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Adoption Level of Building Information Modelling by Selected Professionals in Kwara State

[1]Anifowose, O. M., [1]Babarinde, S. A. and [1,2]Olanrewaju, O. I.
[1]Department of Quantity Surveying, Federal University of Technology, Minna, Niger State, Nigeria
[2]Dollahills Research Consult, Lagos, Nigeria

Adoption of Building Information Modelling (BIM) is a major issue of discuss among professionals concerned within the construction industry and built environment in various countries of the world. BIM represents the development and use of computer-generated n-dimensional (n-D) models to simulate the planning, design, construction and operation of a facility and it presents a paradigm shift and upturn of construction process from the traditional mode. This study assessed the adoption level of BIM by the selected professionals in the built environment. One hundred and thirty-six (136) questionnaires were administered to practising Architects, Builders, Civil Engineers, Estate Surveyors and Quantity Surveyors in Kwara-State. Data obtained from the survey were analysed using descriptive analysis (Graphs, Relative Importance Index, Mean Item Score). 40% of the respondents were familiar with the BIM concept, 77% of the respondents agreed that BIM is necessary for their profession, and there is a high level of anticipated use of BIM both for their professional activities and on building projects. Few Studies on BIM and lack of requisite knowledge served as the major deterrent to BIM adoption. The study recommended that BIM should be incorporated in the curricula of all Tertiary Institutions providing training in undergraduate programmes in built environment and also by incorporating a short term BIM training for professionals. The study provides a detailed report on the awareness, perception and disposition as well as the adoption level of BIM in Kwara-State which can be generalized for the country.

Key Words: Building Information Modelling, Adoption, Built Environment Professionals

Introduction

The introduction of technology to activities in the construction industry has proven beyond every reasonable doubt that the future of the industry is hinged on its adoption of technological innovations in its activities (Maurico, 2001). Thus, BIM is to fall in line with the new emerging technologies in the construction industry, towards achieving an efficient and sustainable construction process. Building Information Modelling deals with the use of technology through application of Information and Communication Technology in the design, use, communication and sharing of information relating between the different entities required in the design and construction of building project (Snook, 2011). In contrast to the foundation years of Building Information Modelling introduction, BIM has evolved to encompass different aspects and components, thereby it is also referred to as Building Information Management which is defined as the process in which different construction industry actors work together, efficiently exchange information (data and geometry) and collaborate to provide a more efficient construction process(e.g. less errors, faster construction) then importantly also, efficient buildings that produce less waste and are cheaper but also easier to operate. BIM is the holy grail of the construction industry considering its ardent importance and its great potential for a transformation of the Nigerian construction industry at large (Ogunde et al., 2017; Howard and Bjork, 2008) nevertheless, a lackadaisical attitude is being shown towards it in Nigeria.

Moreover, it is adjudged by Alufohai (2012) that BIM will greatly enhance transparency and accountability in the construction, and also

providing the building team with a better idea of true project costs and financial implications of variations. This has been the desire of the Nigerian Government to have a transparent procurement and construction process which offers optimal value for money to its client. BIM will also come in handy for the Nigerian construction industry due to the current administration lack of tolerance for corruption and sharp practices ensuring that the most qualified and capable contractor executes contracts (Alufohai, 2012). BIM presents a great advantage to the Nigerian professional bodies as its full use will incapacitate and eradicate "quackery" among professionals and this will eliminate 'mushroom' contractors from the bidding process. This also will challenge the qualified professionals to be committed to continuous professional development, as they are presented with newly emerging problems so it is either they develop themselves or they would be left out in the 'technological transformational train' (Babarinde, 2017). Increasingly, there is need to ascertain the level of awareness and adoption of BIM among the professionals in the Built Environment (Aluhofai, 2012; Newton and Chileshe, 2014; Yalcinkaya and Singh, 2014; Ryal-Net et al., 2015). This further requires that the peculiarities associated with BIM adoption in the built environment in Nigeria be identified and viable solutions to such be provided towards enhancing BIM adoption in Nigeria. Also, Ibrahim and Bishir (2012), opined that more research in to the level of knowledge and the use of BIM in Nigeria is required to promote its adoption and also to fill the knowledge gap existing in the body of knowledge on how Nigeria is faring in its drive towards adoption of BIM in comparison with other countries. Therefore, the paper assessed the adoption level of BIM among Built Environment Professionals in Nigeria under the following objectives:

1. To examine the awareness level of BIM uses among the professionals
2. To evaluate the level of usage of BIM software among the professionals
3. To identify and assess the factors influencing BIM adoption.

Literature Review

The introduction of the technology has been defined as a landmark turning point in the construction industry; it has reshaped the way in which construction activities are being carried out in the built environment (Reddy, 2012; Ahmad-Latiff et al., 2013). After the introduction of CAD to the construction industry, it was first championed by sketch pad which was developed by Ivan Sutherland in 1962, subsequently then Autodesk also developed a 2D system named AutoCAD which came with various capabilities and which is being improved upon on each revision and new feature being added to its platform (Vogt, 2010). Then upon later revisions the 3D CAD emerged as a technological revision to solve some problems associated with 2D CAD and became the delight of design firm and architects (Yan and Damian, 2009), it was upon CAD platform that BIM ensued from in which it incorporated intelligent modelling (Vogt, 2010). It is the desire of humans to always improve on existing technology, issues related with the use of 2D & 3D CAD systems necessitated the desire for an improvement which was discovered in BIM. CAD drawings were believed to be unintelligent as it lacks the conflict and clash detection ability, fragmentation of drawings (Plan, Elevations and Sections cannot interrelate automatically), and no collaboration of professionals (Ibrahim and Abdullahi, 2016). Furthermore, CAD drawings have also been criticised by Ibrahim and Abdullahi (2016) for constructability and communication issues, difficulty in understanding the CAD drawings by untrained clients, and the bulk of drawings produced in the building life upon revision of any building component or element.

The BIM concept originated out of major efforts directed at digitizing the paper-based communication existent in the Architectural. Engineering and construction (AEC) industry in the Pre-1960 era (Ibrahim and Abdullahi, 2016), from the period of its inception of use, it has been enriched with more capabilities and this is denoted using the various dimensions of BIM with the dimensions ranging from 3D to 7D and nD (Aouad et al., 2006) as more capabilities will be incorporated. This has furthermore enlarged

the scope of coverage of BIM use from the design stage only (Visualization Properties; 3D) varied to include the Construction and Operation stages of the building process and this include Estimation (5D), Life cycle Management (7D), Sustainability (6D) among others (Reddy, 2012; Ahmad-Latiff et al., 2013).

Due to the ever-evolving nature of BIM, the concept of BIM cannot be given a concise definition as a wide range of definitions ensue from the users and professionals first-hand experience thus giving rise to contradictions. Just as Pentila (2006) opined that BIM has a tripartite interaction: process, policies and technology, while in consonance with Macdonald (2011) that BIM involves the process, culture and technology. This places BIM at the centre of all interactions between the different professions in the built environment (Smith and Tardiff, 2012). BIM has an ardent component of interaction; The BIM software. Across time, various software that are BIM compliant has been and is being developed to meet the rising demand for BIM enabled construction in the AEC industry, a major player in the BIM software remains the Autodesk, being pioneers of BIM software they have continued to maintain the lead in terms of software production to be used in BIM (Ibrahim and Abdullahi, 2016). Software from them include Autocad, Revit Architecture, Autodesk Quantity Takeoff, Green Building Studio among others with other vendors producing Archicad, ArchiFM, Sketchup, PowerCivil among other software (Hergunsel, 2011).

Adopting BIM in Nigeria has been the talk of most professional bodies with some various conferences, seminars and colloquial organized with some of their major agenda being BIM proliferation among their members. Thus, in comparison with other countries, the only BIM project in Nigeria as of present is the Eko-Atlantic City with its inception since 2010; the project is in its final stages. This project is largely acclaimed to have none effect in encouraging BIM adoption use in the country because the major share of the project team was sourced outside the country with the local professionals left an insignificant aspect to be handled by them (Babarinde, 2017). In disparity with other countries like the UK which has a more pronounced application of BIM, with its government mandating its use on public project by 2015 (Granholm, 2011). Like wildfire BIM has continued to spread across the various continents of the world, with its use and implementation strategy being formulated and applied from various countries ranging from Singapore, Malaysia, China and South Korea in the Asian continent (Sharif, 2011) to countries like UK, Canada, Denmark, Czech Republic subsequently to South Africa, Egypt, Nigeria and Ghana in the African Continent. This shows an intercontinental landscape of adoptive strategies of BIM, the result of these strategies is yielding result as shown by NBS International BIM report in 2016 as summarized in Table 1.

Table 1: Summary of the NBS International Report

Countries	UK (%)	Canada (%)	Denmark (%)	Czech Republic (%)	Japan (%)
Awareness	95	98	96	51	92
Current Usage of BIM	48	67	78	25	46
Lack of Clarity on BIM	67	56	77	49	78
Future Usage (5 years' time)	95	85	93	90	88

Source: NBS International BIM report (2016).

From the summarized report above, there is seen to be a dearth of information regarding BIM in Nigeria and Africa as a whole. This study was designed to fill this void.

In adopting BIM as it is with the introduction and application of every new innovation there exists a compendium of factors that influence its adoption and ease of use, this is as identified and highlighted by various authors including Eastman et al. (2011); Hergunsel (2011); Lee et al. (2015); Aderele and Etiene (2016) among others.

Research Methodology

The study employed quantitative research technique with the use of questionnaires to source relevant information from respondents. This method was described as useful for generating and processing measurable key indicators that can be expressed in figures and units (Glatte, 2015; Anifowose et al., 2016). The purpose of this study to assess the adoption level of building information modelling by professionals in the Nigerian built environment. Structured questionnaires aimed at evaluating the awareness level of BIM uses, level of BIM software usage, and influence level of factors affecting BIM adoption in Nigerian built environment was developed from information gathered during literature review. The questionnaires were administered to built environment professionals practising in Kwara State, they included Architects, Builders, Civil Engineers, Estate Surveyors and Valuers, and Quantity Surveyors. A stratified sampling technique was adopted to ensure a fair representation of all the professions, 90 out of the 136 administered questionnaires were retrieved representing a total of 66% response rate. The data collected was analysed using descriptive analysis i.e. frequency, percent, mean item score and relative importance index methods to determine the ranking and relative importance of the factors affecting BIM adoption. Also mean item score ranking was used for ranking BIM uses in order of other level of respondents' awareness. The RII was computed from the rating indicated by each of the respondents with the use of a five-point Likert scale for both factors and the BIM uses while a three point Likert scale was adopted for the usage of the BIM software.

Research Findings

Characteristics of Respondents

The characteristics of the respondents were categorized using the profession, gender, professional background, Academic qualification, working experience and type of practice. The analysis of these shows that 80% were male and 20% female of the total number of the respondents with the quantity surveyors having a majority (24%), followed by Builders and Civil Engineers with 20%, following closely by Architects with 19%and Estate Surveyors with 17%. 1% of the respondents were PhD holders, 40% had Bachelor's Degree. 34% had HND, 22% had Master's Degree and 3% were OND holders. The Descriptive analysis of the research also shows that 40% of the respondents have 5-10 years of working experience, 32% had less than 5 years working experience, 12% had 11-15 years, 10% had 16-20 years with the lowest being 21 years and above having 6%. Furthermore, 47% of the respondents engaged in Government practice, 35% were independent practitioners, and both consortium and academia practices had 9% each.

Awareness Level of BIM Uses in the Nigerian Built Environment

The Mean Score ranking was adopted in assessing the awareness level of BIM Uses among the professionals at different stages of the project lifecycle. The identified uses span from the design, construction to the maintenance/ operation stages. From the table as presented below, it can be inferred that the mean scores are within average this signifies that there is an increasing level of awareness about what BIM is being used for in the Building Construction Industry in Nigeria. At the Design Stage, Cost Estimating was ranked first with a mean score of 3.32 from data analysis, Construction Planning is ranked 2nd with a mean score of 3.32 following Cost Estimating closely with a differential of 0.01, thus both Uses can be deemed as the most popular use of BIM in the design stage. Also, 3D Coordination and Prefabrication are ranked as 3rd and 4th with a mean score of 3.14 and 3.07 respectively, while Sequencing is the least mean score in the design stage with a ranking of 7th. In the Construction Stage, Construction Monitoring

ranked 1st with a mean score of 3.03, Maintenance Scheduling and Fabrication ranked 2nd and 3rd respectively with mean scores 2.97 and 2.79 respectively. Hence, Monitoring of Construction using BIM is reckoned to be the use most professionals are aware of in the construction stage of a building. However, at the maintenance stage, Asset Management ranked as the 1st with Mean score of 2.90, Building System Analysis ranked 2nd with a mean item score of 2.59 and Record Modelling ranked 3rd with mean score, 2.49. This tells us that the respondents are most aware of the use of BIM in Asset Management and has least awareness of its use in Record Modelling in the Maintenance/ Operation Stage.

Level of Usage of BIM Software

From the collected data, relative importance index was used in ranking the software according to their usage level. According to the analysed information, Revit Architecture represents the most used software with a RII of 0.58, this software is mostly employed by Architects and other design professions, it is produced by Autodesk one of the fore-runners in terms of BIM software. Sketchup and Archicad follows with a RII of 0.48, these are also design software mostly used by architects. From the above results, it can be safely agreed that the architects have a comparative advantage over other professionals.

Table 2: Awareness of BIM Uses

	Mean Item Score	Rank
Design Stage		
Cost Estimation	3.32	1
Construction Planning	3.31	2
3D Coordination	3.14	3
Prefabrication	3.07	4
Visualization	3.04	5
Constructability Analysis	3.02	6
Sequencing	2.8	7
Construction Stage		
Construction Monitoring	3.03	1
Maintenance Scheduling	2.97	2
Fabrication	2.79	3
Maintenance/ Operation Stage		
Asset Management	2.9	1
Building System Analysis	2.59	2
Record Modelling	2.49	3

Table 3: Level of Usage of BIM

Software	Frequency of Response			RII	Rank
	3	2	1		
Revit Architecture	25	17	48	0.58	1
SketchUp	12	16	62	0.48	2
Archicad	13	13	64	0.48	2
PowerCivil	13	11	66	0.47	4
Autodesk Quantity Takeoff	9	9	72	0.43	5
QS CAD	11	5	74	0.43	5
Tekla Structures	11	3	76	0.43	5
Bentley BIM Suite	9	4	77	0.41	8
Navisworks Manage	8	5	77	0.41	8
ArchiFM	7	3	80	0.4	10
Digital Project	5	5	80	0.39	11
Green Building Studio	5	3	82	0.38	12
Masterbill	3	3	84	0.37	13
Ecotect Analysis	0	5	85	0.35	14
VICO Software	0	4	86	0.35	15

Factors influencing the adoption of BIM adoption

These factors include the drivers of BIM adoption which encourage its adoption by the professionals and the Barriers which serve as deterring factors are presented in Tables 4 and 5.

Table 4 presents the drivers of BIM Adoption. Construction Process Visualization was ranked as the most importance factor aiding adoption of BIM with a RII of 0.74, followed by increased efficiency and coordination in terms of cost and time with a RII of 0.71. Controlled Whole-Life Costs and Environmental Data, and Improved Quality and Increased Sustainability were ranked 3rd on the list of ranking with RII of 0.69 respectively, while Green Building Standards Incorporation ranked last with a RII of 0.64.

Table 4: Drivers of BIM Adoption

Drivers	Frequency of Response					RII	Rank
	5	4	3	2	1		
Construction Process Visualization	2	5	38	17	28	0.74	1
Increased Efficiency and Coordination: Cost and Time	4	13	28	20	25	0.71	2
Controlled Whole-Life Costs and Environmental Data	5	10	34	21	20	0.69	3
Improved Quality and Increased Sustainability	4	16	25	26	19	0.69	3
Life-Cycle Data	4	17	28	22	19	0.68	5
Improved Productivity and Collaboration	1	15	38	20	16	0.68	5
Clients' Demand	6	10	42	17	15	0.66	7
BIM-Enabled Estimating Capabilities	4	12	42	16	16	0.66	7
Improved Customer Service	2	25	24	23	16	0.66	7
Synchronized Design and Construction Planning	6	12	36	20	16	0.66	7
Potential Economic Benefits	3	15	41	17	14	0.65	11
Improved Decision Making Process	7	16	29	24	14	0.65	11
Green Building Standards Incorporation	7	19	28	19	17	0.64	13

Table 5: Barriers to BIM Adoption

Barriers	Frequency of Response					RII	Rank
	5	4	3	2	1		
Few studies available on BIM and lack of knowledge	0	11	22	35	22	0.75	1
Inexistence or Inadequate Government Policies	2	13	27	28	20	0.71	2
High Cost of Implementation	0	15	22	43	10	0.71	2
Lack of Training and Skills	4	11	33	24	18	0.69	4
Lack of Specified Standards	4	19	24	28	15	0.67	5
Lack of demand for use and Acceptance of BIM	3	12	39	28	8	0.66	6
Inadequate Contractual Coordination	3	22	26	30	9	0.64	7
Technological Availability Issues	5	16	33	28	8	0.64	7
Cost of Data and Information Sharing	5	17	33	26	9	0.64	7
Collaboration Issues	4	15	40	23	8	0.64	7
Reluctance of other stakeholders	7	16	34	26	7	0.62	11
Software Availability Issues	9	16	35	18	12	0.62	11
Data and Intellectual Property Issues	7	18	37	17	11	0.62	11
Interoperability Issues	6	24	42	16	2	0.56	14

Table 5 presents Barriers to BIM Adoption; Lack of Studies and inadequate knowledge being the most influential factor opposing the adoption of BIM with a RII of 0.75, followed by Inexistent Government Policies, and High Cost of Implementation ranked 2nd with RII of 0.71 respectively, Lack of Training and Skills was ranked 4th with RII of 0.69, and lack of specified standards ranked 5th with RII of 0.67, while Interoperability issues having a RII value of 0.56 and was ranked 14th.

Discussion of Results

The first objective of the research is to determine the awareness level of BIM uses by built environment professionals, the results of the data analysis shows that the selected professionals were more aware of BIM uses in the Design Stage with Cost Estimation having a MIS of 3.32, in which Construction Monitoring in the Construction stage has a MIS of 3.03 and Asset management with an MIS of 2.90 in the Maintenance /Operation Stage of projects. This hence is in affirmation with Akerele et al. (2016) but in slight deviation from the ranking of the various uses, the MIS were noticed to be higher than those recorded in their study. This shows that is an increasing awareness level of the uses but this awareness level is still highly deficient in the Post Construction Stage. The result of the research also is in consonance with Rogers et al. (2015) where he claimed that the Design Professionals are the high flyers of BIM Usage in the construction industry.

The second objective of this study is to evaluate the level of usage of BIM softwares among the professionals in the built environment; this listed and evaluated the usage of various BIM-compliant softwares available to professionals. The results show that Revit Architecture; a software majorly used by Design Professionals had the highest usage with a RII of 0.58, subsequently, the next two softwares ranked with the highest uses were also used by design professionals namely Sketchup with RII of 0.48, Archicad with RII of 0.48. This also, clearly outlines that the Design professionals are ahead of others in terms of usage and implementation of BIM and not just in terms of awareness only as

stated by Akerele et al. (2016) and Aluhofai (2012). This study also shows that the Post Construction/Maintenance stage is seriously lagging behind in the adoption of BIM for their professional activities as encouraged by IFMA (2007).

The third objective of this study is to identify and assess the influencing factors of BIM adoption, the factors affecting the adoption of BIM was hence, divided into two major types according to the type of influence they have on its adoption. Some of the identified factors were categorized as drivers of BIM adoption and barriers of BIM adoption. Drivers of BIM adoption was identified and they were analysed in which the construction process visualization with RII of 0.74 and Green building standard incorporation with RII of 0.64 were ranked as most and the least influential drivers of BIM adoption with other uses ranking between these two with fairly higher values of RII as provided by Akerele et al. (2016) and also as enunciated in Yan and Damian (2009). Among the various barriers considered, 'Availability of Few Studies and lack of knowledge with RII of 0.75 was the most influential of all the factors considered. This is because knowledge of a matter and availability of studies triggers knowledge thus this has in a larger proportion prevented the adoption of BIM the most, this goes side by side with studies by Bernstein (2004) and Hosseini et al. (2016). The factor with the least ability to deter the adoption of BIM as considered in the study is Interoperability Issues with an RII of 0.56 barely falling into the category of factors significant enough to deter adoption of BIM. This is because the adoption of BIM by professionals in the Nigerian construction industry is not yet matured enough to evenly distribute its usage across the various stages of building, thus the usage of BIM-Compliant softwares are basically limited to each stage of the building process.

Conclusion and Recommendations

The result of this study shows that: awareness and knowledge of BIM is on the increase among professionals, due to various concerted efforts, also there is a ripple effect of lack of BIM awareness among building management professionals is seen in the extremely low level of Awareness of what BIM can be used for in the post construction stage of the building. Also, the study shows a decline in the awareness of BIM Uses from Design down to the post construction stage. Few Studies on BIM and lack of requisite knowledge served as the major deterrent to BIM adoption. It is evident from the study that BIM adoption in Nigeria is at its infancy stage because majority of the knowledge of BIM that exists only theory. This study recommended thus:

i. BIM should be incorporated in the curricula of all Tertiary Institutions providing training in undergraduate programmes in built environment and also by incorporating a short term BIM training for professionals.
ii. Federal Government should as a matter of urgency, constitute a board consisting of trained and knowledgeable BIM professionals to draft out BIM implementation roadmap in Nigeria and also mandate the use of BIM on Public projects.
iii. Development and mass production of indigenous building industry software should be encouraged. The software developers should be mandated to meet up with international standards and factor in low specifications.

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