ISSN 2409-2665
Journal of Logistics, Informatics and Service Sciences
Vol. 3 (2016) No. 2, pp. 1-36

Analysis of Building Information Modelling Usage Indices and Facilitators in the Nigerian Construction Industry

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(*Received Sep 2016, accepted Dec 2016*)

Abstract: The decision to use building information modelling (BIM) is subject to a lot of factors. Information on the facilitators for BIM usage can spur its widespread usage in the construction industry. Therefore, this study examined the BIM usage indices and facilitators in the Nigerian construction industry. Two hundred and eighty-two construction professionals were surveyed for the study. BIM usage indices were used to elicit information on the extent of BIM usage. It was found that contractual arrangement, ICT literacy and staff cooperation, availability of BIM standards and guidelines, capacity building for BIM implementation, behavioural changes from professionals, and the need to impress prospective clients were the most significant BIM facilitators. It was concluded that BIM is used for residential and commercial buildings owned by private developers and private clients and that government at all levels were not requesting for BIM to be used in their projects. The construction professionals were merely using BIM because they wanted to impress prospective clients and improve on the quality of their professional services.

Keywords: Building Information Modelling; BIM software technologies; BIM usage facilitators, BIM usage indices, Integrated project delivery

1. Introduction

Globally, the construction industry is experiencing a transformation in the form of BIM. Impressed with the ability of BIM to reduce rework and increase project value, governments around the world are taking steps on the usage of BIM. In the United State of America (US), nearly half of the building industry is using BIM; while the United Kingdom (UK) has prepared a strategy for BIM usage on projects (SmartMarket Report, 2010; McGraw-Hill, 2010). According to BuildSmart (2011), the Building and Construction Authority in Singapore implemented the BIM Roadmap in 2010 with the aim that 80% of the construction industry will be using BIM by 2015 as part of the government's plan to improve the construction industry's productivity by up to 25% over the next 10years. Norway has stated its commitment to BIM adoption in 2010 and South Korea's Public Procurement Service has made the use of BIM compulsory for all projects over S$50 million and for all public sector projects by 2016. BIM International Report (2013) gave an account of its survey, where 55% of the respondents in UK, 55% in Canada, 24% in Finland and 46% in New Zealand indicated that they are using BIM for projects. Autodesk (2011) in its study of the realization of the benefits of BIM all over the world found that New Zealand construction industry has made significant steps towards accepting BIM as the future for the Construction Industry.

In its internet survey of frequency of BIM use by the professionals in the U.S construction industry, SmartMarket Report (2010) found that 56% of firms using BIM are using it on 50% of their projects, with only 34% of the total respondents using it on less than one quarter of their projects. UK BIM Strategy

Report (2012) noted that the UK Government has embedded BIM into the UK construction sector and the initial estimated savings to UK construction and its clients is £2billion per annum through the widespread usage of BIM and is therefore regarded as a significant tool for government to reach its target of 15-20% savings on the costs of capital projects by 2015. As a result of the potential of BIM, it was concluded that BIM will soon be deployed in every country in the world. .

According to Liu, Issa and Olbina (2010), the decision to use BIM is subject to a lot of factors and these factors should be identified. Equally, Eadie, Odeyinka, Browne, McKeown and Yohanis (2013) argued that information on the factors influencing the usage of BIM can spur its adoption in the construction industry. When compared to other industries, the construction industry is slow to adopt new technologies and processes (Yang, 2007). A study conducted by McGraw-Hill (2010) and Linderoth (2010) revealed that the rate of adoption of BIM is slow. Yet, the adoption of BIM is imperative to the efficiency and competitiveness of the construction industry (Newton and Chileshe, 2012). Banks (2013) pointed out that studies that would identify the facilitators to BIM adoption will be beneficial to the construction industry and will enable higher adoption rates. Similarly, Ozorhon, Abbott, Aouad and Powell (2010) maintained that barriers must be eliminated through the provision of facilitating factors in order to enable adoption of new process.

Ede (2014) reported the use of BIM software technologies on a modest duplex building project in Nigeria, where 3D BIM software technologies like Autodesk Revit 2014, Navisworks Manage 2013, Orion, Robot, Civil Soft and Staa-Pro were used. The study claims that the project has benefited in terms of cost and time savings and quality improvement; but the factors influencing the usage of BIM for the project was not reported. Dare-Abel et al. (2014) studied the utilization of BIM software technologies by architectural firms in Nigeria. The study found that architectural firms in Nigeria have adopted BIM and have BIM literates that understand collaboration process and can use BIM software technologies. But the study did not investigate the reasons for the adoption of BIM. Kori and Kiviniemi (2015) studied the adoption of BIM in the Nigerian Construction Industry and found that small architectural firms in Nigeria see BIM software technologies as a mere technological transformation without any accompanying benefits and that while the medium and large scale architectural firms in Nigeria are significantly using BIM software technologies to enhance their practices, small firms only use them for visualization owing to the lack of understanding on the use of BIM software technologies for collaboration and integration. Dim et al. (2015) observed that professionals in the Nigerian Construction industry cannot continue to be working with 2D and 3D BIM software technologies and yet hope to catch on the full value that BIM brings to projects. Ibrahim et al. (2015) observed that the utilization of BIM software technologies in Nigeria is limited to 3D visualizations, component details and specifications, whereas it encompasses so much more.

However the full application of BIM cannot be appreciated until the factors influencing its adoption have been investigated. A study conducted by McGraw-Hill (2010) and Linderoth (2010) revealed that the rate of adoption of BIM is slow. Yet, the adoption of BIM is imperative to the efficiency and competitiveness of the construction industry (Newton and Chileshe, 2012). Banks (2013) pointed out that studies that would identify the facilitators to BIM adoption will be beneficial to the construction industry and will enable higher adoption rates. Similarly, Ozorhon, Abbott, Aouad and Powell (2010) maintained that barriers must be eliminated through the provision of facilitating factors in order to enable adoption of new processes. Sawhney (2014) noted that the usage of BIM must be evaluated in order to provide the construction industry with timely and clear understanding of the status of BIM adoption in comparison with global developments. Smith (2013) opined that BIM can be used to transform the construction industry into an efficient and value-oriented sector that can successfully deliver the clients' requirements and that its usage can transform the construction industry to a data-rich environment and knowledge-intensive industry which can enable virtual and automated design, analysis, construction and communication. The construction industry in the developed countries are moving forward. This serves as a challenge for a developing country like Nigeria to develop the ability of its construction industry to use new and innovative processes of delivering projects. The aim of this study is to analyse the BIM usage indices and facilitators in the construction industry in Lagos State, Nigeria with a view to driving a vibrant national policy towards the adoption of BIM in Nigeria.

2. Literature review

The construction industry in the developed world is rapidly adopting BIM, although the level of BIM usage differs in different region. In the United State of America, the General Services Administration has developed a BIM guidelines and standards and pioneered the usage of BIM for public sector projects; while the usage in the United Kingdom, France and Germany was 35, 38 and 36 percent respectively (McGraw-Hill, 2010). SmartMarket Report (2010) argued that the United State of America is the leader in BIM usage with over 70% of the construction projects using BIM; closely followed by Europe, where BIM was used in almost one-third of the projects. Autodesk (2011) noted that six out of ten architects create architectural information model and that half of all contractors are currently using BIM in US. Also, BIM International Report (2013) reported that the Danish government has adopted BIM and mandated its use for all the projects of the Danish state clients. The same report also showed that Hong Kong government has developed a set of modelling standards for effective BIM in the country and has been using BIM in all of its projects since 2014. Chartered Institute of Building (2015) reported that the Russian government has set up 25 pilot BIM-based projects to increase BIM usage and that in Ireland, demand for BIM usage on projects was growing among clients; while the Scottish government has proposed the use of level 2

BIM for projects over £4.32M. Also, Finland's state property services agency has been using BIM for its projects since 2007. In Australia, the majority of firms are using BIM in their projects; while South Korea's public procurement services has mandated the use of BIM for all private sector projects over US$40 million and for all public sector projects by 2016 (SmartMarket Report, 2010).

The progress of BIM adoption in developing countries is far below expected levels. McGraw-Hill (2010) concluded that India, China and the Middle East are still lagging in the usage of BIM. In India, Sawhney (2014) found that BIM is gaining popularity among professionals within the Indian built environment sector and that it is being implemented for private projects, but still largely in visualization phase. The study regarded BIM as the lever that the Indian built environment sector needs to attain the desired productivity gains.

The usage of BIM is regarded as the future and the solution to the construction industry's problems (Lu and Li, 2011). As noted by Shelden (2009), BIM is the most promising recent development in the construction industry and an important tool for the growth of the construction industry. Similarly, Newton and Chileshe (2012) affirmed that BIM is imperative to the efficiency and competitiveness of the construction industry. Succar (2009) argued that BIM can stimulate the process of information exchange and interoperability among project stakeholders. This supports the view of Panuwatwanich, Wong, Doh, Stewart and McCarthy (2013) that the need for BIM stems from the lack of integration along the construction supply chain. Also, BIM Guide (2013) asserted that BIM would change the traditional process of working in the construction industry over a wide range of its typical characteristics, including those of people, processes, communication and work culture. Also, Bjork (2003), Samuelson (2003) and Wikforss and Lofgren (2007) observed that the usage of BIM will probably have considerable effects on the industrialization process of construction projects and enhance the free flow of information within the construction industry. Gayathri et el. (2013) noted that BIM usage can integrate the design and construction process, add value to project delivery, change the traditional process of working in the construction industry and ensure adequate communication and exchange of information.

There are factors that can facilitate the adoption of BIM. BIM as a process creates the opportunity for designers to collaborate with clients, main contractors, sub-contractors and fabricators, and other members of the supply chain for the purpose of integrated project delivery (BIM Handbook, 2011). It follows, then, that contractors aiming to provide collaborative BIM services to their clients will require their sub-contractors and fabricators to be “BIM literate” and securing the competencies further down the supply chain, without which to fully exploit BIM’s potential may be difficult (Jung and Joo, 2011). Staff resistance to the adoption of new technologies and processes can also be witnessed (Ruikar, Anumba and Carrilo, 2005). This is the case especially when staff consider that they have been given insufficient training or that the technology may threaten their employment (Arayici, Khosrowshashi, Marshal-Ponting and Mihindu, 2009). Ozorhon’s et al. (2010) in a survey of facilitators to the implementation of innovations within the construction industry identified leadership, culture, collaboration with partners and a supportive work environment as factors that can facilitate the adoption of a new organizational process. A leader’s vision requires a supportive environment or culture of work to implement new organisational processes. It is apparent these two described factors must be prevailing within an organisation to establish optimal adoption. Constructing Excellence (2008) and Sacks and Barack (2007) observe that the initial costs of moving from traditional 2D CAD based approaches to higher level of BIM modelling are significant, both in terms of the costs of BIM software, and in the upgrading of computer hardware to be able to handle BIM.

An additional prominent facilitator acknowledged by Ozorhon et al. (2010) is collaboration with partners. A foremost barrier to the implementation of innovations is the discontinuous and fragmented nature of the Construction Industry. To transpose this barrier collaboration amongst partners would develop synergy between stakeholders and enable the sharing of information thus facilitating a more mature usage of BIM. Blayse and Manley (2004) maintains a comparable stance claiming collaborative working attitudes will advance a more harmonious working environment amongst stakeholders consequently allowing for improved levels of transferring information. Arayici et al., (2009) opines that it is essential that personnel affected by the implementation of new processes are educated with best practice and that information management and contractual arrangement that are supportive of BIM are put in place to facilitate BIM adoption. BIM Handbook (2011) identified the provision of standardised systems of work and emphasis on research and development as factors that can facilitate the adoption of BIM. Zahrizan, Ali, Haron, Amanda and Zuhain (2013) found that training is critical to increasing BIM adoption and that without adequately trained users, the extent of BIM use cannot progress forward. This was supported by the findings of Gilligan and Kunz (2007) who found that the adoption of BIM is becoming less about technical issues such as hardware and software, but more about training and availability of qualified staff.

Sacks and Barack (2007) observed that the adoption of BIM process requires a complete change in the design process where more engineering and design knowledge and skills would be required to produce the initial building model. Liu et al. (2010) argued that government's inputs and public policy are potentially significant players in facilitating BIM adoption and that lack of demand by clients for BIM usage is a persistent barrier for organisations, with low external pressure being applied for adoption, organisations will consider BIM implementation as not currently relevant or required. Ruikar et al, (2005) suggest that management support for the introduction of new technologies and processes is essential if the benefits are to be realised. Jung and Joo (2011) further confirm this by showing that the strategy and policy for specific levels of adoption is necessary to accelerate practical BIM implementation.

Other facilitating factors for BIM usage as identified by Mom et al. (2011) include enforcement of BIM by government, request for BIM by the client, BIM training program, knowledge management practices, provision of standardized system of work and awareness of project benefits of BIM.

3. Research Methodology

The selection of respondents for the study was done using Respondent Driven Sampling (RDS) technique. RDS is a sampling technique based on the principle of 'six degrees of separation', with the potential to reach any member of a population in six waves and involves a network-based methods that start with a set of driver respondents who refer their peers; these in turn refer their peers up to the sixth wave.

A list of construction professionals who have used BIM at any level in project was compiled using contacts list from social media based on the recommendation of Kossinets and Watts (2006). The construction professionals were divided into professional groups and the contacts list for each professional group was taken as the Personal Network Size (PNS) for the group. PNS for this study is the number of known professionals who have used BIM at any level and it is required to determine the target population. The PNS for each of the professional group is as shown in Table 1. The RDS target population required for the study depends on RDS respondents estimate and this was determined by calculating the degree of person (di) and degree of distribution (Pdij) for the PNS using the summation method proposed by McCarthy et al., (2001). The RDS respondents estimate is presented in Table 1. The potentials of the PNS to name other respondents in six waves were summed to yield an overall estimate. The degree of person (di) was calculated using the formula given by McCarty et al. (2001).

$$di = \sum Pdij$$

Where:

di = the degree of person i;

Pdij = 1 (if person i knows person j); and

$\sum Pdij$ = 6 (for six degrees of separation).

RDS target population was then determined by calculating the minimum target sample size (MTSS) for each of the professional group using the formula given by Glen (2013).

$$n = \frac{N}{1+N(e)^2}$$

Where:

n = sample size;

N = population size; and

e = level of precision.

RDS target population for the study is as presented in Table 1. MTSS is required to compensate for differences in homophily and PNS across group and also to determine when the RDS should be stopped. The RDS for this study was stopped when the MTSS for each professional group was reached.

Mean ranking was used to rank the positions of the professional groups based on their responses and where there were identical scores, joint ranking was used. Kruskal Wallis test was conducted on the responses using the formula given by National Institute of Standards and Technology (2015):

$$H = \frac{12}{n(n+1)} \sum_{i=1}^{k} \frac{R_i^2}{n_i} - 3(n+1)$$

Where:

ni(i-1,2,…….k) = sample sizes for each of the k groups

Ri = sum of the ranks for group i

Table 1: PNS and RDS Respondents Estimate and Target Population

Professional group	Personal Network Size (PNS)	Estimated number of respondents	Minimum Target Sample Size (MTSS)

Architects	16	96	77
Builders	11	66	57
Building services engineers	9	54	48
Facilities managers	4	24	23
Quantity surveyors	4	24	23
Structural/Civil engineers	8	48	43

BIM usage indices such as number of projects, types of projects, types of clients, value of projects, and procurement methods were used to elicit information on the extent of BIM usage among the respondents. Respondents were asked to rate their level of BIM usage on a five-point Likert scale ranging from 'Very low' to 'Very high' with weight value of 1-5 respectively. Frequency distribution and percentage, clustered bar chart and Fisher exact test and mean ranking were used to analyse the data. Fisher exact test was used to determine if there were significant differences in the ratings indicated by the professional groups. The hyper-geometric probability function to determine significance value in Fisher exact test was calculated using the following formula as given by Weisstein (1999):

$$P = \frac{(R_1!R_2!\ldots\ldots R_m!)(C_1!C_2!\ldots\ldots C_n!)}{N!\prod_{ij} a_{ij}!}$$

Where:

N = total number of values in all the groups = $\sum_i R_i = \sum_j C_j$

Ri = row sums

Ci = column sums

aij = number of observations in which $x = i$ and $y = j$

BIM usage Facilitators were identified from literature and were used for the survey. Each of the facilitators were rated by respondents using a five-point

Likert scale as follows: ‘Least significant,’ ‘Fairly significant,’ ‘Significant,’ ‘Highly significant,’ and ‘Most significant’ with weight values of 5, 4, 3, 2, and 1 respectively. Factor analysis and relative significance index (RSI) were used to analyse the data. Factor analysis was used to evaluate the relevance of these facilitators and to describe variability among the facilitators in order to group those with similar patterns of responses together. Principal component analysis (PCA) was used as the method of extraction and Varimax with Kaiser Normalization as the method of rotation. RSI was used to establish the respondents’ ranking on each of the facilitators in order to show the most significant ones. RSI formula as defined by Eadie et al., (2014) was adopted for the study is defined as follows:

$$RSI = \frac{\sum W}{A \times N} (0 \leq index \leq 1)$$

Where:

W = the weighting given to each element by the respondents. This is between 1 and 5, where 1 is the least significant and 5 is the most significant;

A = the highest weight; and

N= the total number of respondents.

Some BIM usage facilitators scored identically when the RSI was conducted to rank them. In order to differentiate between these identically ranked facilitators, joint rankings were given to them.

4. Results

Profile of respondents

Two hundred and eighty two respondents were surveyed for the study. Seventy-eight responses were from Architects, representing 27.7% of the total respondents. Fifty-nine responses were from Builders (20.9%), fifty-one from Building Services Engineers (18.10%), forty-six from Structural Engineers

(16.3%), twenty-four from Quantity Surveyors (8.5%) and twenty-four from Facilities Managers (8.5%). This shows that all the construction professional groups were represented in the survey and the conclusions from this study won't be biased.

Regarding the academic qualification of the respondents, 38.3% of respondents were BSc. holders, followed by respondents holding M.Sc. Degree accounting for 34.0% of the total respondents. Respondents who were HND holders accounted for 27.0% of the respondents; while respondents who were PhD holders accounted for 0.7% of the total respondents. This suggests that the respondents are well educated and would be able to respond to the questions with understanding. The distribution of respondents according to number of projects they had been involved in was also surveyed. Respondents who had been involved in at least 16 projects accounted for 26.2% of the total respondents, followed by respondents who had been involved in at least 11 projects, representing 25.5% of the total respondents. 20.6% of respondents have been involved in at least 5 projects, while 12.8% of respondents have been involved in more than 21 projects. This shows that the average respondents had participated in about seven projects. This shows that the respondents have enough working experience to provide the required information for this study.

On the subject of the experience level of the respondents for this study. Only 50.4% of the surveyed respondents had at least 5 years of experience in the Nigerian construction industry. 32.6% of the total respondents are professionals with at least 11 years of working experience. 8.5% participants have less than 5 years' experience. While 2.1% of the total respondents have worked in the construction industry for 21 years and above. This suggests that there was great depth in the experience possessed by the respondents and that the information provided by these professionals can be considered reliable.

Level of BIM usage across profession in the Nigerian construction industry

The respondents were requested to rate their general level of usage of BIM.

No more than 33.5% of the total respondents indicated average usage, 25.3% indicated high usage; while 6.4% indicated very high usage. Only 20.9% of the total respondents indicated low usage, with 11.7% considering their level of BIM usage as very low. In order to show the pattern of usage of BIM across profession, mean ranking and Fisher exact test were conducted to determine the extent of usage of BIM among construction professionals. The study found that Architects have the highest level of BIM usage (mean = 3.33), followed by Structural Engineers (mean = 3.16), Building Services Engineers (mean = 3.00) and Builders (mean = 2.76) respectively. Quantity Surveyors (mean = 2.27) and Facilities Managers (mean = 2.21) ranked least in the usage of BIM.

Numbers and types of projects where BIM was used by the Nigerian construction professionals

The respondents were further requested to indicate the number of projects where they used BIM. No more than 27.7% of the respondents indicated that they have used BIM in about 10-15 projects, 21.3% claimed to have used BIM in about 5-10 projects. While 12.1% indicated that they had used BIM in over 20 projects. Only 19.5% had used BIM in less than 5 projects, while 13.5% indicated BIM usage in 15-20 projects. Figure 1 shows that 3.5% of the total respondents indicated that they had employed traditional procurement method in projects where they had used BIM. 26.2% of the respondents indicated that they had used design and build procurement method in BIM-based projects, followed by those (14.9%) who claimed to have used design, build and operate procurement method. The least proportion (0.7%) was observed among professionals who had used integrated project delivery.

Regarding the types of projects where BIM was used. Figure 2 shows that majority (28.4%) indicated that they had used BIM in residential and commercial projects, followed by respondents who claimed to have used BIM in residential, commercial and industrial buildings, accounting for 24.1%. the least proportion of usage was observed among respondents who had used BIM in heavy construction projects (0.7%), followed by industrial buildings (5.0%), only 1.1% of the respondents have used BIM in all types of projects.

Figure 1： Procurement Method Used for BIM

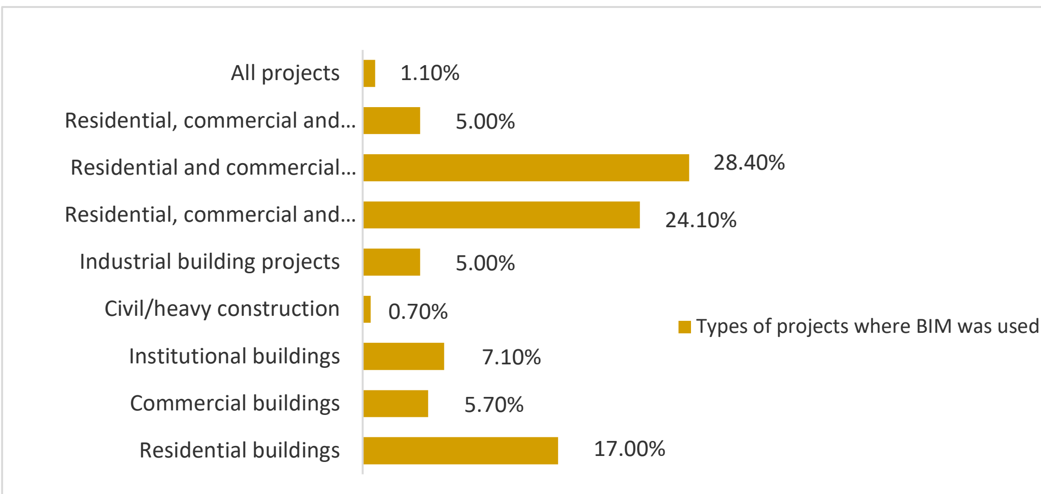

Figure 2： Types of Projects Where BIM Was Used.

Types of clients and value of projects for which BIM was used by the Nigerian construction professionals

Figure 3 shows the usage of BIM for clients. No more than 29.1% of the respondents indicated that they had used BIM for private developers, tertiary institutions and private clients. While only17% of the total respondents indicated that they had used BIM for private developers, closely followed by those who had used it for private clients (8.0%) and state government (6.4%). The results obtained for the usage of BIM across the various categories of project value show that 6.4% of the respondents indicated that they had used BIM in projects worth below fifty million Naira, 9.3% in projects worth 50 - 100 million Naira, 12.1% in projects worth 100 – 150 million Naira and 6.4% in 150 – 200 million Naira projects. However, 58.9% of the total respondents had used BIM in projects worth over two hundred million Naira.

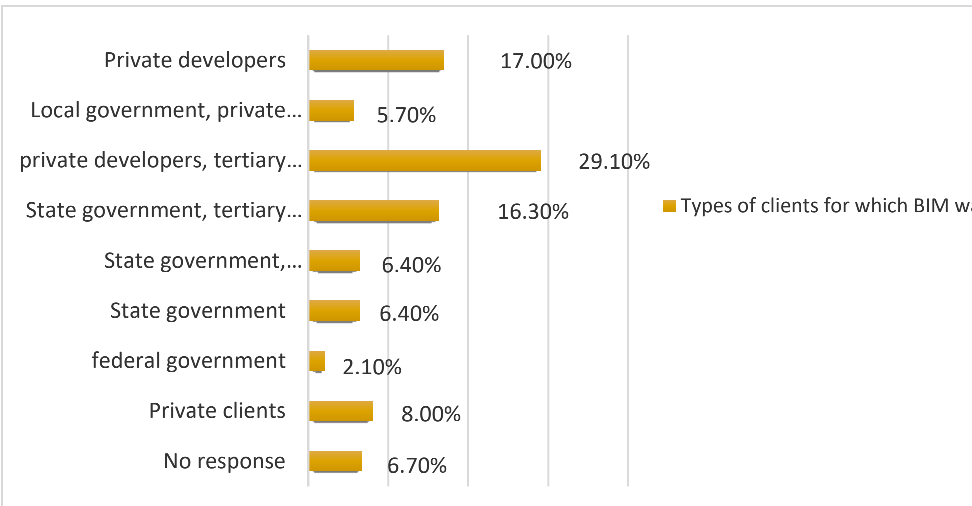

Figure 3： Types of Clients for Which BIM Was Used.

Facilitators for BIM usage by the Nigerian construction professionals

The appropriateness of the factor analysis for the factor extraction was determined by calculating the Kaiser-Meyer-Olkin (KMO) that measures the sampling accuracy and anti-image correlation that determines the strength of relationship among the variables based on partial correlation coefficients. The value of the Bartlett's test of sphericity was 171.000, while the value of KMO was 0.864 exceeding the recommended minimum value of 0.6. Both results imply that factor analysis was suitable for the factor extraction. The Eigen values of each component and the amount of variance of the component in the original variables are presented in Table 2. Facilitators with an eigenvalue ≥ 1 were used to explain the variance and the facilitators that explained the least amount of variance were discarded. However, five facilitators were generated and none of the facilitators had an eigenvalue<1. These facilitators were labelled as follows: Professional Development and Training (PDA), Work Process Advancement (WPA), BIM Awareness and Training (BAT), Organizational Goals and Objectives (OGO), and Clients' Requirements and Satisfaction (CRS).

Professional Development and Training as presented in Table 2 had an eigenvalue of 7.021 and accounted for 36.954% of the observed variance. Work Process Advancement had an eigenvalue of 2.647 and accounted for 13.933% of the observed variance; while the eigenvalues and percentage of observed variance of BIM Awareness and Training, Organizational Goals and Objectives, and Clients' Requirements and Satisfaction were as shown in Table 2. The factors that constitute Professional Development and Training as a BIM usage facilitator include: Contractual arrangement, ICT literacy and staff cooperation, Availability of BIM standards and guidelines, Capacity building for BIM implementation, Behavioural changes from professionals, and the need to impress prospective clients. Work Process Advancement has the following factors: Emphasis on research and development, Knowledge management practice. Commitment to BIM training, Provision of standardized system of work, and Information management; while the variables that constitute BIM Awareness and Training as a BIM usage facilitator are availability of BIM training program, BIM education in higher institution, BIM requirement by other project team members, and Awareness of the project benefit of BIM.

Organizational Goals and Objectives as a BIM usage facilitator has supportive organizational culture and leadership, Supportive work environment, and Emphasis on research and development as constituent variables. Lastly, Clients' Requirements and Satisfaction comprises of Enforcement of BIM by government and Request of BIM by client.

Table 2: Dimensions of BIM facilitators in the Nigerian Construction Industry (Rotated Component Matrix)

BIM Facilitators	PDA	WPA	BAT	OGO	CRS	Communality
Enforcement of BIM by government					.767	.786
Request of BIM by client					.833	.767
BIM training program			.777			.756
BIM education in higher institution			.794			.785
BIM requirement by other project team members			.719			.734
Awareness of the project benefit of BIM			.505			.717
A supportive organizational culture and leadership				.669		.689
Supportive work environment				.727		.834
Emphasis on research and development		.518		.637		.765
Knowledge management practice		.707				.743
Commitment to BIM training		.831				.798
Provision of standardized system of work		.809				.743
Information management		.643				.665
Contractual arrangement	.696					.776

ICT literacy and staff cooperation	.735					.899
Availability of BIM standards and guidelines	.639					.760
Capacity building for BIM implementation	.517					.662
Behavioural changes from professionals	.773					.717
To impress prospective clients	.793					.881
Eigenvalue	7.02	2.64	1.50	1.15	1.10	
% of total variance	17.6	16.2	14.0	12.0	10.9	
Total variance					70.7	

PDA= Professional Development and Training, WPA= Work Process Advancement, BAT= BIM Awareness and Training, OGO= Organizational Goals and Objectives, CRS= Clients' Requirements and Satisfaction.

To determine the key facilitators for usage of BIM by construction professionals in the study area. The respondents were asked to rank the variables that contributed most significantly to their decision to use BIM for construction projects. As presented in Table 3, the need to impress prospective clients (mean = 4.20), ICT literacy and staff cooperation (mean = 4.05) and behavioural changes from professionals (mean = 4.00) were ranked as having most significant influence on decisions to use BIM for construction projects.

Table 3: Relative Importance Index (RII) for ranking the BIM usage Facilitators.

Variables	**MS**	**HS**	**S**	**FS**	**LS**	Mean
	5	4	3	2	1	
To impress prospective clients	152	62	36	30	2	4.20
ICT literacy and staff cooperation	138	60	48	30	6	4.05
Behavioral changes from	122	70	68	16	6	4.00

professionals						
Contractual arrangement	100	78	68	32	4	3.85
BIM education in higher institution	76	96	86	20	4	3.80
Availability of national BIM standards and guidelines	88	80	78	32	4	3.75
Request for BIM by the client	94	76	60	34	18	3.70
BIM requirements by other project team members	82	72	84	38	6	3.65
BIM training program	74	78	96	26	8	3.65
Awareness of the project benefits of BIM	68	74	110	22	8	3.60
Enforcement of BIM by government	90	62	70	46	14	3.60
Capacity building for BIM implementation	60	90	96	24	12	3.55
Information management	40	94	100	42	6	3.45
Commitment to BIM training	34	80	94	62	12	3.20
Provision of standardized systems of work	34	84	86	66	12	3.20
Supportive work environment	22	78	102	74	6	3.15
Knowledge management practices	28	76	92	68	18	3.10
A supportive organizational culture and leadership	30	78	82	64	28	3.05
Emphasis on research and development	26	84	62	102	8	3.05

MS=Most Significant, HS= Highly Significant, S=Significant, FS=Fairly Significant, LS=Less Significant

5. Discussion

BIM usage indices in the Nigerian construction industry

Based on the findings of this study, the extent of BIM usage among construction professionals is at average level. It also seems to be the case that the traditional process of working which has been identified as the major cause of fragmentation, ineffective communication practices and disintegration in the design and construction process is generally changing and construction professionals are embracing new process of developing, integrating and disseminating information. This is in line with the observation of Gayathri et al. (2013) that BIM usage can change the traditional process of working in the construction industry. The average level of usage of BIM among construction professionals as found in this study could be the beginning of the desirable change in the Nigerian construction industry. This could also mean that the construction professionals are beginning to show concerns about the construction industry problems and taking the initiative through BIM usage to address the problems within their capacities and domain, given that the government is not making efforts to address these problems. This findings support the study by Lu and Li (2011) which reported that the usage of BIM is the solution to the construction industry's problems.

The observed difference in the extent of BIM usage among construction professionals was statistically significant at significant value of 0.001 which is within the level of significance of 0.05. The construction professionals with the lowest level of BIM usage were Quantity Surveyors and Facilities Managers. This finding shows that Architects, Engineers and Builders were adopting BIM more than other construction professionals. This findings corroborate the findings by Newton and Chileshe (2014) and Zhou et al. (2011) which found that Architects, Engineers and Builders have higher rate of BIM usage and that the uptake of BIM by Quantity Surveyors is relatively low.

Architects have since adopted Computer Aided Drafting and Computer Aided Design (Oladapo, 2006). This could also explain why there is high usage of BIM among Architects as compared to the other construction professionals. The beauty of information models of buildings is much pronounced in the geometry of buildings as it serves as the most attractive and visible part to the clients. To effectively capture the clients' brief, Architects have resulted to BIM because it helps the clients to visualize the proposed project. Also, high usage of BIM among the Building Service Engineers could be as a result of their efforts to present building services information in a clear and understandable way that is devoid of omissions and clashes. Building services information are abstruse and are best developed as a model rather than using the traditional lines and symbols. The ease and clarity with which structural systems and details of building can be presented in BIM could be responsible for high usage of BIM among the Structural Engineers. The usage of BIM for projects among the Builders could be as a result of the need to deliver projects according to clients' requirements in terms of quality and appearance and also to avoid rework; the occurrence of which may affect their profitability and reputation.

Owing to the fact that BIM is a new concept, it may be that construction professionals are still using BIM moderately in their projects, as shown by the findings of this study. The findings also show that BIM is currently being used in a variety of projects in the construction industry. However, the usage of BIM in projects inclined towards residential and commercial buildings, particularly residential buildings. The result also shows that the usage of BIM in heavy construction projects and industrial projects is still low. This finding is consistent with the earlier study by Sawhney (2014), which found that BIM is mostly used for residential and commercial projects and rarely used for civil engineering projects.

The findings on the types of clients that construction professionals are using BIM for suggests that BIM is mostly used for private developers and private clients; but barely used for federal government projects. This could be as a result of lack of adoption of BIM by the federal government of Nigeria. The need to get value for money may be responsible for the usage of BIM for private clients and developers who are investing hard earned money in their projects.

The sole aim of private developers is to generate profit as opposed to the government which aims to provide affordable buildings for social and welfare reasons. From project conception to completion, private developers and private clients are concerned about value for money and cost effectiveness which will mandate the construction professionals to resort to BIM for delivering the projects. Accountability, transparency and merit associated with an academic environment which might impose more demands on construction professionals involved in construction projects undertaken by tertiary institutions may be responsible for usage of BIM for tertiary institutions. As noted by Gayathri et al. (2013) and Smith (2013), BIM adds value to project delivery and can transform the construction industry to a value-oriented sector. The uptake of BIM by construction professionals to meet the requirements of private clients and developers supports this finding.

The findings on the value of projects for which BIM was used by the Nigerian construction professionals show that BIM is being used for projects of high value and that BIM is barely used for projects of small value. Another reason for this may be that using BIM for projects demands money and time which the construction professionals cannot afford to expend on projects of small value but would rather expend them on high value projects which can impact their reputations positively.

The complexity and demands of high value project may also be the reason why construction professionals prefer using BIM for high value projects. The profit margin in small value projects may not allow the usage of BIM for the projects by construction professionals and clients may not be cooperative to pay extra charges for BIM.

The findings on procurement methods indicates that the employment of traditional procurement method for BIM-based projects is very low and that integrated project delivery (IPD) is the most appropriate procurement method to be employed in BIM-based projects. With IPD being a relatively new concept as BIM, professionals are delivering BIM-based projects by design and build procurement system because of its collaborative attributes. This finding is consistent with the study by Rahman and Alhassan (2002) which indicated that most BIM-based projects are delivered by design and build procurement system. Design and Build procurement systems was developed to address the inherent fragmentation among the construction professionals in the traditional procurement systems. Its high usage among construction professionals could mean that construction professionals appreciate the interrelationship allowed by the procurement system. Furthermore, the appreciable proportion of construction professionals using Design, Build and Operate to deliver projects suggests that the construction professionals and the Nigerian construction industry as a whole are ready for the adoption of IPD, if only IPD could be promoted and adapted to the Nigerian settings. For the Design, Build and Operate procurement method to be rightly applied in a project, at least the design team comprising the Architects and Engineers, the construction team comprising the Builders and Quantity Surveyors, and the maintenance team headed by Facilities Manager have to work together to deliver the project. This level of collaboration and integration of efforts could be easily transferred to IPD where deeper level of collaboration and integration as required in BIM are allowed, only if the benefits of IPD are well presented to the stakeholders in the Nigerian construction industry. The experimentation with different procurement systems by the construction professionals as revealed by the data shown in Figure 9 could mean that the construction professionals were searching for the ideal procurement system that will suit the Nigerian settings and yet meets BIM requirements.

BIM facilitators in the Nigerian construction industry

BIM facilitators in the Nigerian construction industry as found by this study were Professional Development and Training, Work Process Advancement, BIM Awareness and Training, Organizational Goals and Objectives, Clients' Requirements and Satisfaction. Contractual arrangement as a variable under Professional Development and Training determines the procurement system to be employed in a project; therefore, the usage of procurement systems with collaborative attributes such as Design and Build, Design, Build and Operate, or IPD could influence BIM usage. Also, majority of the construction professionals were using BIM moderately or have adopted it unintentionally when they apply CAD or ICT to their work process, trained their staff members in ICT, and employ collaborative procurement systems in their projects.

The inclusion of availability of BIM standards and guidelines as a variable under Professional Development and Training could only mean that construction professionals have been using the BIM standards and guidelines of other countries; the availability of which has influenced their usage of BIM. However, if national BIM standards and guidelines were to be available in Nigeria, it would have great influence on widespread usage of BIM in Nigeria as protocols and processes to be followed in BIM would be known. BIM standards and guidelines together with BIM training are required to build capacity for BIM implementations. As reported by Autodesk (2011), BIM building capacity for BIM implementation will require the staff members in an organization or professionals collaborating in BIM-based projects to be trained in the operational processes and technology requirements for BIM. Building the capacity of construction professionals for BIM implementation either for projects or in an organization will significantly influence BIM usage.

The usage of collaborative procurement systems in projects and the application of CAD to various aspects of project design and construction by construction professionals indicate a behavioral change from the construction professionals, which is also as a variable under Professional Development and Training. Although, the usage of BIM among construction professionals is still unintended and at a lower level since no outright adoption of BIM has been made and construction professionals are not familiar with BIM terminologies, processes and protocols. Nonetheless, the need to impress prospective clients and secure businesses amidst the competition in the construction industry is significantly influencing BIM usage among construction professionals as they are desperate to stay relevant and remain in business. Mom et al. (2011) reported that the main factors influencing BIM usage could be categorized as internal readiness and external pressure factors. Considering the facilitators in the first and second group as shown in Table 3 in this light; contractual arrangements, availability of natural BIM standards and guidelines, and the need to impress prospective clients would be categorized as external pressure factors; while the facilitators to be grouped as internal readiness factors would be ICT literacy and staff cooperation, capacity building for BIM implementation, behavioral change from professionals, emphasis on research and development, knowledge management practice, commitment to BIM training, provision of standardized system of work, and information management.

Moreover, the request for BIM by client as a variable in Clients' Requirement and Satisfaction shows that clients were fascinated by 2D and 3D models obtainable in the Nigerian construction industry. This did not mean that clients in the Nigerian construction industry were aware of BIM and its benefits. However, the request for 2D and 3D models by clients could have motivated the construction professionals to be making efforts to impress clients with BIM rather than clients requesting for BIM in their projects. With clients not aware of BIM, it will be difficult for them to be realizing the full benefits of BIM as construction professionals would only be using BIM for clients based on their level of BIM understanding and convenience. In countries with widespread adoption of BIM and higher level of BIM development, the government of those countries have championed BIM adoption and are enforcing BIM usage in their respective countries. However, in Nigeria, the enforcement of BIM usage by government is non-existent. This suggests that the management of the Nigerian construction industry is not taking the initiative and were unenthusiastic about the continuous development of the construction industry as being observed in countries like South-Korea, Singapore, United States, United Kingdom, New Zealand, Norway and Australia. Similar study carried out by NBS-International BIM report (2013) showed that the need to impress and meet client's requirements is the major driver for BIM usage among construction professionals.

The most significant facilitators for BIM usage among construction professionals according to their ratings were the need to impress prospective clients, ICT literacy and staff cooperation, and behavioral changes from professionals. This shows that clients' requirements, improvement in quality of professional services and widespread adoption of collaborative procurement systems can influence widespread usage of BIM among construction professionals. A previous study by Liu et al. (2010) showed that enforcement of BIM by the government is an important factor that can influence BIM usage among construction professionals. However, the findings of this study show that the enforcement of BIM usage is not a significant factor influencing BIM usage among construction professionals. This could mean that government as the major construction client was not demanding for BIM on its project nor enforcing its usage as a national policy to develop the construction industry. It may be the case that, the authorities and stakeholders in the Nigerian construction industry were not aware of the concepts and benefits of BIM or may just be indifferent to its adoption. The indication of demand for BIM by other project team members as one of the most significant factors influencing BIM usage supports and adds to the findings of Ozorhon et al. (2010) who found similar results in the UK. This demonstrates that construction professionals are beginning to appreciate the benefits of collaboration, integration and interoperability.

Reduction in the cost of paperwork and transportation as well as time savings may be the reasons why project team members would opt for digital exchange of information. Another reason for this may be the contractual arrangement. The availability of flexible collaborative procurement systems makes contractual arrangement suitable for project demands and other demands of project team members. Arayici et al. (2009) found that capacity building for BIM implementation can significantly influence the usage of BIM among construction professionals. This study didn't find that to be the case in Nigeria. Also, Gilligan and Kunz (2007) and Zahrizan et al. (2013) found that commitment to BIM training is a significant factor influencing BIM usage among construction professionals in the US and Malaysia. Their findings contradicts that of this study. This could mean that organized BIM training programs and seminars may not be available or adequate for construction professionals in Nigeria or the construction professionals themselves did not see the need to be committed to the training since the usage of BIM is neither being enforced by the government nor being demanded for by the clients. It could also be that construction professionals may not have seen the correlation between BIM usage and competitiveness in the construction industry and this may be responsible for their indifference to BIM training.

BIM handbook (2011) and Ruikar et al. (2005) indicated that emphasis on research and development and a supportive organizational culture and leadership are significant factors influencing BIM usage. The result of this study is not consistent with their findings. It could be inferred from the findings of this study that the leadership of construction firms in Nigeria are not paying close attention to research and development, because they are unaware of its benefits and are therefore not supportive of innovation and new processes of working.

6. Implications of the findings of the study to the construction professionals and policy makers

BIM is the future and the solution to the problems of the Nigerian construction industry. However, in order to ensure widespread usage of BIM; clients should employ the usage of procurement systems with collaborative attributes. Also, clients should be demanding for BIM in all of their projects regardless of project sizes, types and values.

Construction professionals on their parts should adopt and implement BIM in their work processes as it would help them to be competitive. They should also train their staff members to be BIM proficient. The construction professional bodies should organize conferences and seminars for their members in order to create BIM awareness and train members on BIM technologies.

The government as public clients should be demanding for BIM in all of their projects. Also, the government should adopt BIM formally and develop BIM implementation strategies and guidelines as other countries have done.

7. Conclusion

The BIM usage indices show that Architects, Engineers and Builders have higher rate of BIM usage. Less than one-third of the surveyed construction professionals have used BIM in projects. Also, about one-third of the surveyed professionals have used BIM in residential and commercial projects, while less than one-third of the surveyed professionals have used BIM for private developers, tertiary institutions and private clients. About two-third of the surveyed construction professionals have used BIM in projects worth two hundred million and above; while design and build procurement method was the major procurement system used by the construction professionals in BIM. Most BIM-based projects are delivered by Design and Build procurement method. This procurement system contributes to the isolation of other professionals during the creation of BIM and also affects the use of full collaboration, since the organization delivering the project will limit the BIM team to the available professionals in the organization. Construction professionals are using BIM in projects; however, extent of usage is at average level, and only Architects, Engineers and Builders have high usage of BIM owing to the fact that they form the core of design and construction team. BIM is used for residential and commercial buildings owned by private developers and private clients; while government at all levels are not requesting for BIM to be used in their projects. Although, the time and cost of BIM limit its usage for small projects. Integrated Project Delivery as a procurement system was developed to provide a better environment for BIM owing to its ability to facilitate information exchange across both project phases and project team members. However, it is rarely being used for project delivery.

The widespread adoption of contractual arrangement like IPD which supports collaborative working will actually induce the widespread adoption of BIM. The usage of BIM by construction professional was actualized contractually by design and build procurement system which allows collaborative working to some extent and allows information models to be developed and integrated within the capacity and resources of the consulting firm. The level of ICT literacy of construction professionals also had a great influence on the usage of BIM as ICT literacy improves the competency of construction professionals to use available BIM software technologies. The adoption of BIM can be greatly encouraged when the construction professionals have national BIM standard and guidelines to follow in BIM. The study concluded that construction professionals in the study area are merely using BIM because they want to impress prospective clients, meet contractual obligations and improve on the quality of their professional services and also because they know how to use discipline-specific software technologies through their knowledge of ICT.

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