et al. (2015)	Survey	Professional	Adoption
39	S. A. Kori and Kiviniemi (2015)	Survey	Architecture firms	Adoption
40	M Abubakar et al. (2014)	Survey	Contracting firms	Adoption
41	Dare-Abel et al. (2014)	Survey	Architecture firms	Awareness
42	Ede (2014)	Case Study	A Duplex Building	Implementation
43	M. Abubakar et al. (2013)	Survey	AEC firms	Awareness
44	Munir and Jeffrey (2013)	Literature Review		Adoption
45	Ibrahim and Bishir (2012)	Literature Review		Adoption
46	Alufohai (2012)	Literature review		Adoption

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3.0 MAIN DISCUSSION

The first paper on BIM in Nigeria was published in 2012 as seen in Table 1. Over the years there has been an increase in BIM publications in Nigeria. 40% of the papers were published in 2018 and this may be related to the increase in the level of awareness of the professionals and stakeholders in the Nigerian Construction Industry. A large percentage of the papers also focused on awareness and adoption, with only four of the papers discussing BIM implementation. This is related to the fact that there have been only two reported BIM projects in Nigeria, Eko Atlantic City in Lagos State (Olugboyega, 2016) and a Duplex in Enugu State (Ede, 2014). There is a need to focus more on adoption and implementation of BIM in the construction Industry as there has been an increase in the level of awareness.

3.1 Status of BIM in the Nigerian Construction Industry

Extant studies have assessed the level of awareness, adoption and implementation of BIM in the industry at the organisation/firm level and professional/individual level. Table 2 shows the status of BIM from the reviewed papers in reverse chronological order. There has been an increase in the level of awareness over the years and the architects/architecture firms have a high level of awareness. This can be related to the fact that they are conversant with CAD tools before the advent of BIM. Similarly, the facility management professionals have the least level of usage/implementation of BIM. Most of the BIM studies are conducted in Lagos because of its status as the 'economic capital' of the country. Thus, there are many ongoing construction projects, and many AEC firms have their head offices or branch offices in Lagos.

Table 2: Status of BIM

Area	Result	Respondent	Source
Kaduna	76.4% level of awareness	144 (Professionals)	Ruya et al. (2018)
Lagos	97% level of awareness	110 (Architectural firms)	Ibem et al. (2018)
Lagos	28.8% aware and demand	45 (clients)	Olugboyega and Aina (2018)
Kwara	40% level of awareness	90 (Professionals)	Anifowose et al. (2018)
Lagos	6.45 % level of usage	31 (FM firms)	Olapade and Ekemode (2018)
Lagos	58.1% level of awareness	74 (Professionals)	Olabode and Umeh (2018)
Lagos, Abuja, Ibadan, Edo	89.39% awareness	132 (Professionals)	Ogunde et al. (2017)
Lagos	25.3% level of high usage	282 (Professional)	Olugboyega and Aina (2016)
Anambra and Enugu	33% level of awareness	135 (Professionals)	Ugochukwu et al. (2015)
Lagos,	73.4% level of awareness	118 (Architecture firms)	Dare-Abel et al. (2014)

3.2 Challenges of BIM

The challenges limiting the adoption and implementation of BIM in Nigeria is as shown in Table 3. The major challenges of BIM are the lack of skilled and trained personnel to help with implementation in organisations. The cost of training and software is also high, and most firms

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may not be able to afford it. This problem is complicated with the lack of BIM benefits evaluation, as there are no studies in the Nigeria AEC to empirically show the benefits of BIM. Most firms are also resisting the adoption of innovations such as BIM which they consider having high risk and high investment. No clear mandate on BIM by the government and lack of clients' demand make the firms' top management to be reluctant with the adoption and implementation. Similarly, there is a lack of standards and guidelines for implementation and adoption for the Nigerian Context.

Table 3: Barriers to BIM adoption and Implementation in Nigeria

Barriers	Source ID (See table 1)
Lack of skilled/trained personnel	43,40,36,34,32,28,23,22,17,05,13,16,14
Lack of awareness/ technical knowledge	40,43,36,38,34,26,32,22,23,21,19,13,02,03,17,10
Cost of software	43,38,36,35,32,22,26,21,23,28,03,17,19,10,02,05
Lack of client demand	40,26,32,19,10,13,03,17,38,36
Cost/Effort of training	40,26,32,30,21,12,03,17,22,38,35,36
Lack of Infrastructure (ICT, Power)/BIM Tech	43,40,10,21,13,05,03,22,38
Lack of top management support	26,10,03,17
Interoperability	19,37,30,23,05,28,03,10
Lack of supply chain understanding	40,26,19,37,10,08,34,10,17,22,03,36
Contractual arrangement	26,19,03,17,38
Risk	26,40,19,21,03,17,10
No ROI/Lack of BIM benefits	26,40,21,03,17,10
Resistance to change/Existing is okay	26,40,32,10,21,39,03,17,03,22,36
Lack of standards and guidelines	40,26,32,19,30,10,21,13,27,17,22,36
No government mandate	40,26,32,19,10,21,13,05,17,35,36

3.3 Benefits of BIM adoption and Implementation

Benefits of BIM have been reported widely in the literature. Similarly, these have been reported in the extant literature in Nigeria. However, the reported benefits in the Nigerian context are perceived benefits and most of the benefits are not empirically proven as shown in table 4. There are two BIM project that have been reported in the Nigerian Context. The Eko Atlantic City adopted the BIM for design visualization mostly as reported by Olugboyega (2016). Similarly, the Duplex construction reported by Ede (2014) discussed BIM implementation on the project, however, no quantitative empirical evidence of the benefits were presented in the study.

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Table 4: Benefits of BIM adoption and Implementation in Nigeria

Benefits	Source ID (See table 1)
Facilities management	32,19,07,31,27,15,17,38
Health and Safety	25,31,28,17,36
Energy management	07,31,36
Time saving	46,04,25,12,28,38,17
Better coordination	46,19,25,07,28
Cost savings	46,25,07,12,15,17
Increase productivity	46,04,25,07,12,28,17,36
Design visualization	32,46,19,04,42,25,07,27,34,29,17,38
Clash detection	46,18,36,38
Auto quantity takeoff	46,18,04,07,36,38
Cost estimating	32,46,18,19,04,27,17
Improves stakeholder collaboration/understanding	46,42,07,12,28,29,17,36
Reduce error	42,25,07,12,34,29,17,36
Prefab	32,19,17
Improves design	18,25,07,12,34,

3.4 Drivers of BIM adoption and Implementation

The drivers of BIM are as shown in Table 5. These are some of the drivers that can help with the proliferation of BIM in the Nigeria AEC industry. The government mandate has been reported to have a positive effect on BIM in developed countries such as the UK, USA, Malaysia, Singapore and others. This mandate will make the firms to adopt BIM to be able to implement it on the government projects.

The availability of trained personnel and training is also a key driver of BIM in the industry, as these would increase the level of awareness. Also, institutions should include BIM knowledge and skills in their curriculum to produce BIM compliant graduates.

Table 5: Drivers of BIM adoption and Implementation in Nigeria

Drivers	Source ID (See table 1)
Competition	04,03
Improve design capability	34,03
Top management support	30,09,03,33,22
Clients demand	43,40,19,03,09,04,33,10

Availability of trained professionals/BIM training	43,40,32,03,37,20,30,09,33,22,16,10
Institutional bodies (government institutions and professional bodies)/Educational bodies	43,40,32,03,20,30,04,33
BIM requirement by project members/Stakeholder involvement	40,32,37,09,33,10
BIM awareness and benefits	40,32,19,03,37,20,09,33,10
BIM standards, Implementation guides and strategies	32,03,09,33,10
Change of perception	40,20,09,33,22
Contractual arrangement	43,40,20,33,10
Government mandate	43,30,32,03,37,20,30,10

4.0 CONCLUSION AND RECOMMENDATION

There has been an increase in studies on BIM in Nigeria since the inception of the discussion in 2012. A total of 2 papers in 2012, 2 papers in 2013, 3 papers in 2014, 4 papers in 2015, 7 papers in 2016, 9 papers in 2017 and 18 papers in 2018. The year 2018 accounts for 40% of the total papers published on BIM in Nigeria. This is related to the increase in the level of awareness among the stakeholders in the Nigerian AEC. Consequently, most of the papers were focused on awareness, and adoption with a few papers discussing implementation. There is a need to start a new discussion on BIM implementation in the industry now and there is a need to publicize BIM projects in Nigeria; as there are only two reported BIM projects so far.

Extant studies have focused on BIM from the perspective of academia and industry perspective. The academia perspective is from those of the students and lecturers, whilst the industry perspective is from professionals and firms. The clients who are a major stakeholder in the industry are often missing and evidently, there is a lack of demand for BIM by the clients. There is thus a need for sensitization of the clients as regards the benefits of implementing BIM on their projects.

The industry perspective of BIM in previous studies are often from professionals with no specific focus on a profession. This is also applicable to the organisation level of BIM studies with exception of specific studies on the architecture firms and facility management firms. It is necessary to conduct profession specific studies so as to know the present status of BIM in each of the profession. Also, the perceived challenges and benefits of BIM differ across professions and firms as against the generalized perspective in the extant studies. The architects/architecture firms have a high level of awareness and have recorded a high level of usage compared to other professions. This is due to their familiarity with the CAD tools before the advent of BIM. The Quantity surveyors are used to the traditional approach of preparing a bill of quantities from the 2D drawings provided by the architects/structural engineer/MEP consultants, thus, they often resist adoption of BIM in their organisations. They also have the fear that the BIM will usurp the responsibilities of the quantity surveyors. The facility management, on the other hand, is a new fast-growing profession in Nigeria and there are only two papers on BIM in FM in Nigeria and the studies concluded that the level of awareness is still low among the professionals and consequently there is a low level of implementation.

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Challenges such as lack of skilled professionals, the high cost of software and training, resistance to change, lack of clients' demand, lack of BIM benefits evaluation, lack of BIM tools, lack of standard guidelines and strategies are impeding the proliferation of BIM. There is a need for more empirical studies on BIM benefits and cost to ease the adoption and implementation. Does the benefit outweigh the cost? In the short run or long run? There is also a need for more studies focusing on the implementation and adoption strategies at the organisation level and project level. The issue of lack of trained professionals should be nib at the bud by including BIM skills and knowledge in the curriculum of built environment students to produce BIM compliant graduates for the industry. The risk and legal issue of BIM in the Nigerian context have not been addressed and the contractual arrangements such as the integrated project delivery have not been a theme.

Drivers such as the government mandate, institutional bodies support, BIM benefits awareness are needed to drive the adoption and implementation of BIM. There is a need for a clear government policy on BIM as seen in some developed countries and there is a need for further support from the institutional bodies such as government institutions, professional bodies and educational institutions.

This paper has presented a systematic review of the status quo of BIM in the Nigerian context which is of benefits to both practitioners and researchers. Also, it has set the scene for future studies in this area for the proliferation of BIM.

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