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Original Research Article

Implementation of Building Information Modelling Among Construction Professionals in Lagos State, Nigeria

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ABSTRACT

Despite the global clamour for the uptake of Building Information Modelling (BIM), Nigerian construction professionals are slow in adapting to its implementation. This paper assessed BIM implementation among construction professionals in Lagos State, Nigeria with a view to enhancing its adoption. Structured questionnaires were administered on a random sample of 212 construction professionals comprising 47 Architects, 75 Engineers and 90 Quantity Surveyors. The professionals were accessed through the consulting firms of Architects, Engineers and Quantity Surveyors in the study area. The questionnaire elicited data on required skills, and software and facilities as well as drivers of BIM implementation. Out of the 212 questionnaires distributed, 157 were returned and used for analysis. Data collected were analysed using Mean Score and Analysis of Variance. Findings showed that computing, cost modelling and computer-aided design skills were mostly required by construction professionals for BIM implementation. The software mostly required by Architects, Engineers and Quantity Surveyors were Revit, Autodesk Naviswork and Cost X, respectively. Internet connectivity was the facility mostly required for BIM implementation in the study area while organisational skills and knowledge in BIM processes and technology was the major driver of BIM implementation by construction professionals. Consequently, it was concluded that BIM uptake was slow in the study area because of skill gaps and inadequate infrastructure.

1. INTRODUCTION

Current advancements in information and communication technology (ICT) have changed the work process of most industries including the construction industry (Chan, 2014; Gerges et al., 2017). The adoption of Building Information Modelling (BIM) by the construction industry is a major innovative

trend that has improved the efficiency of the industry. Traditionally, the construction industry is known for fragmented activities, errors, unsatisfactory performance and high level of waste generation (Arayici et al., 2009). This has made the industry lag in its contributions towards economic growth and development.

Studies have admitted that the acceptance and adoption of BIM technology and process by all construction stakeholders will substantially reduce the problems facing the industry (Mahbub, 2015; Abubarka et al., 2014). Interestingly, several developed countries in Europe, North America, Australia and some parts of the Middle East have applied BIM on numerous projects with resounding benefits (Lee, *et al.*, 2014). It is interesting to note that the adoption of BIM by these countries was facilitated by the policies and supports received from their respective governments in the quest for efficient sustainable construction (Akinade, *et al.,* 2017).

BIM is a set of digital tools that can manage construction projects effectively (Latiffi et al., 2013). Abubarka et al. (2014) described BIM as a digital representation of the physical and functional characteristics of a facility which serves as a share knowledge resource for information about a facility. It involves shared information space technology used for collaborative digital design work across construction projects execution and facility maintenance (Buiab et al., 2016). Globally, BIM is an innovation and productivity catalyst in the construction industry which is changing work process from the traditional base to more efficient and effective innovative technology and process for project delivery. It is an emerging technological and procedural shift and an expansive knowledge domain within the Architecture, Engineering and Construction (AEC) industry (Kassem et al., 2014). BIM as an innovative technology exerts significant impact on design, construction, management, operation, and maintenance of building projects (Doumbouya et al., 2017).

Despite the global rise in BIM uptake and its recognised capacity to solve major construction industry problems, its adoption and application is relatively low among construction professionals in developing countries (Gerges *et al.*, 2017; Arayici, *et al.*, 2009). Most developing countries suffer from poor infrastructure supply and lack initiative to enhance quick implementation of innovative trends especially in the construction industry (Buiab et al., 2016). The construction professionals in these regions of the world find it difficult to upgrade their knowledge base and skills from traditional mode of practice to innovative ICT trends. The Nigerian construction industry is not left out in this slow switch from traditional mode of practice to innovative ICT trends such as BIM.

Several local researches on the state of BIM concept within the Nigerian construction industry have identified the rate of BIM awareness, adoption possibility, and barriers to the adoption of BIM among construction professionals (Akerele and Etiene, 2016; Oke, 2016; Abubarka, *et al*., 2014) with paucity of literature on BIM implementation, hence, this study. Consequently, this study assessed the implementation needs of BIM among construction professionals in Lagos State, Nigeria, with a view to enhancing its adoption.

2. METHODOLOGY

Data for the study were collected using structured questionnaires. The questionnaires were administered on 212 construction professionals comprising 47 Architects, 75 Engineers and 90 Quantity Surveyors, who were randomly selected. The professionals were accessed through the consulting firms of Architects, Engineers and Quantity Surveyors in the study area. The questionnaire elicited data on skills required, the software and facilities used and drivers of BIM implementation. Out of the 212 questionnaires distributed, 157 were returned and used for analysis. The data collected were analysed using Mean Score and Analysis of Variance (ANOVA).

3. RESULTS AND DISCUSSION

Regarding the skills required for BIM implementation among construction professionals in the study area, Table 1 shows that, for Architectural practice, computer aided design ranked highest with mean score of 4.45. It is closely followed by construction technology (MS=4.40), design (MS=4.33) and

virtual modelling skills (MS=4.15). Similarly, cost modelling, computing, time modelling, and coordination skills were the top ranked skills required by Quantity Surveyors for BIM implementation with mean scores of 4.70, 4.56, 4.44 and 4.39, respectively. The top ranked skills required for structural engineers for BIM implementation are design, construction technology, computer aided design and cost modelling skills with mean scores of 4.29, 4.24, 4.10 and 4.00, respectively. Furthermore, both mechanical and electrical services and computer aided design skills (5.00) were top ranked skills for both mechanical and electrical engineers in BIM implementation in the study area. This is closely followed by coordination skill (MS=4.83) and both computing skill and design skill (MS=4.79). Overall, computing, cost modelling and computer aided design skills with mean values of 4.47, 4.33 and 4.28, respectively were ranked highest in that order for BIM implementation among construction professionals in the study area.

Table 1: Skills required for BIM implementation among construction professionals

Skills Required for BIM Implementation	Arch		Q.S		St. Eng.		M&E Eng		Overall			
	M.S	R	M.S	R	M.S	R	M.S	R	M.S	R	F	Sig.
Computing skill	3.98	5	4.56	2	3.24	9	4.79	4	4.47	1	7.593	.000*
Cost modelling skill	3.80	8	4.70	1	4.00	4	4.42	5	4.33	2	8.944	.000*
Computer Aided Design skill	4.45	1	4.00	8	4.10	3	5.00	1	4.28	3	6.684	.000*
Construction technology skill	4.40	2	4.26	5	4.24	2	3.96	7	4.25	4	.984	.402
Coordination skill	3.78	9	4.39	4	3.67	7	4.83	3	4.23	5	9.414	.000*
Time modelling skill	3.98	5	4.44	3	3.86	6	3.83	10	4.14	6	2.756	.044*
Design skill	4.33	3	3.64	10	4.29	1	4.79	4	4.08	7	6.608	.000*
Virtual modelling skill	4.15	4	3.74	9	3.95	5	4.29	6	3.96	8	1.971	.121
Sustainability skill	3.90	7	4.03	7	3.38	8	3.88	9	3.91	9	2.578	.056
Building life cycle skill	3.53	10	4.06	6	3.05	11	3.29	11	3.69	10	7.573	.000*
Mechanical and Electrical services skill	2.85	11	3.43	11	3.10	10	5.00	1	3.50	11	10.858	.000*
Average mean value	3.92		4.11		3.72		4.37		4.08			

*Significant at 5% Level; M.S = Mean Score; R = Rank

The above findings from this study agree with the opinions of Oyewole (2017), Jung (2015) and Aftab *et al.* (2014) that skills like computing, cost modelling and computer aided design among others are required for BIM implementation among construction professionals. It is hence suggested that construction professionals need to possess considerable skill in computing, cost modelling and computer-aided design to enhance BIM implementation in the study area. This opinion is also supported by Akerele and Etiene (2016).

Analysis of Variance (ANOVA) was also conducted to test for the statistical relationship between the opinions of the respondents in respect of the skills required for BIM implementation among construction professionals in the study area. The asterisked variables are significant at 5% level indicating that the respondents are not in agreement that the asterisked eight skills are required for BIM implementation among construction professionals in the study area. On the other hand, the respondents are unanimous in opinion that only three out of the 11 skills investigated are required for BIM implementation among all the respondents in the study area. These skills are construction technology, virtual modelling and sustainability skills.

Table 2 contains a ranked order of the software applications required for BIM implementation among construction professionals in the study area. The top ranked software packages required for BIM implementation by Architects are Revit Autodesk with a mean score of 3.75. It is followed by AutoCAD (MS=3.53) and ArchiCAD (MS=3.18). Similarly, Autodesk Naviswork ranked highest with mean score of 4.15 for BIM implementation for engineering practice. This is closely followed by Revit and

CADDUCT with mean scores of 4.11 and 4.05, respectively. Cost-X, QS plus, and Innovaya with mean values of 4.44, 4.35 and 4.15, respectively are the highest-ranked software packages for BIM implementation by Quantity Surveyors in the study area. Moreover, Bentley Generative Components (MS=2.66), Synchro Project Constructor (MS=2.65), Solibri Model Checker (MS=2.59) and dassault systems CATIA (MS=2.45) are the least essential software packages required for BIM implementation among construction professionals in the study area.

Table 2: BIM enabled software for BIM implementation among construction professionals

BIM Software	Level of significance	
	Mean Score	Rank
Architectural Packages		
Revit Autodesk	3.75	1
AutoCAD	3.53	2
Autodesk	3.18	3
ArchiCAD	3.08	4
Graphisoft Archicad	2.75	5
Autodesk Navisworks	2.55	7
Bentley Arch	2.20	8
Engineering Packages		
Autodesk Navisworks	4.15	1
Revit	4.11	2
CADDUCT	4.05	3
Bentley Struct	3.85	4
Bentley Mech	3.83	5
Nemetschek Vector works	3.68	6
FireCAD	3.39	7
Quality Function Deployment	3.05	8
Quantity Surveying Packages		
Cost X	4.44	1
QS Plus	4.35	2
Innovaya	4.15	3
VICO	2.68	4
General BIM Software		
Bentley Generative Components	2.68	1
Synchro Project Constructor	2.65	2
Solibri Model Checker	2.59	3
Dassault Systems CATIA	2.45	4

The results from this study revealed that the highest ranked software package by Architects for BIM implementation is Revit Autodesk which was also highlighted as one of the important design software application for required for BIM implementation by Succar (2009) and Chan (2014). Wong, Salleh and Rahim (2014) and Jung (2015) also identified that Autodesk Navisworks among others were relevant for BIM implementation among construction engineers. Similarly, CostX was the highest ranked software application for BIM implementation by Quantity Surveyors in the study area. This is in agreement with Boon and Prigg (2012) and Ezeabalisi *et al.* (2015) who identified that Cost X was a veritable BIM tool for Quantity Surveying Practice.

Regarding the facilities required to expedite BIM implementation among construction professionals in the study area, Table 3 shows that, workshop (MS=4.50), availability of BIM software (MS=4.23) and availability of powerful CPUs (MS=4.20) are the top ranked for Architectural practice. Similarly, in the

opinion of the Quantity Surveyors, stable internet connectivity ranked highest among the facilities required for BIM implementation among construction professionals in the study area with mean score of 4.78. This is closely followed by integrated computer systems and availability of BIM software with mean score of 4.68 and 4.58, respectively. The top ranked facilities required for structural engineers for BIM implementation are stable internet connectivity (4.82), integrated computer systems (4.77) and availability of well-trained BIM staff or operator (4.71). Furthermore, both availability of well-trained BIM staff or operator and uninterrupted power supply (MS=5.00) are top ranked facilities required by both mechanical and electrical engineers in BIM implementation in the study area. These are closely followed by availability of powerful CPUs (MS=4.94). Overall, stable internet connectivity, integrated computer systems and availability of BIM software with mean scores of 4.57, 4.53 and 4.52, respectively are ranked highest facilities required in that order for BIM implementation among construction professionals in the study area.

Table 3: Facilities for BIM implementation among construction professionals

Facilities required for BIM implementation	Arch		Q.S		St. Eng.		M&E Eng		Overall			
	M.S	R	M.S	R	M.S	R	M.S	R	M.S	R	F	Sig.
Stable internet connectivity	3.88	8	4.78	1	4.82	1	4.73	7	4.57	1	9.698	.000*
Integrated computer systems	3.98	4	4.68	2	4.77	2	4.38	11	4.53	2	12.080	.000*
Availability of BIM software	4.23	2	4.58	3	4.35	8	4.75	6	4.52	3	3.027	.020*
Workshop	4.50	1	4.37	6	4.35	8	4.81	5	4.49	4	1.610	.175
Availability of well-trained BIM staff or operator	3.98	4	4.54	4	4.71	3	5.00	1	4.45	5	4.185	.003*
Powerful CPUs	4.20	3	4.17	10	4.71	3	4.94	3	4.37	6	3.291	.013*
BIM Training Package	3.90	7	4.46	5	4.35	8	4.56	9	4.36	7	5.101	.001*
Uninterrupted power supply	3.83	9	4.31	8	4.71	3	5.00	1	4.35	8	7.497	.000*
Large data storage device	3.93	6	4.26	9	4.41	7	4.90	4	4.29	9	3.021	.020*
Interoperability system component	3.13	13	4.34	7	4.24	12	4.50	10	4.11	10	11.949	.000*
BIM business vendor	3.60	11	4.09	12	4.24	12	4.67	8	4.10	11	4.241	.003*
Communication Devices	3.63	10	4.10	11	4.47	6	4.31	12	4.09	12	3.805	.006*
Large Screen Monitors	3.55	12	3.90	12	4.29	11	4.31	12	3.97	13	3.900	.005*
Video Conferencing with Large display screens	3.03	14	3.73	13	4.06	14	4.06	14	3.75	14	7.703	.000*
Average Mean Value	3.81		4.31		4.46		4.64		4.28			

*Significant at 5% Level; M.S = Mean Score; R = Rank

Overall, the Table shows that stable internet connectivity, integrated computer systems and availability of BIM software are highly ranked facilities required for BIM implementation among construction professionals in the study area. These findings are in tandem with the facilities recommended for BIM implementation in the construction industry by Fadason, Kaduma and Chitumu (2018), Dong (2017) and Kekana (2014). There is hence the need to put in place these facilities to enhance BIM implementation among construction professionals in the study area.

Analysis of Variance (ANOVA) was also conducted to test for the statistical relationship between the opinions of the respondents in respect of the facilities required for BIM implementation. The test showed that the respondents are not in agreement that the asterisked 13 out of 14 investigated facilities required for BIM implementation are significant at 5% in the study area. In other words, these facilities are not required for BIM implementation in the study area. On the other hand, the respondents are unanimous in opinion that only one out of the 14 facilities investigated is essential for BIM implementation among construction professionals in the study area. This required facility is organizing workshop.

Regarding drivers of BIM implementation among construction professionals in the study area, Table 4 shows that, for Architectural practice, both organizational skills and knowledge in BIM processes and technology and the use of information technology services ranked highest with mean score of 4.18, respectively. These are closely followed by required BIM software packages (MS=4.03). Similarly, financial capacity of the organization, organizational skills and knowledge in BIM processes and technology and required BIM software packages were the top ranked drivers of BIM implementation among/for Quantity Surveyors with mean scores of 4.57, 4.56 and 4.51, respectively. The top ranked drivers of BIM implementation for structural engineers are organizational skills and knowledge in BIM processes and technology, financial capacity of the organization and both required BIM software packages and interest and readiness of staff to learn new technology with mean scores of 4.53, 4.47 and 4.41, respectively. Moreover, the use of information technology services (MS=5.00), interest and readiness of staff to learn new technology (MS=4.94) and organisation's management interventions and support for adopting new technology (MS=4.75) were top ranked facilities of BIM implementation by both mechanical and electrical engineers in the study area. Overall, organizational skills and knowledge in BIM processes and technology, the use of information technology services and financial capacity of the organization with mean scores of 4.52, 4.47 and 4.43, respectively were ranked highest drivers in that order for BIM implementation among construction professionals in the study area.

The findings from this study revealed that Organisational skills and knowledge in BIM processes and technology, the use of information technology services and financial capacity of the organization are highly rated drivers of BIM implementation among construction professionals in the study area. This is relevant to some identified drivers by Abubarka *et* al. (2014), Buiab *et al.* (2016), Gerges *et al.* (2017) and Le *et al.* (2018).

Analysis of variance (ANOVA) was conducted to test for the statistical relationship between the opinions of the respondents in respect of drivers of BIM implementation. The test showed that the respondents are not in agreement that the asterisked 20 drivers of BIM implementation are significant at 5% in the study area. This means that these variables are not relevant drivers of BIM implementation in the study area. On the other hand, the respondents are undivided in opinion that only two out of the 22 drivers investigated are responsible for BIM implementation among construction professionals in the study area. These drivers are interest and readiness of staff to learn new technology and nature of the construction industry.

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Table 4: Drivers of BIM implementation among construction professionals

Drivers of BIM implementation	Arch		Q.S		St. Eng		M&E Eng		Overall		Level of Sig.	
	M.S	R	M.S	R	M.S	R	M.S	R	M.S	R	F	Sig.
Organisational skills and knowledge in BIM processes and technology	4.18	1	4.56	2	4.53	1	4.63	6	4.52	1	6.670	.000*
The use of information technology services	4.18	1	4.46	6	4.35	5	5.00	1	4.47	2	3.422	.010*
Financial capacity of the organisation	3.88	4	4.57	1	4.47	2	4.69	5	4.43	3	9.213	.000*
Required BIM software packages	4.03	3	4.51	3	4.41	3	4.00	16	4.32	4	2.152	.077
Interest and readiness of staff to learn new technology	3.75	5	4.33	8	4.41	3	4.94	2	4.29	5	5.973	.000*
Organisation's management interventions and support for adopting new technology	3.55	8	4.49	5	4.06	11	4.75	3	4.28	6	10.616	.000*
Availability of BIM Specialists	3.73	6	4.39	7	4.06	11	4.56	9	4.25	7	6.203	.000*
Continuous investment in BIM training programme	3.25	12	4.51	3	4.18	8	4.75	3	4.20	8	9.816	.000*
Availability of Standardized work procedure for BIM	3.43	10	4.06	11	4.35	5	4.44	12	4.05	9	8.494	.000*
Nature of the construction industry	3.60	7	4.21	9	4.35	5	3.92	19	4.01	10	2.069	.088
Possibility of differences in organisation's work procedure	3.05	14	4.10	10	4.06	11	3.67	22	3.87	11	11.515	.000*
Clients requesting or enforcing the use of BIM	3.28	11	3.79	16	3.88	15	4.63	6	3.83	12	5.717	.000*
Government Policy towards implementation of BIM	2.98	16	3.96	12	4.00	14	4.29	13	3.81	13	6.633	.000*
Provision of pilot project for BIM implementation by the Clients	2.93	20	3.79	16	4.18	8	4.56	9	3.79	14	10.973	.000*
Differences in Organisation's Objectives	3.00	15	3.91	13	3.88	15	3.96	18	3.74	15	5.380	.000*
Provision of grant scheme for BIM training	2.55	22	3.89	14	4.18	8	4.63	6	3.73	16	15.663	.000*
Reduction in the purchase and operational cost of BIM	3.53	9	3.43	21	3.82	17	4.46	11	3.71	17	3.891	.005*
Strategic implementation of BIM via collaboration by other stakeholders	2.75	21	3.86	15	3.82	17	4.13	15	3.70	18	8.727	.000*
Existing CAD system meeting design and draft needs	2.98	16	3.70	18	3.82	17	3.98	17	3.64	19	4.657	.001*
Nature of organization technical capacity	3.18	13	3.47	20	3.59	21	4.23	14	3.58	20	4.034	.004*
Differences in Organisation's culture	2.98	16	3.50	19	3.71	20	3.90	20	3.54	21	5.694	.000*
BIM awareness by other team members	2.98	16	2.60	22	3.24	22	3.90	20	3.11	22	7.872	.000*
Average Mean Value	3.35		4.00		4.06		4.36		3.95			

*Significant at 5% Level; M.S = Mean Score; R = Rank

4. CONCLUSION

This study assessed the implementation of BIM among construction professionals in Lagos State, Nigeria with consideration to the required skills, Software applications and facilities as well as drivers of BIM implementation. Structured questionnaires were used to elicit primary data from random samples of Architects, Engineers and Quantity Surveyors in the study area. Data collected were analysed using Mean Score and Analysis of Variance. From the findings of the study, it is concluded that there are gaps with regard to the require skills, software packages and facilities for BIM implementation among construction professionals. It is hence recommended that efforts be directed on training construction professionals on computing, cost modelling and computer-aided design skills as well as on organisational skills and knowledge in BIM processes and technology. It is also recommended that softwares such as Revit, Autodesk Naviswork and Cost X and internet connectivity be provided to enhance BIM implementation among construction professionals in the study area.

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6. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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