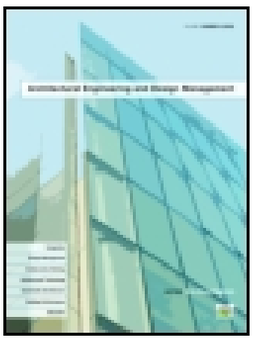

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Assessing the relationships between underlying strategies for effective building information modeling (BIM) implementation in Nigeria construction industry

Adefemi Aka, Justina Iji, Rasheed Babatunde Isa and Adebisi Abosede Bamgbade

Department of Building, Federal University of Technology, Minna, Nigeria

ABSTRACT

Effective communication among construction stakeholders has been a serious challenge in the global industry. Implementation of Building Information Modeling (BIM) has been established as a useful approach to overcome the challenge. However, lack of a single strategy for effective implementation of BIM tool during construction activities has made its application in a developing nation such as Nigeria to be very slow. Therefore, this paper aims to identify a single strategy that can be used to effectively implement BIM in Nigeria construction industry. This was achieved by conducting a mixed methods research in some selected construction firms located in Abuja the capital city of Nigeria in the year 2019. Interview and questionnaires were the main instruments used for data collection in the mixed methods research design. The findings of the study showed that BIM has not been maximally tapped by construction firms in Nigeria. The finding of the study also revealed that establishment of enforcement bodies that will ensure BIM application in every project is a significant strategy for BIM implementation in Nigeria construction industry. Such finding streamlined several strategies that can be used by project actors to understand the concept of BIM adoption in the study context. This could lead to affordable BIM projects delivery in Nigeria and consequently improve the performance of global construction industry. The study recommends that the underlying strategies that can be used to overcome the challenges of BIM enforcement in Nigeria construction industry should be investigated by prospective BIM researchers.

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BIM; construction; effective; relationships; strategies

Introduction

The significance of construction industry to a nation cannot be over emphasized. The industry is a prime source of employment generation for the populace of any country in the world (Oladinrin, Ogunsemi, & Aje, 2012). In the developed and developing countries, the industry provides infrastructures mainly in forms of roads, railways, airports as well as health care centers, schools, housing, and other buildings (Ruya, Lot, & Danladi, 2018). The office of national statistics reveals that there is a turnover of more than £100 billion annually in the UK construction, which accounts for virtually 10% of the country's Gross Domestic Product (GDP). The Nigeria construction industry sector also occupies an imperious place in the nation's economy (1.4% of its GDP). This implies that the sector holds great potentials for improving the national economy through its networks activities. (Aibinu & Jagboro, 2002; Banaitiene, Audrius, & Arturas, 2011; Dantata, 2007; Okoye, 2016;

CONTACT Adefemi Aka aka.femi@futminna.edu.ng; akafemi@yahoo.com PMB 64, Department of Building, Federal University of Technology, Minna, Niger State, Nigeria.

Olanipekun & Saka, 2019). This has made construction industry to be globally considered as the basic industry in which the development of any country can depend (Farooqui, Masood, & Aziz, 2008).

Despite the aforementioned benefits of construction industry to the economy of any nation, the sector often experienced drawbacks while trying to innovatively integrate construction in projects development. These drawbacks often lead to project delays accompanied with poor project performance (Mohammed & Ahmad, 2017). An understanding of the driving forces behind such drawbacks is necessary if the performance of the industry is to be improved. Therefore, researchers worldwide have investigated the drivers of some of the challenges in the industry. The finding in the reviewed literature indicates that ineffective communication among project actors is the major contributor (Project Management Body of Knowledge (PMBOK), 2008). Communication has been identified as one of the main reasons for project success or failure. Openness in communication within the project team and between the project manager and all external stakeholders is said to be a gateway to teamwork and high performance. This confers that effective communication improves relationships among project team members and creates mutual trust (PMBOK, 2008). Hence, when communication is at the maximum, employees performed best at the work place (Harris & Nelson, 2008).

Several studies have been conducted to investigate how the problem of poor communication in the traditional methods of projects execution can be subdued so as to improve project delivery (Khosrowshahi & Arayici, 2012). Among these is the adoption of Building Information Modeling (BIM). Smith (2007) defined BIM as a digital representation of the physical and functional characteristics of a facility and shared knowledge resource for information about a facility, forming a reliable basis for decisions during its life-cycle, from the earliest conception to demolition. This implies that BIM involves so many more project participants than just the architect (Hanif, Haq, & Shahbaz, 2010; Weygant & Robert, 2011), which enable the problem of ineffective communication among the projects team in the traditional methods of construction to be overcome. Therefore, BIM is believed to be a solution to many of the communication problems that occur in the construction industry.

In spite of the benefits of BIM to the above-mentioned industry, the reviewed literature reveals that several countries specifically the developing ones such as Nigeria are yet to fully implement or adopt BIM in their construction projects. This is due to some of the challenges experienced by such countries while trying to implement the tool (Fadason, Kaduma, & Chitumu, 2018; Nuruddeen & Usman, 2018). It is imperative to note that the challenges of BIM implementation in Nigeria construction industry have led to the development of several strategies such as government support and frequent training of construction professionals. To afford and successfully implement such strategies for effective BIM implementation in Nigeria is another 'battle' or 'tug of war'.

Therefore, to overcome this 'battle' for effective BIM implement in Nigeria construction industry, further studies are required on the relationship among the fundamental strategies of BIM implementation. This is essential as it will enable the strategies to be streamlined into a single entity that could be afforded by project actors in the study context. Based on this requirement, this study was conducted to investigate the challenges of BIM implementation in Nigeria construction industry, identified the various strategies that can be applied to reduce the challenges and establish the relationships among the strategies for effective single BIM implementation approach in the study contexts.

Literature review

An overview of BIM implementation in developing nations' construction

The literature indicates that not less than 135 middle and low income economies countries exist all over the world. Such countries are generally referred to as developing countries. These countries are characterized as developing as they have limited and occasional technological innovation (World Bank, 2015). In a study conducted by Jones and Bernstein (2012) and John (2018) on the survey

of BIM implementation, it was discovered that there are relatively few instances of BIM use reported in the developing countries construction industry. Whereas, BIM was primarily viewed as useful for promoting contractor competitiveness in China, India, and Malaysia construction industry (Harris, Ani, Haron, & Husain, 2014). Similarly, USA has BIM adoption rates of above 70% (Jones & Bernstein, 2012). While many construction projects in developed countries are progressively enforcing BIM, the cultivation of the technology in developing countries is lagging behind. Though, BIM adoption has slowly increased in some developing countries in the Middle East. However, the adoption level is still unsatisfactory (Gerges, Ahiakwo, Jaeger, & Asaad, 2016).

The challenges of BIM implementation in the developing nations construction industry

The adoption of BIM in the developing nations to include Nigeria is not rapid as expected compare to advanced economic countries where the strength of adoption is high (Abubakar, Ibrahim, Kado, & Bala, 2014; Akerele & Etiene, 2016; Ullah, Lill, & Witt, 2019). Some of the factors that inhibit BIM implementation in the developing countries are lack of government; clients, and contractors supports, lack of training of professional bodies relevant in the construction industry, and lack of retraining of professional members on BIM use and application, lack of initiative/education, inability to change the existing work practices, and lack of clarity on the roles/benefits of using a BIM approach (Ibrahim & Birshir, 2012; Ismail, Chiozzi, & Drogemuller, 2017). Hence, all efforts to adopt BIM in Nigeria's private and public sectors and amongst different building professionals (Architects, Quantity Surveyors, and Civil Engineers) have been very slow. Architects have been adopting BIM in projects, but the profession adopts it mainly to enhance visual quality of presentation (Alufohai, 2012). In addition, among the professional bodies interested in construction in Nigeria, there is limited use of BIM mainly due to their inability to keep pace with the modern advancement in technology (Onungwa & Uduma-Olugu, 2017). Other challenges of BIM implementation in the developing nation's construction are fear of change (Hassan & Yolles, 2009), high front-end cost of BIM implementation (Azhar, Khalfan, & Maqsood, 2011; Crotty, 2012), lack of BIM skilled labor in the construction industry (Aouad, Wu, & Lee, 2006; Azhar, 2011), lack of clients' interest and issues related to data ownership, cultural resistance, longer processes, uncertainty about the return on investment (Enshassi, AbuHamra, & Mohamed, 2016; McAuley, Hore, & West, 2017; Ullah et al., 2019).

Overcoming the challenges of BIM implementation in the developing nations construction industry

To effectively adopt and implement BIM in any nation, its application needs to be supported by clients, contractors, and government (Ayinla & Adamu, 2018; Cao et al., 2015). This has proven to be very effective in Finland, Norway, Denmark, and Singapore. For instance, several large construction clients in Norway demand for BIM in open formats in all or most of their projects (Demirdoven, 2015). To further encourage the adoption and implementation of BIM in the developing nations, there is need to disseminate BIM knowledge to construction firms operating in such countries. Doing so will result in detailed knowledge of BIM's benefits and increase the technical expertise required for implementation. Succeeding with this knowledge dissemination would require concerted efforts involving professional bodies, industry, and academia (Demirdoven, 2015; Nuruddeen & Usman, 2018; Poirier, Staub-French, & Forgues, 2015). Also, Norway has an active research community and governmental building authorities focusing on national BIM development (Silva, Salvado, Couto, & Azevedo, 2016). Further, Kassem and Succar (2017) developed different strategies that provide opportunities for BIM professionals to improve their understanding on BIM adoption dynamics across countries in the globe. Whilst, Ahmed and Kassem (2018) proposed for taxonomy and a set of drivers/determinants that can be adopted by BIM professionals to perform various analyses of BIM adoption process, delivering evidence and insights for decision makers in different organizations.

Methodology

This research aims to propose for a single strategy that could be adopted for effective implementation of BIM in Nigeria construction projects, with a view to overcome the financial difficulty in implementing the several strategies in the existing literature. To achieve this aim, mixed methods research design was adopted. This method enabled the researchers to obtain a robust data from different sources and at a wide population. It is imperative to know that mixed methods research design is a study approach that collects and analyses data, integrates the findings and draws inferences using both qualitative and quantitative approaches in a single inquiry (Wium & Louw, 2018). In the mixed methods, face to face interview with semi-structured questions was conducted after an extensive literature review. The interview was conducted with some selected construction practitioners that have requisite knowledge in BIM practice in the study context. The practitioners include Architects, Builders, Quantity Surveyors, Structural and Civil Engineers. Detailed information of these professionals is concise in Table 1.

Typical questions that were raised during the interview study are: the extent of adoption of BIM by the participants in different projects; the nature of the projects in which the tool is being adopted over the years; the challenges that hinder its adoption and the strategies that can be used to overcome the challenges. For consistency, the interview was conducted three times with each of the participants (Stringer, 2014). Each of the interview conducted ranges between 30 and 45 min in duration. All the interviews took approximately four months. As recommend by Stringer (2014), the entire interview discussions were tape-recorded and transcribed. After transcription, the resultant information was analyzed using content analysis (Krippendorff, 2012). The extracted themes of the interview were used to prepare questionnaire that was later used to conduct a survey study in the research.

This implies that the data obtained in the interview phase of the study was used to prepare questionnaires that were later distributed to 157 construction professionals that were randomly selected from 31 registered large and medium (both private and public) construction firms located in Abuja the capital city of Nigeria where there were several ongoing medium and large projects as at when the study was conducted. The questionnaire was carefully designed and pre-tested during the pilot study to avoid complications such as poor response rates, ambiguity, and inappropriateness that are associated with questionnaire surveys. Out of 157 questionnaires administered during the survey exercise, 101 were completed and returned which represents 64.33% response rate. This response rate is considered to be adequate for a survey study that intends to obtain information from industry practitioners (Lucko & Rojas, 2010). The academic qualifications of the respondents in the survey study ranges from National Diploma (ND) to master's degree.

In the questionnaires distributed, the respondents were asked to indicate on a Five-point Likert scale the extent of their agreement on the information obtained in the interview phase of the study (Doloi, Sawhney, Iyer, & Rentala, 2012). The information obtained from the respondents in the survey study was analyzed quantitatively (Gray, 2014). Hence, the reliability of the outcomes of the Five-point Likert scale was determined through standard deviation (SD), Skweness and Kurtosis tests during the analysis (Curran, West, & Finch, 1996; Gliem & Gliem, 2003). Therefore, all variables that have MIS of 3.5 and above in the analysis were considered to be very significant, while the one

Table 1. Demographical information of the participants of the interview study.

Participants of the interview study	Level of experience (in years)	Number of participants initially invited for the study	Number of participants that turn up for the study
Architects	5–8	10	4
Builders	6–8	10	6
Quantity Surveyors	3–6	7	3
Structural Engineers	5–10	10	6
Civil Engineers	5–10	8	6
Total		45	25

that have less than 3.0 but above 2.5 were considered as less important. Whereas, construct that have less than 2.5 MIS were measured as insignificant (Sakaram & Bougie, 2010).

It is essential to know that the essence of the questionnaire exercise was to validate the outcomes of the interview study and to establish the relationships among the identified strategies. Therefore, ANOVA test was conducted during the analysis to verify the significance of each discovered BIM implementation strategy. Thereafter, Pearson Correlation coefficient was conducted to determine the relationships among the established strategies.

Results and discussions

The interview phase

The opinions of the participants in the interview conducted in this study are explained as follow:

Construction stakeholders' perspective on BIM in the study context

In the interview conducted, some of the participants emphasized that BIM is 3 or 4 or 5D processes that give the architect, Civil/Structural Engineers and builders the insight to build, design, and manage building infrastructures. Some of the participants were of the view that BIM is a digital modeling of buildings in which information about a project is stored. All the participants agreed that BIM is mainly used for design, visualization, simulations, and collaborations.

Some of the participants of the interview study have contrary opinions regarding what BIM implies. The participants were of views that BIM is just a package or a platform for effective design. The interviewees expressed that the idea of BIM comes from the principle of object-oriented programming, and can be ascribed as a digital representation of the physical and the functional characteristics of a facility which is an extract of the definition of Smith (2007) and Eastman, Teicholz, Sacks, and Liston (2011). Despite the fact that the adoption of BIM in projects in the study context is very slow, the outcomes of the interview reveal that most of the professionals are cognizance with what BIM can be used to achieve in projects.

The type of projects in which BIM is being adopted in the study context over the years

When asked of the type of projects they have been making use of BIM over the years, most of the participants said they have made use of it in different type of projects ranging from mini (medium/mega projects), residential, and commercial projects. One of the participants (Quantity Surveyor) attested that

> … BIM has been used on several occasions to generate quantities, estimate cost and is used for institutional building projects …

This implies that there are quantitative and qualitative elements in the BIM process (Deutsch & Randy, 2011). It also denotes that BIM tool can spit out measurable quantities using metrics, which is in accordance with the findings of Deutsch and Randy (2011) that BIM can be used for cost estimation and scheduling in projects.

The challenges of BIM implementation in Nigeria construction industry

When the participants were asked of some of the challenges they normally encounter while trying to adopt BIM in construction projects, the participants stated that clients do not normally demand or request for it in their previous projects. Some of the interviewees also contented that some of the professionals do not understand how to effectively use BIM in projects. One of the participants declared that there is no encouragement from Nigerian government. The opinions of the interview participants confirmed the information earlier observed in the reviewed literature that BIM needs to

be supported from clients, contractors, and government before it can be welcomed in the developing countries (Cao et al., 2015).

Further, some of the interviewees pointed that lack of awareness among stakeholders, lack of standard to guide implementation, lack of information technology (IT) infrastructure, lack of education and training, lack of government direction are the major challenges faced in the adoption of BIM technologies. This is similar to the view of The Royal Institute of Chartered Surveyor (2015) on the problems encountered by construction stakeholders in implementing BIM in the construction process. It is imperative to note that the last participant that was interviewed pointed that:

> … the size of BIM is relatively large and is expensive. Thereby, consumes a lot of space as the interface of the graphics is heavy. In other words, within the architectural space, the BIM software system requirement is high … .

When the participants were asked of the root causes of the identified challenges, some of them mentioned that little or no awareness and traditional way of doing things are the root cause of the problem of BIM implementation in projects. All the participants of the interview also pointed that the root causes of the problem are lack of skilled personnel in firms to teach how to use the software, power interruption, high cost of data and poor internet facility.

Strategies for reduction of the challenges of BIM implementation in Nigeria construction industry

The literature indicates that adequate knowledge of the drivers and process of BIM adoption is of paramount importance to BIM adopters and policy makers at every level (Ahmed & Kassem, 2018). Similarly, participants of the interview study agreed that adequate training of professionals in terms of how to use BIM or establishment of BIM institute for the training of young/fresh graduates for a period of six months, practical awareness through regular conferences and seminars on the application of BIM, increase in the cost of traditional methods of design/construction to discourage client in it adoption, making the cost of BIM projects execution at a give a way price to encourage clients, appropriate budget for BIM implementation and outsourcing for BIM expert will be of great help to reduce the challenges of BIM implementation in the study context. This implies that establishment of BIM institute just as other professional foundations for the raining of young school leavers will help to overcome the challenges of non-availability of BIM experts that is presently prevalent in the study context. Virtually all the clients in the study location are fully aware of some of the benefits of BIM. Therefore, they will be happy and willing to adopt the tool if the professional experts are at their reach.

Some of the participants further expressed that incorporation of BIM in school curriculum at higher institution level will also help Nigeria to effectively implement BIM in construction projects. This implies that if BIM is incorporated in students' curriculum at every higher learning institution, BIM will already be 'part and parcel' of every student. Such students can start practicing immediately after graduation without the need for further training. Few of the interviewees further suggested that owners of construction firms (both private and public establishments) should be committed to BIM implementation by providing uninterrupted power supply and free Wi-Fi to accommodate fast working condition for employees. Some of the participants agreed that setting up a standard where BIM software will be fully implemented for use in various projects, making the approval process of BIM projects faster and cheaper while compared with the traditional methods and establishment of enforcement bodies that will be moving from one site to another to monitor and ensure compliance by every client/professionals will be of advantage.

The approval process of every project specifically the large ones such as commercial, industrial, and high-rise buildings in Nigeria normally takes time with strenuous exercise. At time, some of them may be abandoned by the approval authority for a long time before attending to them. This is due to the fact that the design of some of the projects may contain one mistake or the

other that may be required to be corrected before approval. Therefore, attention should be given to a BIM project by the approval authority with the perspective that error or mistake will be minimal. Based on this perspective, approval of BIM projects should be faster and cheaper, which will consequently encourage prospective clients for its adoption.

The questionnaire strand

The data obtained in the questionnaire phase of the mixed methods study conducted are explained as follow: (Table 2).

The extent of adoption of BIM in Nigeria construction projects

Table 3 shows the results on the analysis of the data collected on the extent or frequency of adoption of BIM in the previously executed projects. Based on the weighting of the mean score, a reasonable number of the respondents indicated that they have applied BIM in few of their previous projects (6–10 projects, and closely followed by 11–15 projects over the past five years). Based on the opinions of the respondents, it can be concluded that BIM adoption in projects is very slow in Nigeria construction industry. Regarding the type of project in which BIM is being adopted, the result shows that it is more in used in commercial building (MIS = 4.13), followed by residential building (MIS = 4.03). This implies that BIM can be applied in all projects regardless of the function. Looking at the skewness and kurtosis values in Tables 3 and 4, the values obtained revealed that the analyzed data are accurate as suggested by Curran et al. (1996). Curran et al. (1996) are of the view that data are considered to be in excellent form when the skewness range is fewer than 2 and the kurtosis is fewer than 7. From the tables, the skewness values are less than 2 and kurtosis are less than 7.

Factors that inhibit effective BIM adoption in Nigeria construction projects

The study conducted revealed that the main factors that hinder BIM implementation in Nigeria construction projects are inadequate knowledge of BIM or lack of skilled personnel in most construction firms (MIS = 4.66), Lack of financial support (MIS = 4.60) and high initial cost of implementation of BIM (MIS = 4.13) (see Table 5).

Table 2. Number of the questionnaire distributed and returned.

Respondents of the questionnaire study	Number of questionnaires distributed	Number of questionnaires returned and analyzed
Architects	47	33
Builders	23	15
Quantity Surveyors	21	13
Structural Engineers	34	21
Civil Engineers	32	19
Total	157	101

Table 3. The extent of adoption of BIM in Nigeria construction projects.

Number of BIM adoption in previous projects	MIS	SD	Rank	Skewness	Kurtosis
0	2.14	1.20	4	1.085	0.381
1–5	3.50	1.00	1	−0.379	−1.057
6–10	3.15	1.26	2	−1.044	0.033
11–15	2.31	1.51	3	−0.481	−1.577
16 and above	1.82	1.28	5	0.079	−1.323

Table 4. The various forms of projects executed with BIM in the past 5 years.

Projects	MIS	SD	Rank	Skewness	Kurtosis
Residential buildings	4.03	1.26	2	−0.848	−1.034
Institutional buildings	3.97	1.34	3	−1.135	−0.031
Commercial buildings	4.13	0.88	1	−1.236	1.211
Industrial building	3.85	1.40	4	−0.554	−1.443

Table 5. Inhibitors of BIM adoption in Nigeria construction projects.

Factors	Mean statistic	Std. Devi.	Rank	Skewness	Kurtosis
Difficulty to change from the traditional methods of projects execution	4.29	0.668	3	−0.419	−0.763
Lack of awareness of BIM among construction stakeholders	3.82	1.284	6	−1.271	0.467
Poor internet service/facility	4.12	1.339	5	−1.645	1.36
Inadequate knowledge of BIM or lack of skilled personnel in most construction firms in Nigeria	4.66	0.871	1	−3.103	2.37
Unstable electricity supply	3.45	1.21	7	−0.382	−1.66
Lack of financial support specifically for continuous training of professionals	4.60	0.888	2	−2.021	2.903
High initial cost of implementation of BIM	4.13	1.408	4	−1.305	0.043

BIM implementation strategies in Nigeria construction industry

The outcomes of the survey study justified what the researchers have observed in the interview exercise. Therefore, some of the strategies that can further be used to reduce the factors hindering BIM implementation in Nigeria construction industry (Table 6) are to make the approval process of BIM projects faster and cheaper while compared with the traditional methods, increase the cost of traditional methods of design/construction to discourage clients, make the cost of BIM projects execution at a give a way price to encourage clients and establishment of BIM institute for the training of young/fresh graduates for a period of six months or establishment of training centers for better knowledge of BIM technology. It is imperative to note that many projects leaders specifically in the developing countries are under the impression that BIM implementation is costly and time-consuming due to several strategies that are needed for its implementation (Abubakar et al., 2014; Sahil, 2016; Smith, 2014). Therefore, for affordability in a developing nation such as Nigeria

Table 6. Strategies for effective BIM implementation in Nigeria construction industry.

Strategies	Mean statistic	Std. Devi.	Rank	Skewness	Kurtosis
Incorporation of BIM in students' curriculum at tertiary institutions (S_7)	3.62	0.832	7	−0.499	−1.378
Increasing the cost of traditional methods of design and construction to discourage clients from its adoption in projects (S_4)	4.49	0.644	4	−0.874	−0.293
Establishment of BIM institute for the training of young/fresh graduates for a period of six months or establishment of training centers for better knowledge of BIM technology (S_3)	4.59	0.911	3	−1.918	2.669
Uninterrupted power supply and free Wi-Fi to accommodate employees' fast working condition (S_9)	3.13	0.784	9	−0.224	−1.334
Making the cost of BIM projects execution at a give a way price to encourage clients (S_5)	4.39	0.473	5	−0.213	−1.891
Appropriate budget for BIM implementation and outsourcing for BIM (S_8)	3.31	0.489	8	−0.457	−1.818
Making the approval process of BIM projects faster and cheaper while compare with the traditional methods (S_1)	4.71	0.454	1	−0.954	−1.107
Regular conduction of workshops trainings and conferences on BIM benefits and implementations (S_2)	4.67	0.472	2	−0.727	−1.494
Establishment of enforcement bodies that will be moving from one site to another to monitor and ensure compliance by every client/professionals (S_6)	3.71	0.794	6	−0.231	−1.671

where project fund has always been a serious challenge in both government and private organizations, this study streamlined the several strategies into a single entity using correlation analysis.

ANOVA analysis of the strategies for effective BIM implementation in Nigeria construction industry

Based on the MIS values (Table 6), nine strategies were identified as significant strategies for effective BIM implementation in Nigeria construction industry. These strategies were used to run an ANOVA analysis (Table 7). In the analysis, the identified strategies served as the independent variables while effective BIM implementation is the dependent variable.

The ANOVA results in Table 7 indicate that the *F*-value is 6.933 at 0.000 (*P*-value) significant level. This led to the conclusion that all the identified strategies could be used for effective BIM implementation in Nigeria construction industry. However, seven of these strategies have their MIS above 3.5 (very significant). These strategies were used to run correlation test in the study.

Correlation analysis of the relationships among BIM implementation strategies

The outcomes of the Pearson correlation test conducted reveal that there is a strong bond between S_2, S_3, and S_7. Based on the reviewed literature, the essence of the three strategies is to ensure that BIM professionals are always available while executing projects. Therefore, for affordability, any of the three strategies can be used to overcome the challenge of inadequate or lack of BIM expert in the developing nations construction sector. Strong relationship also exists between S_4 and S_5. Which also confers that any of the strategies could be used to overcome the problem associated with clients not having adequate interest in BIM projects. Lastly, S6 has a fair relationship with S_1, S_2, S_3, S_4, S_5, and S_7. Which implies that enforcement may be the last decision for BIM implementation in Nigeria construction industry. Based on the fair relationship in the results, the strategy may not necessary be the best option. However, it may bring out a reasonable result at long run and all other discovered strategies may not be needed (Table 8).

Research implications

It is clear that the earlier the construction firms invests in BIM the better the firms will be well positioned to benefit from the various BIM's initiatives and capabilities that will continue to evolve (Smith, 2014). However, many project actors in Nigeria and other developing nations are under the impression that BIM implementation is costly and time-consuming due to several strategies it involves. Thus, these several strategies have made it difficult for actors in Nigeria to effectively implement BIM in projects. Therefore, this study streamlined the several strategies into a single entity so as to effectively understand the concept of BIM and its adoption in Nigeria construction industry. In other words, the study enables BIM professionals in Nigeria to identify a gap in their implementation efforts and offers a guiding information on how such gap can be bridged, leading to effective BIM adoption and implementation in the study context. This implies that the study conducted presents an effective adoption of a single approach to project leaders and BIM researchers rather than the complicated and capital intensive multiple concepts in the existing literature. This by implication would lead to affordable BIM projects delivery in the country, provide

Table 7. ANOVA analysis of effective BIM implementation strategies in Nigeria construction industry.

Model		Sum of squares	Df	Mean square	*F*	Sig.
1	Regression	0.421	1	0.419	6.933	0.000
	Residual	1.357	9	0.687		
	Total	1.778	10			

Table 8. Pearson correlation analysis among BIM implementation strategies (Variables with MIS above 3.5 only).

Strategies	(S_1)	(S_2)	(S_3)	(S_4)	(S_5)	(S_6)	(S_7)	BIM implementation
(S_1) Pearson's correlation	1.000							
Significance (two-tailed)	0.000							
N	124							
(S_2) Pearson's correlation	0.667	1.000						
Significance (two-tailed)	0.000	0.000						
N	124	124						
(S_3) Pearson's correlation	0.696	0.861	1.000					
Significance (two-tailed)	0.000	0.000	0.000					
N	124	124	124					
(S_4)	0.717	0.567	0.790	1.000				
Significance (two-tailed)	0.000	0.000	0.000	0.000				
N	124	124	124	124				
(S_5)	0.512	0.674	0.613	0.942	1.000			
Significance (two-tailed)	0.000	0.000	0.000	0.000	0.000			
N	124	124	124	124	124			
(S_6)	0.681	0.691	0.683	0.625	0.667	1.000		
Significance (two-tailed)	0.000	0.000	0.000	0.000	0.000	0.000		
N	124	124	124	124	124	124		
(S_7)	0.681	0.861	0.846	0.581	0.514	0.771	1.000	
Significance (two-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
N	124	124	124	124	124	124	124	
BIM implementation	0.612	0.890	0.831	0.613	0.618	0.673	0.531	1.000
Significance (two-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
N	124	124	124	124	124	124	124	124

motivation for continuous improvement of work process and consequently improve the performance of global construction industry.

Conclusions

The modern BIM strategies which have paved progress for many of the construction firms' in the developed world would be an improvement over the traditional method with its accompanying problem of ineffective communication among the projects team. Hence, BIM is believed to be a solution to many of the communication problems that occur in the construction industry. However, the adoption of BIM in Nigeria construction industry has been very slow due to certain challenges such as lack of financial support, lack of BIM skilled personnel in most construction firms, and high initial cost of BIM implementation. This implies that BIM has not been maximally tapped by construction firms in Nigeria, and to attain this maximum potential stage will entail adapting and implementing certain underlying strategies.

Based on the findings of the researched conducted, there are three underlying strategies that can be used to overcome the challenges of BIM implementation in Nigeria construction industry. These strategies are to create BIM institute for the training of young/fresh graduates, discourage clients from the traditional methods of construction through cost and establish BIM implementation enforcement bodies. For affordability purpose, these three strategies can further be simplified into a single entity which is establishment of BIM implementation enforcement bodies.

Premised on the research conclusion, the study recommends that Nigerian government should establish BIM institute for the training of young/fresh graduates for not less than six months; ensure that the approval process of BIM projects is cheaper and faster than the traditional method of project execution and enforce the adoption of BIM implementation in medium and mega projects. All construction stakeholders to include clients should also be encouraged to always request for BIM adoption in every projects.

The study is limited to construction firms in Abuja, Nigeria that was selected for the study based on the researchers' perception that there might be more number of BIM professionals/experts than

any other city. Therefore, to generalize the findings of the study, similar research may be conducted in other cities such as Lagos and Kaduna where BIM projects/experts may also be available. It should be noted that enforcement of BIM in construction industry in Nigeria and other developing nations may trigger new dynamics. On this premise, this study further identifies a research gap that requires further attention from BIM researchers across the globe. Such gap is to investigate the challenges of BIM enforcement in construction projects specifically in the study context and other developing nations. The strategies that can be deployed to overcome the challenges should also be investigated by future BIM researchers. Focusing on affordability of these strategies in the developing nations construction industry, the relationships between the underlying strategies may also be investigated by prospective BIM researchers.

Disclosure statement

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