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Inhibitors to the Adoption of Building Information Modelling in Modular Construction: A Case Study of the Nigerian Construction Industry

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Abstract: Building information modelling (BIM) adoption transforms how construction projects are delivered. Modular construction (MC) is a modern construction method that drives continuous improvement and value addition globally. BIM and MC offer enormous benefits in enhancing project delivery and attaining sustainable construction. This is a major driving force causing the drift from traditional methods to a more digitised approach anchored on technology. Despite these benefits, the level of sophistication in project delivery and the application of these innovative methodologies are low and housing construction projects are delivered with poor performance outcomes in developing countries like Nigeria. This study assessed the inhibitors to the use of BIM in driving MC and the measures for improving the adoption of BIM in MC project deliveries in Nigeria. A well-structured quantitative questionnaire was administered to construction experts using Snowball sampling techniques via electronic means to collect data. With a response rate of 70% and a reliability index of above 0.80, the collected data were analysed using frequencies, percentages and mean item scores. It was found that the level of BIM and MC was high, but BIM adoption in MC was low. The inhibitors to this low adoption level are the high cost of investment in hardware and software, the comfort with the existing methods and resistance to change, the lack of management support, the complexity of BIM software, the lack of interest in sharing information among stakeholders, the problems with collaboration and the legal issues with multiple designs and fabrication. It is recommended that collaboration between construction and technology firms be encouraged to improve BIM application in MC for better productivity and project outcomes. The government should support the use of modern methodologies in the delivery of projects to help improve infrastructure provision, value addition and citizens' well-being.

Keywords: BIM, Modular construction, Project delivery, Nigeria, Modern construction methods

INTRODUCTION

Globally, the construction industry is recognised as an influential sector that stimulates growth and development in nations because the construction sector drives infrastructure provision and job creation (Onyeagam, Eze and Adegboyega, 2019). Regardless of the vital role the construction sector plays in the economic development of nations, it is known for low-cost and time-consuming performances as well as poor productivity and quality issues, among others (Sekou,

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2012). This situation is worsened by the fragmented and conservative nature and the sluggishness towards the adoption of novel and innovative production methodologies, technologies and approaches (Ruparathna and Hewage, 2015). Two major changes in production methodologies are the advent of building information modelling (BIM) and modular construction (MC) (Wuni and Shen, 2019; Wu et al., 2021; Abanda, Tah and Cheung, 2017).

MC is one of the modern construction methods that drive continuous improvement and value addition globally. It is a method that involves the production or fabrication of structural modules or units off-site, then transported and assembled where they are needed on a construction site (Bipat, 2019). This results in MC to be supporting and driving a sustainable built environment. MC also has advantages over traditional, conventional approaches, including improvement in the quality of product, better schedule performance, better health and safety performance, reduced number of on-site workers and reduced noise and air pollution and other environmental impacts. Therefore, MC is recognised as a "cleaner" approach because of its capability to minimise waste, dust, noise, labour requirements and resource depletion while improving safety performance (Lu et al., 2018; Jaillon et al., 2009). Lawson and Ogden (n.d.) posit that MC has gained a strong market in residential, health and educational buildings where the importance of construction delivery speed is paramount.

BIM is one of the shifts in construction that is technology-based, enabling innovations that support virtual designing, construction and management of construction projects (Hardin, 2009; Eastman et al., 2011; Saka and Chan, 2019a). Activities such as planning, drawing development, analysis of designs, construction scheduling and scheduling of fabrication, among others, are facilitated by BIM practices (Singh, Sawhney and Borrmann, 2015). BIM adoption is transforming the way construction projects are delivered by facilitating virtual models and modules in construction. According to Tan et al. (2019), BIM plays a critical role in facilitating the fabrication and modularisation of construction components and structures. In the same vein, Lu and Korman (2010) submit that BIM practice increases the potential of using modular coordination and prefabricated modules. As a result, BIM tools have improved the production of model-driven fabricated building components and thus enhanced the dependability on prefabrication methods (Singh, Sawhney and Borrmann, 2015; SmartMarket Report, 2011). Despite the role it plays in overcoming the ills of building production and sustainability and that studies of BIM in MC are growing in Europe, the United States, the United Kingdom and other advanced countries, related literature in this area is almost non-existent in Nigeria. Even though BIM-driven modularisation and fabrication have increased in developed nations, the same cannot be said of developing countries such as Africa (Leśniak, Górka and Skrzypczak, 2021). Nigeria is one of the countries in Africa with a slow uptake of innovative construction technologies (Akinradewo et al., 2021; Sholanke et al., 2019). This is attributed to awareness issues, a lack of local experts and the problem of poor financing (Aigbavboa et al., 2019; Oke et al., 2018). In addition, the slow BIM in MC has contributed to the housing and other construction projects being delivered behind schedule, over cost, poor quality and other associated problems. It is based on the foregoing that this study assessed the inhibitors to the use of BIM in driving MC project delivery in Nigeria. It also explored the measures for improving the adoption of BIM in MC.

The outcome of this study helps construction companies in Nigeria to develop implementable policies that will entrench the adoption of modern and innovative methodologies in the production of structural components and buildings. This can only be attained where there is a comprehensive understanding of the key inhibitors to BIM adoption in MC. This study also supports sustainable infrastructure production, as BIM and MC drive and impact the economic, social and environmental dimensions of sustainability. The study will also add to the limited number of studies on MC driven by BIM in developing nations such as Africa.

LITERATURE REVIEW

Level of BIM Adoption in Construction

In the global construction industry, BIM is an innovative technology that has transformed the way construction projects are delivered, but its adoption is still below the expectations of stakeholders. This has been confirmed by Ayinla and Adamu (2018), who posit that the rate of adoption and implementation among construction businesses is still slow and below what was envisaged.

In developed nations, governments have made an appreciable effort to make BIM an integral part of every construction operation and project, even reports have shown that more still needs to be done (Okereke, Muhammed and Eze, 2021). For instance, BIM adoption is high in Singapore, even though with some hitches. For instance, it was projected that over 80% of construction organisations in Singapore would use BIM by 2015 (Building and Construction Authority, 2011; Zahrizan et al., 2013). This is because, in Singapore, BIM adoption and implementation are made mandatory by the government for projects and construction firms (Liao et al., 2019; Liao and Teo, 2017; Liao et al., 2020). Similarly, in the UK, it was reported that BIM implementation improved from 13% in 2011 to 74% in 2018 (NBS, 2018). The same improvement in implementation is also reported in South Korea, Brazil, Japan, Denmark, Canada, Australia and the US, among others (Saka, Chan and Siu, 2020). BIM usage in 2013 in South Korea was 24% and grew to 73% in 2015 (SmartMarket Report, 2015). In 2015 in the US, BIM usage was reported to be 79% (Fitriani et al., 2019). In short, government support and policies are behind the progress made in BIM implementation in these advanced nations.

However, in developing nations, for example, the Middle East and Africa, the level of adoption of BIM in general construction activities are low (Yang and Chou, 2018; Gerges et al., 2017; Othman et al., 2020; Al-Ashmori et al., 2020; Telaga, 2018; Okereke, Muhammed and Eze, 2021). The absence of government support, weak government, lack of guidelines and strategies for implementation and high cost are advanced as the reasons for the low and slower rate of BIM adoption and implementation in developing countries (Jayasena and Weddikkara, 2013; Lam et al., 2017; Saka and Chan, 2019b).

Level of BIM Adoption in MC

Despite the low BIM implementation in Malaysia and other developing countries, attributed to a lack of national policies on BIM, issues related to software integration and the reluctance to share skills and knowledge among experts (Zahrizan et al., 2013; Farooq et al., 2020; Okereke, Muhammed and Eze, 2021), the advent of modern technologies and the urgency for the construction industry to upgrade its production system solve the myriad of problems associated with its performance have provided a suitable opportunity for BIM implementation in MC and other prefabricated construction (Tan et al., 2019).

Globally, BIM implementation in the architectural, engineering and construction industries grew from 26% in 2007 to 57% in 2016 (Bhatti et al., 2018). This achievement has been because of policies that made BIM usage compulsory in some developed nations. In China, BIM implementation in prefabricated construction is still in its infancy (Tan et al., 2019). This is despite the technological advancement it has achieved in recent years. In South Korea, BIM has been used for over ten years in public and private projects. MC has also been implemented in the country since the year 2000 in projects such as schools, housing and barracks. Research has shown the application of these technologies in middle- to high-rise buildings (Lee et al., 2020). While there has been a continuous shift from 2D CAD to BIM in Hong Kong, Chan (2014) reports that BIM implementation is limited among designers, attributed to clients' lack of interest in the use of BIM. In the Australian construction industry, Schesinger (2014) reports that about 3% of construction projects are undertaken using prefabricated methods.

Furthermore, in multi-trade MC projects, the use of prefabrication is anticipated to increase by over 10% and this can be achieved via BIM technology implementation. BIM in MC is however challenged by certain factors which vary from country to country. As the factors are inhibiting the wide adoption of BIM in MC, major inhibitors to the use of BIM in MC should be reviewed.

Inhibitors to BIM Adoption in MC

A major hindrance to BIM implementation in modular and other prefabricated construction in China are cost-related issues, the absence of BIM research and the lack of standards and domestic-oriented tools (Tan et al., 2019). These factors have kept BIM in prefabricated construction at a low level.

BIM implementation comes with unavoidable changes in the way projects are delivered and it also impacts the organisational structure. Over-reliance on conventional paper-based methods and lack of inclination to adopt new technologies are critical resistance to changing attitudes of stakeholders in the construction industry (Tan et al., 2019; Eastman et al., 2011; Arayici et al., 2011; Panuwatwanich and Peansupap, 2013). Also, the ambiguous nature of the economic benefits of BIM implementation (Papadonikolaki and Aibinu, 2017; Zhang et al., 2018), the negative attitudes towards data sharing and the misunderstanding of BIM by stakeholders (Zhang et al., 2018), the absence of professional interactivity (Jin et al., 2017) and the absence of insurance applicable to BIM implementation (Eadie et al., 2014) are barriers have hindered the adoption of BIM in construction. Piroozfar et al. (2019) and Sarhan and Fox (2013) discover that the absence of management commitment, awareness and knowledge issues, collaboration problems, cultural and human issues and issues related to interoperability are the barriers to the implementation of BIM in construction in the UK. In Germany, VonBoth (2012) and Johansen and Walter (2007) report that the major barriers to BIM implementation are BIM software complexity, functional limitations of model-based BIM software, issues related to technology, management and organisational issues and resource availability to invest in BIM. In addition, Peng and Pheng (2011) and Shen, Edirisinghe and Yang (2016) find that lack of training as a result of top management unwillingness, organisational restructuring, unwillingness to adopt new methods, systems and innovative technologies, technical competence and investment-related concerns, among others are the barriers to BIM implementations in Singapore.

Moreover, the major barriers to prefabricated construction in the Australian construction sector are the changes in business practices to back BIM adoption, the replacement of CAD technologies with BIM, the cost of investing in hardware, software and training, the legal issues with fabrication and multiple designs and the lack interest among stakeholders to collaborate and share information (Mostafa et al., 2020). On the other hand, the major barriers to BIM adoption in the construction industry in Hong Kong, according to Chan (2014), are the non-availability of qualified in-house staff, the problems with training and education, the absence of standards and demand from clients and the government lack of lead and/or support. In a similar but different study by Chan, Olawumi and Ho (2019), resistance to change, organisational structure not supporting BIM and inadequate interoperability of computer software are the top three barriers to BIM adoption in construction.

In Poland, Leśniak, Górka and Skrzypczak (2021) discovered that people are the weakest link to BIM adoption and the emphasis is placed on their limited knowledge and reluctance to change. Wu et al. (2021) identify the major project stakeholders and financial-related barriers to include a lack of support from senior management, a low level of cooperation between project participants, a lack of experience in using BIM, unclear responsibilities for BIM, a lack of collaborative working processes, the reluctance to share information publicly, the lack of demand for BIM, the high cost of BIM software, a high risk of ROI and a lack of benefits brought by BIM. In the South African construction industry, it is reported that the biggest inhibitors to BIM adaptation and implementation are the absence of skills and the lack of education and knowledge (Kekana, Aigbavboa and Thwala, 2015; Kekana, Aigbavboa and Thwala, 2014). Olanrewaju et al. (2020) reported that lack of knowledge, inadequate government policies and high cost of implementation are the major barriers to BIM application.

Measures for Improving BIM Adoption in MC

Chan (2014) emphasises the need for governments to collaborate with built environment stakeholders, such as higher learning educational institutions and professional bodies, to establish proper standards and policies that will entrench the use of BIM in construction. Therefore, programmes can be tailored towards the development of local experts and students using a proactive approach that involves training and education in all courses related to BIM technology being advocated as a suitable measure for improving the level of BIM usage (Leśniak, Górka and Skrzypczak, 2021). Besides that governments should show high-level commitment to the development of training and educational programmes to improve the implementation of BIM and other innovative methodologies, Sriyolja, Harwin and Yahya (2021) recommend that governments make regulations that will guide consultants, contractors and other stakeholders to lead BIM adoption. Kekana, Aigbavboa and Thwala (2015) have identified 15 ways of improving BIM adaptability and implementation. They reveal that BIM adoption and implementation in construction can be improved primarily through education in BIM-related skill development and increasing the availability of BIM tools and technologies. MC and other innovative technologies can be improved in the construction industry, as submitted by Wuni and Shen (2019), including the development of loan schemes for financing innovative methodologies, public-private partnerships and improvement in collaboration among project stakeholders.

In Singapore, the use of innovative technologies and management initiatives such as BIM has been normalised as a result of strong government policies and backing (Liao et al., 2020). While further wider adoption is still designed amongst the key players in the Singaporean construction industry, the level of implementation achieved so far can be improved through a sound BIM vision and leadership from the management of construction businesses, increasing the appetite of owners to lead in the adoption of BIM, better design coordination among various discipline through cash detection and resolution, BIM certification course to gain new skillset and better ways of working with BIM projects and strengthening of the government system of BIM-related policies, standards and guides from the government. In Liao's earlier studies (i.e., Liao and Teo, 2017; Liao et al., 2019), similar suggestions on how to overcome hindrances to BIM implementation are also made. Liao et al. (2021) confirm that BIM use is mandatory by the Government of Singapore. However, this cannot eliminate the prevalence of non-value-adding practices. The study of Liao et al. (2021) aids the diffusion of BIM and reduction in non-value-adding BIM implementation activities to improve the production of the construction sector.

RESEARCH METHODOLOGY

A set of questionnaires is utilised because questionnaires are simple, easy to use and can cover wide audiences at an economical cost (Tan and Yeoh, 2011; Eze et al., 2021). The questionnaire in the current study was developed after adopting a detailed literature review to meet the aim of this study. Data were collected from construction professionals who had at least five years of work experience and knowledge of BIM and MC, as well as were actively involved in construction projects in the five states in the southeast geopolitical zone of Nigeria.

A 150-item questionnaire employing a five-point Likert scale was developed. They were distributed electronically via email, WhatsApp and LinkedIn using Snowball sampling techniques. The Snowball technique, which depends on referral, can significantly increase the sample size (Heckathorn, 2011; Atkinson and Flint, 2001). Also, electronic means help to reduce paper questionnaires and an eco-friendly means of survey (Nwaki and Eze, 2020).

After a sample survey period of 13 weeks, a total of 105 usable responses were received and this represents an effective response rate of 70%, which is well above the acceptable rate of 20% to 30% for an online-based survey (Pallant, 2011). The data were analysed using frequencies, percentages and mean item scores (MIS). Frequency and percentage were used to analyse the participant's background information. In contrast, MIS was used to analyse the data on inhibitors to BIM in MC and the measures for improving the usage of BIM in MC. The reliability evaluation using Cronbach's alpha showed high reliability of the research instrument and data internal consistency. This is evident in the alpha values of 0.903 and 0.838, obtained for data on inhibitors to use BIM in MC and measures for improving the adoption of BIM in MC, respectively. The summary of the methodological flow is shown in Figure 1.

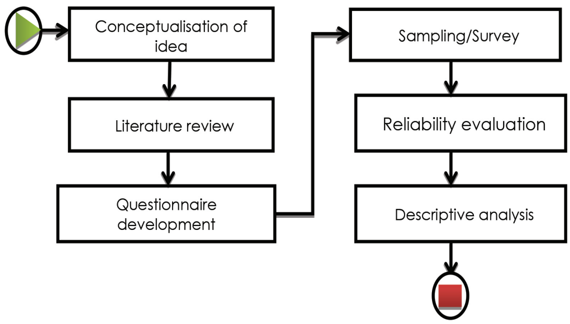

Figure 1. Research methodological flow chart

FINDINGS AND DISCUSSIONS

Respondents' Background Information

The analysis of the participant background information showed that 14.29% were from Abia state, 18.10% were from Anambra state, 16.19% were from Ebonyi state, 20.95% were from Enugu state and 30.48% were from Imo state. It was further revealed that 36.19% of the participants worked with public organisations and 63.81% worked with private organisations. In terms of their professional composition, 28.5% were architects, 8.57% were builders, 36.19% were engineers in civil or structural services and 26.67% were quantity surveyors.

Regarding their years of work experience, 27.62% of the participants had 5 years to 10 years of experience, 37.14% had 11 years to 15 years of experience, followed by 20.0% with 16 years to 20 years of experience and 15.24% had over 21 years of experience in the industry. The highest academic qualification of the participants was Bachelor of Science (BSc)/Bachelor of Technology (BTech) (52.38%), followed by Master of Science (MSc)/Master of Technology (MTech) (20.0%), postgraduate diploma (PGD) (9.52%), higher national diploma (HND) (16.19%) and lastly, doctorate (PhD) (1.90%). Finally, 80% of the participants were chartered members of their various professional bodies, while 20% were probationer members.

Level of Awareness and Adoption of BIM and MC

The participants were asked to rate the level of awareness and adoption of BIM in MC in the delivery of construction projects in Nigeria. The results in Figure 2 show the level of awareness of BIM and MC. Based on Figure 2, 59% of the participants had a very high awareness level, 30% had a high awareness level, 8% had a moderate awareness level and 3% and 1% had low and very low awareness levels, respectively. It is concluded that the awareness level of BIM and MC is high. Figure 3 shows the level of adoption of BIM in MC. It is concluded that the adoption of BIM in MC is low, which is premised on the distribution of the responses, as 56% of the participants indicated a low adoption of BIM in MC. The results obtained in the current study support the findings of previous studies (e.g., Sholanke et al., 2019; Akinradewo et al., 2021).

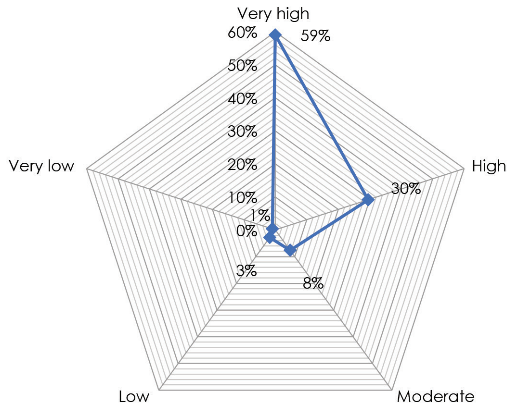

Figure 2. Level of awareness of BIM and MC

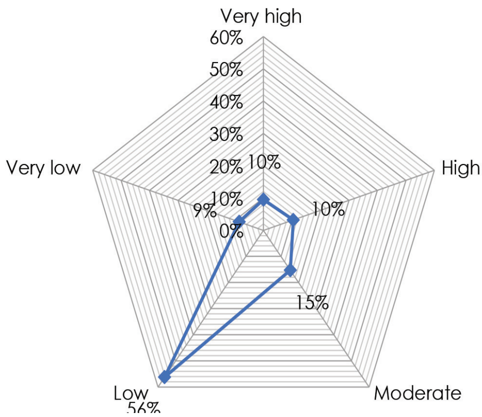

Figure 3. Level of adoption of BIM in MC

Inhibitors to Use of BIM in MC

Table 1 shows the results of the analysis of the data collected on the major inhibitors to the use of BIM in MC. The top 10 major inhibitors to BIM adoption in MC were the "High cost of investment in hardware and software" (MIS = 4.52; standard deviation, SD = 0.9104), "Comfortable with the existing method and resistance to change" (MIS = 4.50; SD = 0.8893), "The lack of management support" (MIS = 4.46; SD = 0.7848), "BIM software complexity" (MIS = 4.43; SD = 0.8419), "Stakeholders lack the interest to share information" (MIS = 4.43; SD = 1.0271), "Collaboration problems" (MIS = 4.41; SD = 1.1240), "Legal issues with multiple designs and fabrication" (MIS = 4.4; SD = 1.0706), "Problems of training and education" (MIS = 4.34; SD = 0.9591), "Unwillingness to adopt new methods, systems and innovative technologies" (MIS = 4.32; SD = 1.3045) and "High-cost BIM and MC training" (MIS = 4.30; SD = 0.9896).

In addition, there were at least five inhibitors to BIM in MC, namely the "Absence of BIM research" (MIS = 4.15; SD = 1.1332), "The absence of insurance applicable to BIM implementation" (MIS = 4.04; SD = 1.3077), "The non-availability of qualified in-house staff" (MIS = 3.98; SD = 1.0918), "Issues related to technical competence" (MIS = 3.97; SD = 1.2126) and "The lack of demand from clients" (MIS = 3.90; SD = 1.3440).

Overall, the average MIS was 4.26 out of 5 (85.20%) and the maximum and minimum MIS for the variables were 4.52 out of 5 (90.48%) and 3.90 out of 5 (77.90%), respectively. Furthermore, notwithstanding the relative ranking of the assessed inhibitors, they had an impact on the level of adoption of BIM in MC in Nigeria and other countries with similar construction markets. The result obtained in this section supports the findings of previous studies (i.e., Leśniak, Górka and Skrzypczak, 2021; Wu et al., 2021; Mostafa et al., 2020; Chan, Olawumi and Ho, 2019; Piroozfar et al., 2019; Peng and Pheng, 2011; Tan et al., 2019; Eastman et al., 2011; Arayici et al., 2011; Panuwatwanich and Peansupap, 2013). A critical inhibitor to the adoption and implementation of BIM in construction, particularly in MC, is the high cost involved in securing both the hardware and software needed to set up BIM. Olanrewaju et al. (2020) and Wu et al. (2021) report that the high cost of implementation of BIM, especially investment in critical hardware and software, is the major factor that inhibits the adoption and implementation of this innovative technology in MC.

Another major barrier to the adoption of BIM was the lack of support from top management, who had the responsibility of resources and powers to make decisions that affect the implementation of novel ideas and methodologies. This was reported in the study by Wu et al. (2021) that one of the major barriers to stakeholder-related inhibitors to BIM adoption is the lack of support from senior management. The absence of commitment and unwillingness by the management of construction businesses is among the barriers to BIM adoption in MC in studies from the UK and Singapore (Piroozfar et al., 2019; Sarhan and Fox, 2013; Peng and Pheng, 2011; Shen, Edirisinghe and Yang, 2016). Management and leadership go together; hence, without committed management, leadership will not be effective, especially when introducing new techniques and methods.

Reluctance to make changes usually evolves from people being too conformable to the conventional ways of doing things. This was one of the major drawbacks to the full uptake of BIM in construction and this has been reported in construction management literature. For example, Leśniak, Górka and Skrzypczak (2021) find that reluctance to change is one of the main factors that impact the adoption of BIM in constriction. Chan, Olawumi and Ho (2019) equally observe that resistance to change is the major factor that inhibits BIM adoption in the Hong Kong construction industry. In addition, the reluctance of the stakeholders to share project information is another barrier to BIM implementation. This is part of what Mostafa et al. (2020) found in Australia that stakeholders' lack the interest to share information is a critical barrier to BIM adoption in prefabricated construction.

Table 1. Inhibitors to use BIM in MC

No.	Variables	MIS	SD	Rank
1	High cost of investment in hardware and software	4.52	0.9104	1st
2	Comfortable with the existing method and resistant to change	4.50	0.8893	2nd
3	Lack of management support	4.46	0.7848	3rd
4	BIM software complexity	4.43	0.8419	4th
5	Stakeholders lack the interest to share information	4.43	1.0271	4th
6	Collaboration problems	4.41	1.1240	6th
7	Legal issues with multiple designs and fabrication	4.40	1.0706	7th
8	Problems of training and education	4.34	0.9591	8th
9	Unwillingness to adopt new methods, systems and innovative technologies	4.32	1.3045	9th
10	High cost of training in BIM and MC	4.30	0.9896	10th
11	Issues related to interoperability	4.29	1.0894	11th
12	Lack of domestic-oriented tools	4.28	1.2897	12th
13	Misunderstanding of BIM by stakeholders	4.28	1.0237	12th
14	Lack of standards	4.26	1.1769	14th
15	Absence of professional interactivity	4.25	1.2918	15th
16	Awareness and knowledge issues	4.22	1.0189	16th
17	Inadequate government policies	4.22	1.0829	16th
18	Organisational restructuring	4.20	0.9747	18th
19	The ambiguous nature of the economic benefits of BIM implementation	4.19	1.1359	19th
20	Functional limitations of model-based BIM software	4.18	1.1584	20th
21	Absence of BIM research	4.15	1.1332	21st
22	The absence of insurance applicable to BIM implementation	4.04	1.3077	22nd
23	Non-availability of qualified in-house staff	3.98	1.0918	23rd
24	Issues related to technical competence	3.97	1.2126	24th
25	Lack of demand from clients	3.90	1.3440	25th

Measures for Improving the Adoption of BIM in MC

Table 2 shows the results of the analysis of the data collected on the measures for improving the adoption of BIM in MC. The top five measures for improving the adoption of BIM in MC were "Incorporating BIM-related courses into the curriculum of higher education in all built environment disciplines" (MIS = 4.29; SD = 1.3135), "Programmes targeted toward the development of skills in the use of BIM, MC and prefabricated construction methods" (MIS = 4.18; SD = 1.3358), "Government enforcing the use of BIM as a primary requirement in the built environment sector"

(MIS = 4.17; SD = 1.1220), "Increasing the availability of BIM technology" (MIS = 4.16; SD = 1.3525) and "Management and organisational supports" (MIS = 4.16; SD = 1.2099). Whereas the least measures for improving the adoption of BIM in MC were devising means of moving from conventional practice towards the "Adoption of innovative tools and techniques" (MIS = 3.97; SD = 1.5408), "Improving interoperability of the BIM software with existing applications" (MIS = 3.97; SD = 1.3690), "Develop forms of contracts for the insurance of BIM" (MIS = 3.93; SD = 1.4496) and "Public-private partnership" (MIS = 3.92; SD = 1.3423).

Overall, the average MIS was 4.09 out of 5 (81.82%) and the maximum and minimum MIS for the variables were 4.29 out of 5 (85.71%) and 3.92 out of 5 (78.48%), respectively. In addition, regardless of the relative ranking of the variables, they had a high impact on improving the adoption of BIM in MC in Nigeria and by extension other nations with similar construction market structures. The results in this section support the findings and recommendations from previous studies (i.e., Chan, 2014; Leśniak, Górka and Skrzypczak, 2021; Liao et al., 2020; Kekana, Aigbavboa and Thwala, 2015; Wuni and Shen, 2019). BIM education is one of the ways the awareness and implementation levels of BIM can be enhanced. The courses of the curriculum of the built environmental programme as currently adopted are lacking in BIM-based content. This has been identified in BIM-related studies among construction management researchers. Liao et al. (2020) highlight that BIM certification courses to gain a new skill set and better ways of working with BIM projects are one of the ways to cover some of the hitches experienced in the widespread use of BIM. Incorporation of BIM in the courses of higher institutions is a sure way to increase the number of local BIM users. Leśniak, Górka and Skrzypczak (2021) advise that training and education on courses related to BIM technology is the sure way to improve the awareness of BIM technologies and their usage.

Collaboration of the government in BIM-related matters is also the key as the policies, standards and guidelines developed by the government are laws that must be followed and obeyed. Chan (2014) and Kekana, Aigbavboa and Thwala (2015) stress the need for the government to step in not only for the education and training of built environment professionals but also for the establishment of standards and policies for entrenching BIM in construction. This aids the development of students and the local workforce on BIM. Government and top management support as well as cooperation from organisations and team members are central to improving BIM adoption. For instance, the government must ensure that the regulations and standards are made compulsory for construction payers. These regulations and standards would affect government clients, consultants, contractors and other stakeholders in the sector (Sriyolja, Harwin and Yahya, 2021). As a result, this would improve the adoption level of BIM, similar to that obtained in advanced nations of the world.

Table 2. Measures for improving the adoption of BIM in MC

No.	Variables	MIS	SD	Rank
1	Incorporating BIM-related courses into the curriculum of higher education in all built environment disciplines	4.29	1.3135	1st
2	Programmes targeted toward the development of skills in the use of BIM, MC and prefabricated construction methods	4.18	1.3358	2nd

(Continued on next page)

Table 2. *Continued*

No.	Variables	MIS	SD	Rank
3	Government enforcing the use of BIM as a primary requirement in the built environment sector	4.17	1.1220	3rd
4	Increasing the availability of BIM technology	4.16	1.3525	4th
5	Management and organisational supports	4.16	1.2099	4th
6	Improve on BIM software standardisation	4.14	1.2281	6th
7	Developed policies and regulations to guide BIM usage	4.13	1.2486	7th
8	improvement in collaboration among project stakeholders	4.11	1.4299	8th
9	Workshops and seminars to further increase BIM benefits awareness among stakeholders of the construction industry	4.10	1.2929	9th
10	Develop forms of contracts for stakeholders for the use of BIM technology	4.08	1.1742	10th
11	Development of loan scheme for financing innovative methodologies	4.03	1.3262	11th
12	Devising means of moving from conventional practice towards the adoption of innovation tools and techniques	3.97	1.5408	12th
13	Improve the interoperability of the BIM software with existing applications	3.97	1.3690	12th
14	Develop forms of contracts for the insurance of BIM	3.93	1.4496	14th
15	Public-private partnership	3.92	1.3423	15th

CONCLUSION

This study assessed the inhibitors to the use of BIM in driving MC project delivery in Nigeria. It also explored the measures for improving the adoption of BIM in MC. A well-structured questionnaire was administered to construction professionals via electronic means and snowballing sampling techniques were used to collect data from the five states of the southeast geopolitical zones of the country. MIS was used to analyse the collected data and report the key findings. The current study discovers that while the awareness level of BIM and MC is high, the adoption of BIM in MC is low. The major factors that inhibit the use of BIM in MC are the high cost of investment in hardware and software, comfortable with the existing method and resistance to change, lack of management support, BIM software complexity, stakeholders' lack of interest in sharing information, collaboration problems and legal issues with multiple designs and fabrication. The measures for improving the adoption of BIM in MC are incorporating BIM-related courses into the curriculum of higher education in all built environment disciplines, programmes targeted toward the development of skills in the use of BIM, MC and prefabricated construction methods, government enforcing the use of BIM as a primary requirement in the built environment sector, increasing the availability of BIM technology and management and organisational supports. Management commitment is identified as the key to encouraging collaboration between construction and technology firms to improve BIM application in MC for better productivity and project outcomes. The government should also support the use of modern methodologies in the delivery of projects to help improve infrastructure provision, value addition and citizens' well-being. The key players in the construction industry should take advantage of this study to develop implementable policies that will get BIM and prefabricated methodologies entrenched in the production processes of construction organisations. This study adds to the few existing studies on BIM and MC adoption in developing nations.

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