Challenges Of Building Information Modelling Implementation In Africa A Case Of Nigerian Construction Industry

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Keywords: Building Information Modeling, Challenges, Implementation, Nigeria Construction Industry

SUMMARY

This paper discusses the challenges of Building information modeling implementation in the Nigerian construction Industry. The need to innovatively integrate the construction process and address project development challenges has to do with the integration of building information modeling (BIM) in the building design and development cycles. However the adoption of BIM in the Nigerian construction Industry is not encouraging and its implementation is poor. Data were collated through a designed questionnaire by identifying the challenges affecting BIM implementation and the various approaches to overcoming BIM challenges in the Nigerian construction industry. Data were analyzed and ranked using Relative Importance Index (RII), simple percentages, pie charts and bar chart. Research findings indicate that lack of BIM education with an RII value of 0.79 and lack of information on BIM with an RII value of 0.76 are very significant challenges of BIM implementation in the Nigerian construction Industry. It also reveals that Increase research for BIM technology in Institutions of Higher learning with RII of 0.78, Conduct BIM skills development programmes with RII values of 0.76 are very significant approaches to overcoming the challenges of BIM implementation in Nigeria. The study suggests that BIM education should be a priority and information on BIM should be made available in the Nigerian construction industry.

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1.0 INTRODUCTION

Building Information Model is a perception which has been identified and viewed by many authors in different ways. Karen (2014) defined BIM as an integrated, structured digital database, informed by the architecture, engineering, and construction, operations (AECO) industry that consist of 3D parametric objects and allow for interoperability. BIM is an improved process and tool, which contains a set of virtual aspects, concepts and systems of a facility within one environment (Azhar, *et al* 2012). Sacks (2010) described BIM as the utilization of a database infrastructure to summarize built facilities with specific viewpoints of stakeholders, so that stakeholders can query, simulate and estimate activities and monitor the building process as a lifecycle entity. Arayici and Aouad (2010) also defined BIM as the use of ICT technologies to streamline the building lifecycle processes to provide a safer and more productive environment for its occupants, to assert the least possible environmental impact from its existence, and to be more operationally efficient for its owners throughout the building lifecycle. Arayici and Coates (2012) also viewed BIM in most simple terms as the utilization of a database infrastructure to encapsulate built facilities with specific viewpoints of stakeholders. It is a methodology to integrate digital descriptions of all the building objects and their relationships to others in a precise manner, so that stakeholders can query, simulate and estimate activities and their effects on the building process as a lifecycle entity.

BIM involves the detailed and complete replication of a building in a digital environment with the sole goal of providing a collaborative platform for managing Building information throughout the lifecycle of a facility (Aouad et al., 2014). BIM is the process of creating a digital parametric model which represents the physical and functional characteristic of a building in full detail and further shared knowledge pool which can be used to form reliable decisions during the design, construction phases and throughout the life cycle of the facility (Eastman *et al.*, 2011; Suranga and Weddikkara, 2012).

(Mohammed & Ahmad 2017) asserted that Construction companies are faced with the need to innovatively integrate the construction process and address project development challenges. One way of doing that is the integration of building information modeling (BIM) in the building design and development cycles.

2.0 BIM AND THE NIGERIAN CONSTRUCTION INDUSTRY

The construction industry plays a significant role in the national economy and economic development of any nation. Its significance is due to the role it has in the economy, but that role varies greatly from one nation to another. In developing countries, the construction industry is a very important sector providing mainly new infrastructure in the form of roads, railways, airports as well as new hospitals, schools, housing and other buildings (Dakhil 2013).
The construction industry is a key industry in many countries, usually making up to 5–10% of the overall gross domestic product (GDP) (Park and Hong 2012). After restructuring and re-basing Nigeria Account at 2010 constant basic price, Nigeria's economy became the largest in the Sub-Saharan African. Consequently, Nigeria's GDP increased from 18% in 2009 to around 32% in 2013 and thus outpaced the South African economy which used to be the largest economy, but whose share decreased from 30% in 2009 to 22% in 2013 (EMIS 2015). The sudden drop was as a result of the current slump in oil prices which caused serious problem for the Nigeria economy and presented a major risk for the construction industry. This has resulted to reduced budget revenues and restricted the government's abilities for infrastructure investment, thereby, leading to freezing of budget-funded projects and increased number of redundant people in the construction Industry (EMIS 2015). Ogwueleka and Ikediashi (2017) asserted that the global construction industry is on the verge of significant shift in the ways projects are delivered by focusing not only on traditional design but environmental, economic and social effects of a building project as a whole. However, Mohammed & Ahmad (2017) asserted that Construction companies are faced with the need to innovatively integrate the construction process and address project development challenges.
The construction industry is undergoing a radical change as project owners are demanding for more project visibility at lower cost and better risk management; this has increased the use of new technologies in project implementations (Ogwueleka and Ikediashi 2017). One way of doing that is the integration of building information modeling (BIM) in the building design and development cycles (Mohammed & Ahmad 2017). Olorunkiya, (2017) posited that the adoption of BIM is a healthy disruption to changing the status quo. It is arguably the right way to go in the face of global competition and increasing clients 'demands for quality projects to be delivered within or below budget and time. The Nigerian construction industry will benefit immensely from the adoption and integration of BIM in order to improve on the current fragmented and highly uncoordinated way of working among construction professionals.

2.1 BIM implementation and it challenges in Nigeria.

Building Information Modeling (BIM) is a cutting edge technology that has addressed prominent challenges in the Architecture, Engineering and Construction (AEC) industries in most of the developed countries. Construction industries in developing countries due to

identified challenges and unavailability of the clear understanding of best practices, are dithering whether to adopt this technology (Sahil 2016).
Research studies over the years have highlighted a number of challenges that affect BIM implementation such authors include; (Ibrahim and Ahmad 2016; Eastman et al. 2011)
Ibrahim and Ahmad (2016) identified the following as BIM challenges; Challenges with collaboration and teaming, legal changes to documentation ownership and production, Changes in practice and use of information, Implementation issues among others. The Royal Institute of Chartered Surveyor (2015) confirmed 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 as major challenges faced in the adoption of BIM technologies. Looking at construction projects in developing countries that still use traditional technology they find that projects in those countries are experiencing challenges within their construction industries due to rework (Sahil 2016).

In order to enable the adoption and implementation of BIM by organizations, designers and managers, need an in- depth understanding of factors that lead and hinder BIM utilization has to be achieved. The factors leading to BIM adoption can be examined on the individual, organizational and institutional levels (Doumbouya etal, .2016)

3.0 RESEARCH METHOD

This paper focuses on the challenges of Building Information Modeling implementation in the Nigerian Construction Industry. It is designed broadly into two parts; the first part of this work comprised of literature survey which was carried out to provide the background information on Building Information Modeling. Information was obtained through literature search; this included books and articles in libraries and online materials. The second part of the study entail field survey and the main instrument employed is structured questionnaires. A well-prepared and structured questionnaire was designed, self-administered and also administered on Google. The data obtained from the questionnaire was tabulated and analyzed using both descriptive and inferential analysis. Tables, means, pie charts, bar charts RII and percentages were used to express the result.

The target population of this research was the Nigerian Building Design firms. The study identified Architectural, Engineering, Building and Quantity Surveying consultancy firms as those responsible for design of buildings in Nigeria. According to Abubakar *et al* (2017) a list of registered Design firms by Corporate Affairs Commission shows that there are 8200 registered design firms across the country.

3.1 Sample Size

The target population is 8200 firms. The sample size of the research was calculated using Yamanes' formula in Singh and Masuku (2014) for calculating sample size as indicated below.

n= N/ {1+N (e) 2}
Where n represents Sample Size, N represents population= 8200, e = 0.050
n=8200/1+8200(0.050)2
Therefore, the sample size equals 321 (Three hundred and twenty one)

QUESTIONNAIRE	NUMBER	PERCENTAGE
1. Distributed	321	100
2. Retrieved Questionnaire	144	44.86
3. Not Returned	177	55.14

Table 2 shows the response rate of respondents in the study. As shown in this Table, out of a total of 321 questionnaires distributed, only 144 (44.86%) were completed and returned, while the remaining 116 (36.14%) were not returned. However, going by Moser and Kalton (1971) assertion that the outcome of an investigation should be regarded as being biased and of little importance if the questionnaire returned is less than 30-40%, the number of questionnaires completed and returned were therefore considered adequate for analysis

3.2 Relative importance index (RII)

Relative importance index was used in the study to rank the challenges militating against the implementation of BIM in Nigeria.

Relative Importance Index (RII) $= \frac{\sum fx}{\sum f} \times \frac{1}{k}$**---------------------------- 3.1**

Where,

$\sum$fx = is the total weight given to each attributes by the respondents.

$\sum$f = is the total number or respondents in the sample.

K = is the highest weight on the likert scale.

Ranking of the items under consideration based on their RII values. The item with the highest RII value is ranked first (1) the next (2) and so on.

3.4 Guide to Degree of Significance

DEGREE OF SIGNIFICANCE	RATING
Very significant	0.76 above
Significant	0.67-0.75
Fairly significant	0.45-0.66
Not significant	0.44 below

Vanduhe (2012)

3.3 Data analysis

The pie chart as shown in figure 1 below describes the distribution of respondents based on their academic qualification. It can be seen that Quantity Surveying tops the list with 37% representation, followed by Architecture with 35%, Building Technology with 10%, Mechanical/Electrical Engineering with 6%, and Structural/Civil Engineering with 4%, while the “Others” category had 4% representation which included individuals with academic qualifications in Procurement and Supply Chain Management, and Industrial Design. This shows that there is adequate representation of professionals in the study.

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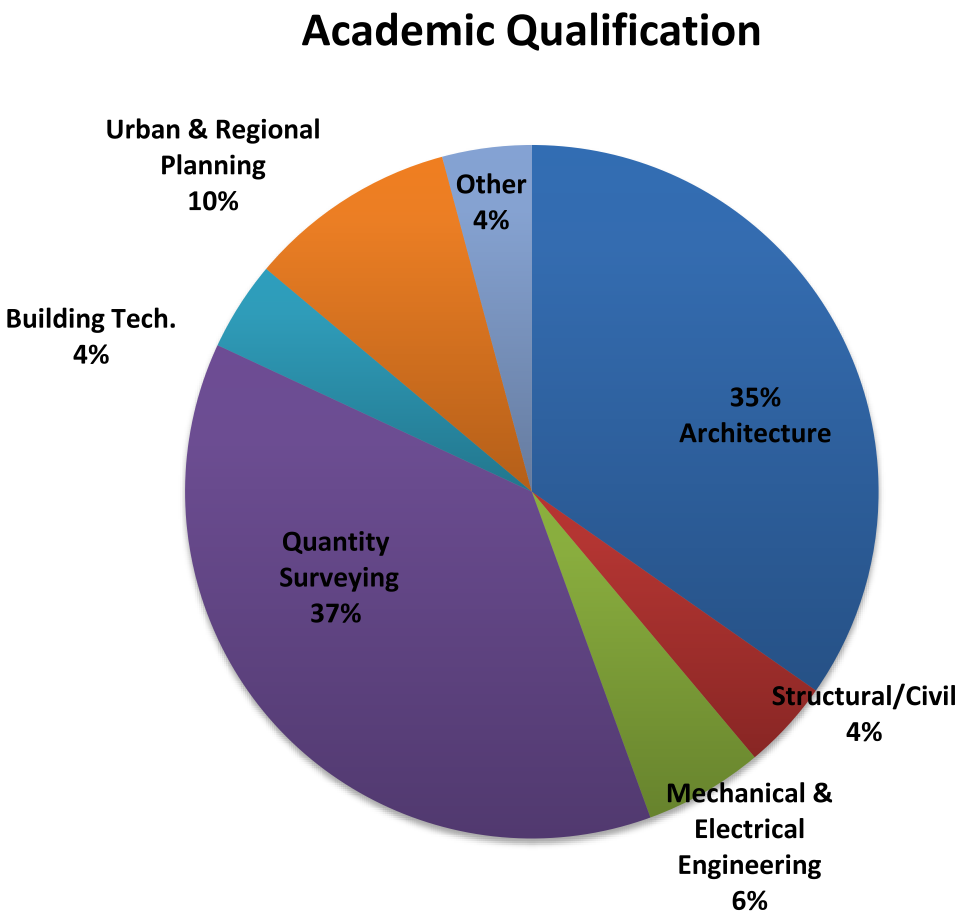

Figure 1: Academic Qualification of Respondents (Source: Field Survey, 2018).

The bar chart as shown in figure 2 below describes the distribution of respondents based on their area of Professional/Practical experience in the Nigerian Construction Industry, where

Consultants topped the list with 45.83% representation, followed by Contractors with 15.28%, Client (Government) with 11.11%, Client (Private) with 9.72%, Academics with 6.94%, while Planning/Regulatory Institution has 2.78% representation. This shows that the consultants have more representation in the study.

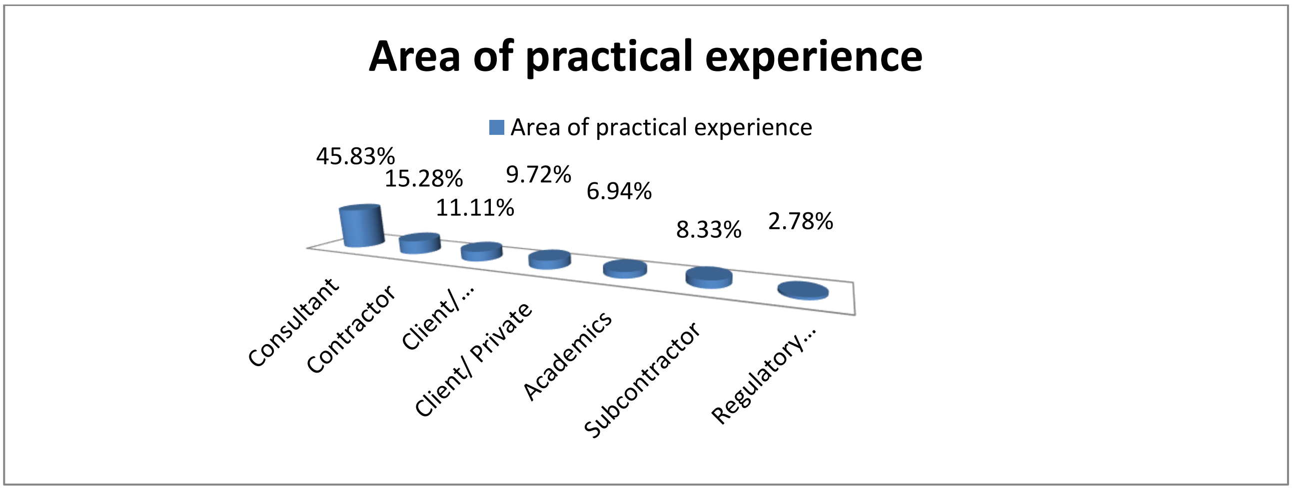

Figure 2: Area of Professional/Practical experience (Source: Field Survey, 2018).

The pie chart as shown in figure 3 below describes the distribution of respondents based on their years of Professional experience, where respondents with 1-5years of experience topped the list with 27.8% representation, followed by respondents with 16-25 years of experience with 26.4%, and respondents with 6-10 years of experience taking 18.1% share. Respondents with 11-15 years experience and above 25 years experience were represented with 15.3% and 12.5% respectively.

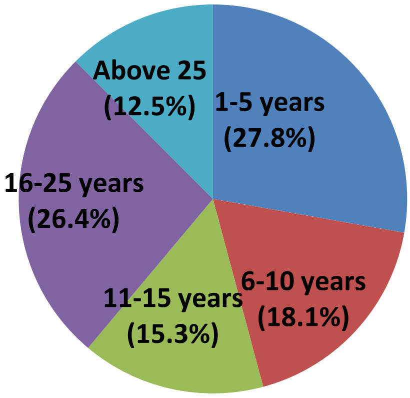

Figure 3: Years of Professional experience (Source: Field Survey, 2018).

The bar chart as shown in figure 4 below describes the distribution of respondents based on BIM users within organizations. It can be seen that Designers are the most users of BIM with 44.4% representation. This is followed by Management and Estimators both tied at 18.1%, Students (i.e. 11.1%), and Teachers (8.3%).

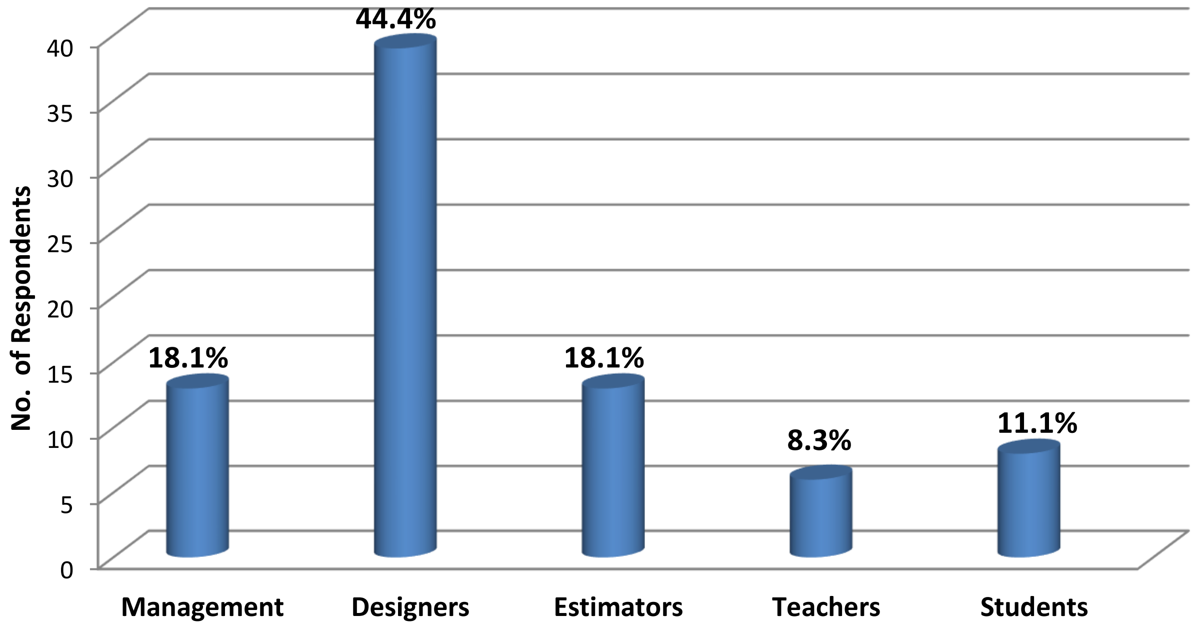

Figure 4: Respondents distribution of BIM Users (Source: Field Survey, 2018).

The pie chart as shown in figure 5 below describes the distribution of respondents based on their years of experience of using BIM. 47.2% of respondents have between 1-5 years experience utilizing BIM, followed by users with 6-10 years of BIM experience at 16.7%, while 12.5% of respondents have less than a year's experience using BIM. However, 23.6% of respondents have no experience using BIM. The responses made it clear that BIM in Nigeria is still in the infant stage owing to the fact that 47.2% of the respondents have 1-5years experience.

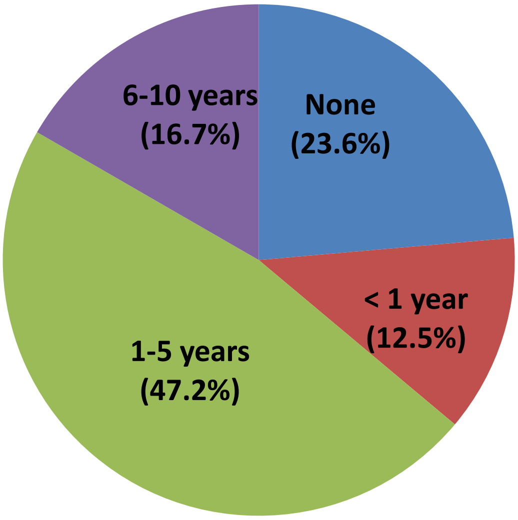

Figure 5: Years of Experience of Using BIM (Source: Field Survey, 2018).

Table 2: BIM Software utilized by Respondents

Building Information Modeling (BIM) Software	No. of Respondents in Ordinance Scale					Total	*Efx*	Mean	Relative Index (RI)	Rank
	1	2	3	4	5					
AutoCAD Architecture	20	12	24	44	44	144	512	3.56	0.71	1
Revit Architecture	40	24	24	28	28	144	412	2.86	0.57	2
ArchiCAD	34	32	26	36	16	144	400	2.78	0.56	3
Sketch up	46	24	24	30	20	144	386	2.68	0.54	4
AutoCAD Civil 3D	66	36	20	16	6	144	292	2.03	0.41	5
Revit Structure	66	28	30	12	8	144	300	2.08	0.42	6
AutoCAD MEP	70	34	20	18	2	144	280	1.94	0.39	7
Arc GIS	74	34	22	10	4	144	268	1.86	0.37	8
Revit MEP	80	28	22	10	4	144	262	1.82	0.36	8
Land Desktop Development	98	12	16	12	6	144	248	1.72	0.34	9
Vector Works	92	24	12	12	4	144	244	1.69	0.34	10
Staad Pro	106	12	8	10	8	144	234	1.63	0.33	11
Orion	102	18	10	10	4	144	228	1.58	0.32	12
Navisworks	104	18	10	8	4	144	222	1.54	0.30	13
Tekla	116	8	12	2	6	144	206	1.43	0.29	14
Bentley Systems	112	16	8	4	4	144	204	1.42	0.28	15
FM Desktop	114	18	6	2	4	144	196	1.36	0.27	16
InfraWorks	116	16	6	2	4	144	194	1.35	0.27	17

Catia	118	14	6	2	4	144	192	1.33	0.27	18

Source: Field Survey (2018)

The most common BIM software often utilized by the respondents are AutoCAD Architecture with an RII Value of 0.71 showing that it is a significant software that is widely used. Revit Architecture, ArchiCAD, and Sketch Up; all ranking between 0.54 to 0.57 RII score indicating that they are fairly significant software that are also used. Also, AutoCAD Civil 3D, Revit Structure, AutoCAD MEP, Arc GIS, and Revit MEP have low utilization by respondents with RII value of 0.44 below implying that they are not significant software that is used. These BIM tools remain less utilized in the Nigerian construction industry.

Table 3: Challenges of BIM Implementation.

Challenges to BIM Implementation	**No. of Respondents in Ordinance Scale**					***E f***	***Efx***	**Mean**	**Relative Index (RI)**	**Rank**
	1	**2**	**3**	**4**	**5**					
Lack of BIM education.	2	20	14	56	52	144	568	3.94	0.79	1
Lack of Information on BIM	4	20	22	52	46	144	548	3.81	0.76	2
Lack of Investment in BIM Technology	10	12	24	60	38	144	536	3.72	0.74	3
Lack of Government Support through legislation	16	12	24	46	46	144	526	3.65	0.73	4
Lack of Standards to Guide Implementation	8	16	30	56	34	144	524	3.64	0.73	4
Lack of sufficient ICT Infrastructure	8	20	26	54	36	144	522	3.63	0.73	4
Lack of Collaborative Procurement Systems to support BIM	6	20	30	60	28	144	516	3.58	0.72	7
Lack of Trained Professionals to handle the tools	8	22	28	52	34	144	514	3.57	0.71	8
Inadequate Power Supply	8	24	36	34	42	144	510	3.54	0.71	8
Lack of Demand from Clients	10	24	26	48	36	144	508	3.53	0.71	8
Lack of Management Support	6	18	50	50	20	144	492	3.42	0.68	11
Social and Habitual Resistance to Change	12	18	36	56	22	144	490	3.40	0.68	11
Challenges arising from licensing procedures	10	22	36	58	18	144	484	3.36	0.67	13
High Cost of Training	10	24	40	48	22	144	480	3.33	0.67	13
Lack of Support from the Industry	16	22	30	50	26	142	480	3.33	0.67	13
Unwillingness to change from traditional paper-based practices	18	34	26	28	38	144	466	3.24	0.65	16
High Cost of Implementation of BIM	12	24	40	60	8	144	460	3.19	0.64	17

Challenges arising from copyright procedures	10	28	46	48	12	144	456	3.17	0.63	18
Hesitation to Learn new technology	12	36	40	30	26	144	454	3.15	0.63	18
Constraints in Interoperability amongst project teams	14	18	58	42	12	144	452	3.14	0.63	18
Culture Shock (Contrary to common practice)	14	22	38	28	20	144	494	3.43	0.69	21
No proof of financial benefits	20	32	44	38	10	144	418	2.90	0.58	22
Challenges arising from insurance issues	12	44	44	38	6	144	414	2.88	0.58	23
Legal and Contractual Constraints	14	44	46	28	12	144	412	2.86	0.57	24
Complicated Modelling process	18	40	44	32	10	144	408	2.83	0.56	25

Source: Field Survey (2018)

The challenges of BIM implementation in Nigeria as opined by the respondent's shows that lack of BIM education with an RII value of 0.79 and lack of information on BIM with an RII value of 0.76 are very significant challenges of BIM implementation in the Nigerian construction Industry. However, Lack of Investment in BIM Technology, lack of Government support through legislation, lack of standards to guide implementation, lack of sufficient ICT Infrastructure, lack of collaborative procurement systems to support BIM, lack of trained professionals to handle the tools, inadequate power supply, lack of demand from clients, lack of management support, social and habitual resistance to change, challenges arising from licensing procedures, High Cost of training, lack of Support from the Industry all are within the RII value of 0.67- 0.75. This shows that they are also significant challenges affecting the implementation of BIM in the Nigerian construction industry.

Unwillingness to change from traditional paper-based practices, high cost of implementation of BIM, challenges arising from copyright procedures, hesitation to learn new technology, constraints in interoperability amongst project teams, culture shock (contrary to common practice), no proof of financial benefits, challenges arising from insurance issues, legal and contractual constraints, complicated modeling process are also within the RII value of 0.45-0.66 implying that they are also fairly significant challenges affecting the implementation of BIM in the Nigerian Construction Industry.

Table 4: Approaches to Overcoming the Challenges of BIM Implementation.

Approaches to Overcoming the Challenges of BIM Implementation	**No. of Respondents in Ordinance Scale**					**Total**	***Efx***	**Mean**	**Relative Index (RI)**	**Rank**
	1	**2**	**3**	**4**	**5**					
Increase research for BIM technology in Institutions of Higher learning	2	20	14	56	52	144	568	3.94	0.78	1
Conduct BIM skills development programmes	4	20	22	52	46	144	548	3.81	0.76	2
Conduct workshops on BIM benefits to create awareness amongst stakeholders	16	12	24	46	46	144	526	3.65	0.73	3

Introduce Collaborative Procurement Systems to support BIM technology	8	16	30	56	34	144	524	3.64	0.73	3
Develop forms of contracts for stakeholders for intellectual property of BIM technology	8	20	26	54	36	144	522	3.63	0.73	3
Develop adequate infrastructure to support BIM technology	6	20	30	60	28	144	516	3.58	0.72	6
Have Government enforce the usage of BIM as a primary requirement for procurement in the construction industry	8	22	28	52	34	144	514	3.57	0.71	7
Develop forms of contracts for stakeholders for insurance of BIM technology	8	24	36	34	42	144	510	3.54	0.71	7
Communicate lessons learned from the pilot projects to all stakeholders	10	24	26	48	36	144	508	3.53	0.70	9
Increase Client demand for BIM in non-public sector projects	12	18	36	56	22	144	490	3.40	0.68	10
Improve on the Standardization of the BIM process	10	24	40	48	22	144	480	3.33	0.67	11
Undertake pilot projects to validate and demonstrate the BIM outcomes	16	22	30	50	26	144	480	3.33	0.67	11
Improve Interoperability of BIM software within existing applications	18	34	26	28	38	144	466	3.24	0.65	13
Integrate BIM into education courses across all built environment disciplines	12	24	40	60	8	144	460	3.19	0.64	14
Establish feasible ways of moving from traditional practice into BIM	12	36	40	30	26	144	454	3.15	0.63	15
Increase the availability of BIM technology	14	44	38	28	20	144	428	2.97	0.59	16
Establish BIM project execution guides to aid BIM implementation	20	32	44	38	10	144	418	2.90	0.58	17
Educate Government departments on 'model-based' deliverables and its benefits	14	44	46	28	12	144	411	2.86	0.57	18

Source: Field Survey (2018)

Approaches to overcoming the challenges of BIM implementation as opined by respondents shows that; Increase research for BIM technology in Institutions of Higher learning, Conduct BIM skills development programmes with RII values of 0.78 and 0.76 are very significant approaches to overcoming the challenges of BIM implementation. More so, Conduct workshops on BIM benefits to create awareness amongst stakeholders, Introduce Collaborative Procurement Systems to support BIM technology, Develop forms of contracts for stakeholders for intellectual property of BIM technology, Develop adequate infrastructure to support BIM technology, Have Government enforce the usage of BIM as a primary requirement for procurement in the construction industry, Develop forms of contracts for stakeholders for insurance of BIM technology, Communicate lessons learned from the pilot projects to all stakeholders, Increase Client demand for BIM in non-public sector projects, Improve on the Standardization of the BIM process, Undertake pilot projects to validate and demonstrate the BIM outcomes with RII values of 0.67 and 0.75 are significant approaches to overcoming the challenges of BIM implementation in the Nigerian construction Industry. However, improving interoperability of BIM software within existing applications, integration of BIM into education courses across all built environment disciplines, establish feasible ways of moving from traditional practice into BIM, increase the availability of BIM technology, establish BIM project execution guides to aid BIM implementation, educate government departments on 'model-based' deliverables and its benefits with RII values of 0.57 – 0.66 are also fairly significant approaches to overcoming the challenges of BIM implementation in the Nigerian construction Industry.

4.0 DISCUSSION OF FINDINGS

The study assessed the perception of the Nigerian Construction Industry on the challenges of Building Information Modeling Implementation in Nigerian Construction Industry. The findings revealed that lack of BIM education with an RII value of 0.79 and lack of information on BIM with an RII value of 0.76 are very significant challenges of BIM implementation in the Nigerian construction Industry which is also in agreement with (Ibrahim and Abdullahi 2016; Umezinwa ,N.J 2017;). Other significant challenges identified are lack of investment in BIM Technology, lack of Government support through legislation, lack of standards to guide implementation, lack of sufficient ICT Infrastructure, lack of collaborative procurement systems to support BIM, lack of trained professionals to handle the tools, inadequate power supply, lack of demand from clients, lack of management support, social and habitual resistance to change, challenges arising from licensing procedures, High Cost of training, lack of Support from the Industry all are within the RII value of 0.67- 0.75. This shows that they are also significant challenges affecting the implementation of BIM in the Nigerian construction industry. The findings are also in tandem with (Gardezi *etal*, 2014; Abubakar etal 2017).

5.0 CONCLUSION

Building Information Modeling (BIM) is a great knowledge area within the design, construction and operation industry and a great deal with Architectural and Construction Engineering industry. It can be observed from the study that BIM adoption is low in the Nigerian construction Industry. However the identified challenges and approaches to overcoming them in this study will assist the Nigerian construction industry to plan for the effective utilization of BIM in their prospective projects.

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BIOGRAPHICAL NOTES

Ruya Tambaya Fadason was born in 1960 in Kaduna State. He holds a HND (QS) from Kaduna Polytechnic in 1989, PGD (Bldg.) and M.Sc. (QS) from Ahmadu Bello University, Zaria in 2009 and 2015 respectively.

With over 25 years of active professional practice in both public and private organisations, Ruya has served at the Nigerian Institute of Quantity Surveyors both at State and National level and other affiliated international organizations at different levels and capacities. He was a member of an Ad-Hoc Committee set up by NIQS National Executive Council in 2013 that produced the Building and Engineering Standard Method of Measurement (BESMM 4) in 2015. He is a Fellow of the Nigerian Institute of Quantity Surveyors and a Registered Quantity Surveyor. He was a board member of the Quantity Surveyors Registration Board of Nigeria (QSRBN) from 2015-2017. He is currently the Managing Director/CEO of Rutfa Quantz Consultants a firm of Quantity Surveyors and Project Managers, Kaduna, Kaduna State, Nigeria.

Danladi Zakari Chitumu was born in 1971 in Kaduna State. He holds a B.Sc. (QS) from Ahmadu Bello University, Zaria in 2004. He has been a member of the Nigerian Institute of Quantity Surveyors and a Registered Quantity Surveyor since 2011 and 2012 respectively.

Danladi began his working career in Rutfa Quantz Consultants in 2005 and later joined the academia in 2006 and lectures at the Department of Quantity Surveying, Nuhu Bamalli Polytechnic Zaria where he has been till date. Danladi has served the Nigerian Institute of Quantity Surveyors at the State level at different levels and capacities.

Lot Kaduma is a graduate of Architecture at Design Marks Concept Ltd and specializes in the design and supervision public-owned built environment projects in Kaduna City, Nigeria. Lot is also the founder of Urban Future Project, a youth-led advocacy initiative centered on the Urban SDG (Goal 11: Sustainable Cities & Communities). He is also a member of the UN Major Group for Children and Youth Habitat III Working Group (West & central Africa). His long term goal is to build inclusive, safe, resilient and Sustainable Cities in Africa,