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USAGE OF BUILDING INFORMATION MODELLING FOR SUSTAINABLE BUILDING PROJECTS IN AKWA IBOM STATE, NIGERIA

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ABSTRACT

Purpose: The study evaluated the application of Building Information Modelling for building projects in Akwa Ibom State of Nigeria with a view to achieving sustainable building projects through effective collaboration among building professionals.
Design/methodology/approach: The study utilised the survey research design in order to obtain the perception of construction professionals on the awareness and level of use of BIM in building construction projects. A total of 191 copies of structured questionnaire were administered on the respondents using stratified random sampling method on the construction professionals in Akwa Ibom State, South-South, Nigeria. The research instrument's validity test was done by experts and a reliability test was carried out using Cronbach's alpha. The perception of the professionals was analysed using binary logistic regression and relative importance index (RII) and the hypotheses were tested by the use of Kruskal-Wallis test.
Findings: The findings revealed that the professionals are aware of BIM, but there is a low level of BIM usage. The hypotheses tested showed that there is a significant variation in the professionals' levels of awareness and usage of BIM in the study area.
Research limitations/implications: The study concluded that the construction industry in the study area is yet to implement BIM in its projects, despite enormous benefits of BIM. However, this conclusion cannot be generalised because the data were collected from only one State in Nigeria.
Originality/value: The study has been able to establish that there is a low level of usage of BIM in the study area. This is arising from the fact that though the professionals are aware of the existence of BIM, its usage especially in the new areas of BIM (4D, 5D & 6D) is very low.

Keywords: Building information modelling; building projects; information technology; sustainable buildings

1. INTRODUCTION

Projects within the construction industry require and generate massive information that is needed to be shared and exchanged among construction project stakeholders on a consistent basis throughout the lifecycle of such projects (Crotty, 2012). Sharing and

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exchanging of construction information among relevant stakeholders have not been so easy due to complex and fragmented nature of construction project delivery processes (Fang & Marle, 2013). These then makes the construction project performance to be at sub-optimal levels (Egan, 1998). The Building Information Modelling (BIM) has, therefore, evolved to deal with such issues. Building Information Modelling (BIM) is an innovation in the global construction industry that has played major roles about information management and collaboration issues during the entire lifecycle of a construction project. Alliance for Construction Excellence (2008) describes BIM as a process of constructing a virtual 3D, 4D (time schedule), 5D (cost schedule), 6D (operations and maintenance) digital model before carrying out the real site activities in a construction project. As such, BIM has evolved as management method of developing a building model through collaboration for use by the project team and facility managers (Alliance for Construction Excellence, ACE, 2008).

Building projects in the Nigerian Construction Industry have experienced many problems on site. The problems, to mention but a few, are project delays, unkempt construction sites, complex site conditions, reoccurring accidents and poor work output. Ryal-Net and Kaduma (2015) noted that about 70% of problems encountered during construction are based on inadequacies in communication and information exchange. Dim, Ezeabasili and Okoro (2015), on the issue of the traditional approach in procuring building projects, noted that it lacks the collaboration but enhances isolation among the stakeholders with regards to the building project delivery process that fails to satisfy the clients' need. The assertion was based on observations that in projects with an architect, engineers and the contractor, the design stage would be completed before engaging the general contractor who would have offered advice on the constructability and buildability of the project. This has led to variations on sites.

In order to have a sustainable building project devoid of the aforementioned problems, the use of BIM in building projects has proved useful. The imperativeness of this study is based on the fact that there have been a low level of BIM knowledge by professionals in the Nigerian construction industry, despite the innumerable benefits it has to offer in bringing about improved project delivery among professionals and clients; and which will also help in solving the construction problems especially collaboration problem among stakeholders. One then wonders whether or not this assertion is right. It is therefore important to assess the usage of BIM for building projects in Nigeria using Akwa Ibom State as a case study. It is necessary to note that there is limited documentation of this kind of study in the South-South area of Nigeria. As such, the specific objectives of the study are to assess the awareness level of BIM and to evaluate the level of BIM's usage by construction professionals for sustainable building projects in the study area. In order to get more insights from the outcomes of these objectives, the following hypotheses were formulated for the study:

H_O: There is no significant variation in the awareness level of BIM among the construction professionals in the study area.

H_O: There is no significant variation on the level of BIM usage among the construction professionals in the study area.

2. REVIEW OF RELATED LITERATURE

2.1 BIM Awareness in the Construction Industry

Studies have shown that BIM is becoming popular in the building industry, as it was properly conceptualised over ten years ago to differentiate the 3D models from the traditional 2D designs (Jalaei & Jrade, 2014). Yusuf, Ali and Embi (2015) explained that the level of awareness of a society is an independent variable that other factors depend upon to achieve any capital development. Hence, this section gives a review of studies that were carried out on the awareness level of BIM. In North America, it was seen that there is a high level (62%) of BIM awareness among project stakeholders, and there is a plan to increase awareness among the 38% population that lacks understanding of BIM benefits (McGraw-Hill, 2012). In Europe, the same author observed that the project stakeholders are much aware and have enjoyed the benefits of BIM in building projects. A study was carried out by Alabdulqader, Panuwatwanich and Doh (2014) in Australia and the findings indicate that 84% of the respondents were aware of BIM, while 16% of them are not aware of these beneficial innovation.

An analysis on the Malaysian government by Enegbuma and Ali (2011) showed that the awareness of the importance of BIM which is a revolution in the building industry is high. The same author recorded that this level of awareness led to the establishment of JabatanKerja Raya (JKR) and the Construction Industry Development Board (CIDB) in Malaysia. In South Africa, a study by Kiprotich (2014) reflected that there is a high awareness level of BIM and its benefits, owing to the fact that the CAD systems previously used where abandoned for BIM usage. Armah (2015) in Ghana revealed that 41.37% of the respondents are not acquainted with the concept of BIM; the study showed that while 27.58% of the respondents had little knowledge of BIM, a lesser of 6.89% had a proficient knowledge of BIM.

Ryal-Net and Kaduma (2014) reported on the study carried out in the Nigerian Construction Industry, Kaduna State, Northern Nigeria and they found out that only 32.6% of respondents are aware of BIM compared to 67.4% of the respondents that are not aware of BIM. The author explained that the stakeholders in the Nigerian Construction Industry are much unaware of BIM. However, in a study by Ugochukwu, Akabogu and Okolie (2015) on the awareness level of BIM by stakeholders in Anambra and Enugu State, Eastern Nigeria; it was seen that 67% of the respondents in the study are aware of BIM, while 33% of them are not aware of this concept. The observation from these studies indicates that though there is a high level of awareness of BIM in several countries, there is need to ascertain the level of BIM awareness in the Nigerian construction industry.

2.2 Usage Level of BIM in the Construction Industry

According to Alliance for Construction Excellence (2008), there are three extents or levels of BIM usage in building projects. They consists thus: the first level relates to the basic and fundamental use of BIM; the second level expresses more notable exploitation of BIM at a project level; the third level is a more advanced, complex, and integrated approach to BIM. The first level of application or implementation ranges or spans from, Preliminary BIM requirements and implementation plan under project initiation, to 3D As-built model under facility management; the second level of implementation spans from 3D site logistics model, under conceptual stage, to intelligent as-built model; the third level of application spans from 4D site logistics model to 5D on site working model under the construction phase (ACE, 2008).

The extent to which BIM is used at the pre-construction stage is more than the construction and post-construction stage. Lattifi, Mohd, Kasim and Fathi (2013) gave the reason by saying that the pre-construction stage is made up of lots of activities like design, scheduling and estimating. In a study by Liu, Issa and Olbina (2010) on the United States AEC Industry, it revealed the extent to which the respondents were committed to using BIM in projects, even as the Autodesk Revit and Naviswork software packages were mostly used by the respondents. In North America, the study by McGraw-Hill (2012) on the usage or implementation level of BIM in building projects revealed that BIM usage has enormously increased over the years and its committed users have benefited a lot from it; it has also led to new plans for the future. It was seen that the application of BIM widely increased from 28% in 2007 to 71% in 2012. The contractors in North America are leading in its usage (74%), followed by architects (70%) and the engineers (67%).

In Iran, the study of Hosseini, Azari, Tivendale, and Chileshe (2015) revealed that only 29.5% of companies used for the study claimed to have used BIM, while 36.4% said they had no plan to use BIM in projects. It showed how the Iranian construction industry is slow in its implementation of BIM. In fact, it can be seen that 56.8% have never used BIM in any project (Hosseini, Azari, Tivendale, & Chileshe 2015). In the South Australian Construction industry, a study carried out by Newton and Chileshe (2012) showed that only 17.24% of the firms in South Australia used BIM to some extent, while 82.76% were confirmed not to be using BIM in projects. The study carried out by Ugochukwu, Akabogu and Okolie (2015) revealed that none of the respondents have used BIM in the projects they were involved in. More so, a study by Ryal-Net and Kaduma (2015) showed that there was low commitment by stakeholders to the use of BIM software packages in projects, and it was obvious that when their purpose for using BIM was assessed, the 3D modelling/presentation passed the test, meaning that BIM is not well utilized in the Nigerian Construction Industry.

The studies reviewed above on the awareness and usage of BIM, gives a good exposure on the present situation surrounding the area of BIM; but that notwithstanding, there are some noticed gaps that needs further improvement. It was obvious that though the studies in the area of BIM were notable around the world, the few studies in the study area were not substantial enough to ascertain the awareness level of BIM in the Nigerian construction industry. The studies reviewed did not take into consideration the advent of new areas of BIM like the 4D, 5D, 6D usages among the professionals, and this reflects a gap in the assessment of BIM usage in the Nigerian construction industry. This necessitates the need for this study.

3. METHODOLOGY

The study was carried out in one of Nigeria's oil-producing states in the South-South region – Akwa Ibom State, Nigeria. The study is based on the assessment of the usage of BIM. Therefore, the survey research design was used to elicit the perception of construction professionals. The population of the study was made up of Architects, Builders, Engineers, Quantity Surveyors, Estate Surveyors, Land Surveyors and Town Planners within Akwa Ibom State only. The population frame was established to be 366 based on the directories of professional bodies in Nigeria. The Taro Yamane's formula (Yamane, 1967) was then applied to estimate the sample size, which is 191. The population was stratified on the basis of professional bodies involved in the study and proportional representation was applied to distribute the sample size of 191 respondents among the various groups as shown in Table 1.In each group years of professional registration was used as basis for sample selection with preference given to early registration.

Table 1: Sample size of each component of the population frame

Registered Professionals	Population (N)	Sample size (n)
Architects	49	26
Builders	24	12
Engineers	117	62
Quantity Surveyors	47	24
Estate Surveyors	28	14
Land Surveyors	40	21
Town Planners	61	32
Total	366	191

The questionnaire was examined and criticised by experts to ensure its adequacy and effectiveness in achieving the intended results. The reliability analysis was also carried out on the research instrument using Cronbach's alpha. Table 2 reveals the outcome of the reliability test carried out on the data gathering instrument. The results are satisfactory implying internal consistency of test items.

Table 2: The reliability test

	Cronbach's Alpha	
	Awareness Level of BIM	Level of BIM Usage
Minimum	0.910	0.904
Maximum	0.912	0.908

The responses on the research objectives were analysed using the Binary Logistic Regression and the Relative Importance Index (RII) method, while the test of hypotheses was carried out using the Kruskal-Wallis test. Table 3 shows the response rate of the questionnaires administered. One hundred and forty-one (141) out of the one hundred and ninety-one (191) copies of questionnaire that were administered on the respondents were returned and properly filled. This represents a response rate of 74.2%, which is far above the 30% rate as an acceptable response rate in construction studies (Ryal-Net and Kaduma, 2015). Hence, the total of one hundred and forty-one copies of questionnaire was used for the analysis.

Table 3: The response rate of the research instrument

Responses	Number	Percentage
Questionnaires properly filled and returned	141	74.2
Questionnaires not properly filled and returned	50	25.8
Total	191	100

4. PRESENTATION AND DISCUSSION OF RESULTS

4.1 Respondents' Socio-economic Characteristics

Table 4 shows the result of the respondents' characteristics which were gotten from the one hundred and forty-one (141) questionnaires used for the analysis. The characteristics are: sex, nationality, profession, years of experience, age, educational status, professional affiliation, and registration status.

Table 4: Outcome of respondents' characteristics

Characteristics	Frequency	Percentage
Sex		
Male	130	92.2
Female	11	7.8
Nationality		
Nigerian	141	100
Non-Nigerian	0	0
Profession		
Builder	12	8.5
Architect	22	15.6
Estate Manager	14	9.9
Quantity Surveyor	20	14.2
Land Surveyor	8	5.7
Town Planner	4	2.8
Engineer	61	43.3
Years of Experience		
1-5 years	28	19.9
6-10 years	52	36.9
11-15 years	12	8.5
16-20 years	11	7.8
21-25 years	17	12.1
Above 25 years	21	14.9
Respondents' Age		
21-30 years	10	7.1
31-40 years	64	45.4
41-50 years	28	19.9
51-60 years	33	23.4
Above 60 years	6	4.3
Educational Status		
OND	0	0
HND	3	2.1
B.Sc	43	30.5
M.Sc	62	44
Ph.D	29	20.6
Others	4	2.8

Table 4: *Continued*

Professional Affiliation		
NIOB	12	8.5
NITP	4	2.8
NIESV	16	11.3
NIQS	20	14.2
NIA	22	15.6
NSE	61	43.3
NIS	6	4.3
Registration Status		
Student	0	0
Technician	0	0
Licentiate	0	0
Graduate	25	17.7
Corporate	108	76.6
Fellow	8	5.7
Honorary	0	0

As shown on Table 4, the sex distribution outcome reflects that 92.2% of the respondents were male, while 7.8% of them were female. This shows a low participation of the female gender in the construction industry which in turn affects their proficiency in BIM. It could be said that when there is an increase in women's participation in the industry, it may influence the implementation of BIM in projects. The nationality characteristic of respondents reveals that 100% of the respondents were Nigerian. The study has to do with the application of BIM in the Nigerian environment; therefore this outcome will give a suitable and satisfactory result, since Nigerians who are aware of their environment are completely involved in the study.The result of the respondents' profession returns that 43.3% of them are engineers, the architects are 15.6%, quantity surveyors 14.2%, estate mangers 9.9%, and the builders are 8.5%. The land surveyors and town planners represented 5.7% and 2.8% of the respondents, respectively. This shows that the appropriate professionals were represented in the study.

The result of the respondents' years of experience reveals that 19.9% of the respondents are experienced between 1-5 years, 36.9% of them are experienced between 6-10 years, 8.5% are between 11-15 years, 7.8% are between 16-20 years, 12.1% are between 21-25 years, and 14.9% of the respondents had experience above 25 years. Since BIM is an innovation in the Nigerian construction industry, the result of the study will be true and satisfactory enough; this is so because 36.9% of the respondents are experienced within the range of 6-10 years, and those between 1-5 years. The age distribution of the respondents outlines that 7.1% of the respondents' had ages between 21-30 years, 45.4% of them were between 31-40 years, 19.9% were between 41-50 years, 23.4% were between 51-60 years, while 4.3% were above 60 years. This also reveals that the outcome of the study will be satisfactory, since the respondents with lower ages are more in percentage, and it is expected that the younger ones will be more proficient in the application of BIM in construction projects.

The result also shows that none of the respondents were at the level of ordinary national diploma (OND) in the educational status of the respondents, 2.1% of them have attained the higher national diploma (HND) level, 30.5% have the bachelor of Science

(B.Sc) degree, 44% had attained the master of science (M.Sc) degree, 20.6% had attained the doctor of philosophy (Ph.D) status, while 2.8% filled for other educational qualifications. This shows that the respondents are qualified through experience, expertise and training to give the appropriate information needed for the study. It can also be seen from the Table that all the respondents were affiliated to their respective professional bodies which are the Nigerian Institute of Building (NIOB), Nigerian Institute of Town Planners (NITP), Nigerian Institute of Estate surveyors and valuers (NIESV), Nigerian Institute of Quantity Surveyors (NIQS), Nigerian Institute of Architects (NIA), Nigerian Society of Engineers (NSE), and the Nigerian Institution for surveyors (NIS). This shows that the right hands that are not quacks have been selected for the study; and this would give the needed outcome.

The result on the registration status of respondents exposes that 76.6% of the respondents were corporate members, 17.7% graduate members, and 5.7%were fellow members. This means that the study is in line with its scope of using registered professionals, since 82.3% of the respondents were fully registered with both their professional and regulatory bodies.

4.2 The Awareness Level of BIM in the Study Area

Tables 5 and 6 shows the result of the construction industry professionals with respect to their level of awareness of the BIM concept for sustainable building projects. The binary logistic regression was adopted for the analysis to determine whether the construction professionals are aware or not aware of BIM. The result showed that the professionals were probably aware of BIM in the study area with 65.7% awareness probability against 45.1% non-awareness probability level. The overall classification accuracy of the model was 55.3% which showed a perfect fit to model in the data.

Table 5: The awareness level of BIM by construction professionals in the study area

BIM Concepts	Yes Freq.	%	No Freq.	%	Not Freq.	Sure %
Collaboration of design and construction techniques	119	84.4	6	4.3	16	11.3
Communication between project stakeholders	121	85.8	9	6.4	11	7.8
Clarification and reduction of risk	104	73.8	18	12.8	19	13.5
Reduction of change orders and request for information	100	70.9	13	9.2	28	19.9
Facilities and asset management for owners	88	62.4	29	20.6	24	17.0
Linking of Quantity take-off to construction drawings	107	75.9	19	13.5	15	10.6
Linking of project budgets & schedules to construction drawings	115	81.6	19	13.5	7	5.0

Table 5: *Continued*

BIM Concepts	Yes Freq.	%	No Freq.	%	Not Freq.	Sure %
Linking of 3D model to construction drawings	117	83	9	6.4	15	10.6
Production of As-Built drawings	108	76.6	20	14.2	13	9.2
Clash detection	77	54.6	21	14.9	43	30.5
Improved visualisation for project stakeholders	118	83.7	11	7.8	12	8.5
Fast-tracking building process due to virtual building model	112	79.4	14	9.9	15	10.6
Improved productivity due to easy determination of information	119	84.4	12	8.5	10	7.1
Quicker building and system start-up times and personnel training due to the virtual building BIM model	112	79.4	17	12.1	12	8.5
Average	108.4	76.8	15.5	11.0	17.1	12.2

Table 6: The awareness level of BIM by construction professionals in the study area

Observed		Predicted Awareness Probabilities		
		Not Aware	Aware	Percentage Correct
Awareness Probabilities	Not Aware	32	39	45.1
	Aware	24	46	65.7
Overall Percentage				55.3
The cut value is .500				

4.3 Test of Hypothesis One on Awareness Level of BIM in the Study area

A certainty in the study was needed to affirm if there is a variation in the awareness level of BIM among the different professionals in the study area. Hence, the following hypotheses were tested:

H_O: *There is no significant variation in the awareness level of BIM among the construction professionals for sustainable building projects in the study area.*

H_1: *There is significant variation in the awareness level of BIM among the construction professionals for sustainable building projects in the study area.*

The H-test was carried out on the hypothesis and the decision rule is such that if the *p*-value is less than 0.05, it means the null hypothesis is rejected and the alternative hypothesis is accepted. Otherwise, the null hypothesis is accepted and the alternative hypothesis is rejected.

Table 7: Variation on the awareness level of BIM by professionals in the study area

BIM Concept	Designation of Respondent	N	Mean Rank	Chi Square	D/f	Sig.	Remark
Collaboration of design and construction techniques	Builder	12	96.75	28.519	6	0.000	S
	Architect	22	79.05				
	Estate Surveyor	14	68.93				
	Q.S	20	60.00				
	Land Surveyor	8	94.00				
	Town Planner	4	60.00				
	Engineer	61	64.82				
Communication between project stakeholders	Builder	12	73.50	18.908	6	0.004	S
	Architect	22	74.64				
	Estate Surveyor	14	86.36				
	Q.S	20	70.75				
	Land Surveyor	8	93.50				
	Town Planner	4	61.00				
	Engineer	61	63.46				
Clarification and reduction of risk	Builder	12	92.25	24.127	6	0.000	S
	Architect	22	76.36				
	Estate Surveyor	14	95.68				
	Q.S	20	60.45				
	Land Surveyor	8	83.00				
	Town Planner	4	52.50				
	Engineer	61	62.32				
Reduction of change orders and request for information	Builder	12	63.33	17.953	6	0.006	S
	Architect	22	71.50				
	Estate Surveyor	14	89.75				
	Q.S	20	58.20				
	Land Surveyor	8	103.13				
	Town Planner	4	50.50				
	Engineer	61	69.35				
Facilities and asset management for owners	Builder	12	87.00	5.992	6	0.424	N.S
	Architect	22	65.77				
	Estate Surveyor	14	73.36				
	Q.S	20	71.88				
	Land Surveyor	8	80.38				
	Town Planner	4	44.50				
	Engineer	61	69.42				
Linking of Quantity take-off to construction drawings	Builder	12	67.33	21.398	6	0.002	S
	Architect	22	61.27				
	Estate Surveyor	14	94.86				
	Q.S	20	72.30				
	Land Surveyor	8	101.25				
	Town Planner	4	54.00				
	Engineer	61	66.48				
Linking of project budgets & schedules to construction drawings	Builder	12	84.67	12.478	6	0.052	N.S
	Architect	22	64.09				
	Estate Surveyor	14	77.14				
	Q.S	20	74.75				
	Land Surveyor	8	91.50				
	Town Planner	4	58.00				
	Engineer	61	66.33				

Table 7: *Continued*

BIM Concept	Designation of Respondent	N	Mean Rank	Chi Square	D/f	Sig.	Remark
Linking of 3D model to construction drawings	Builder	12	84.00	17.128	6	0.009	S
	Architect	22	72.64				
	Estate Surveyor	14	93.07				
	Q.S	20	66.50				
	Land Surveyor	8	59.00				
	Town Planner	4	59.00				
	Engineer	61	66.62				
Production of As-Built drawings	Builder	12	67.92	9.336	6	0.156	N.S
	Architect	22	66.14				
	Estate Surveyor	14	86.64				
	Q.S	20	62.55				
	Land Surveyor	8	86.50				
	Town Planner	4	54.50				
	Engineer	61	71.59				
Clash detection	Builder	12	79.50	13.225	6	0.040	S
	Architect	22	67.09				
	Estate Surveyor	14	63.36				
	Q.S	20	67.35				
	Land Surveyor	8	96.00				
	Town Planner	4	120.00				
	Engineer	61	67.20				
Improved visualisation for project stakeholders	Builder	12	72.17	24.140	6	0.000	S
	Architect	22	73.32				
	Estate Surveyor	14	68.71				
	Q.S	20	65.95				
	Land Surveyor	8	113.63				
	Town Planner	4	59.50				
	Engineer	61	67.28				
Fast-tracking building process due to virtual building model	Builder	12	69.42	27.385	6	0.000	S
	Architect	22	62.23				
	Estate Surveyor	14	102.18				
	Q.S	20	56.50				
	Land Surveyor	8	88.00				
	Town Planner	4	56.50				
	Engineer	61	70.80				
Improved productivity due to easy determination of information	Builder	12	72.75	27.029	6	0.000	S
	Architect	22	60.00				
	Estate Surveyor	14	69.36				
	Q.S	20	60.00				
	Land Surveyor	8	109.13				
	Town Planner	4	60.00				
	Engineer	61	74.33				
Quicker building and system start-up times and personnel training due to the virtual building BIM model	Builder	12	69.67	22.823	6	0.001	S
	Architect	22	62.36				
	Estate Surveyor	14	91.86				
	Q.S	20	68.35				
	Land Surveyor	8	104.88				
	Town Planner	4	56.50				
	Engineer	61	66.97				

N.S = Not Significant; S = Significant; N = Number of Respondents
D/f = Degree of freedom; Sig. = Significant Level

From Table 7, most of the variables are with p-values less than 0.05, which by indication means they are significant. This means that the null hypothesis is rejected, while the alternative hypothesis is accepted for the variables. However, there were three variables with p-values greater than 0.05; this means that for those three variables, the null hypothesis is accepted, while the alternative hypothesis is rejected. Hence, due to the significant variation of eleven variables, a post hoc test was carried out on these variables using Mann-Whitney U test to determine the variations' contributing respondents. Its findings are explained below.

For the collaboration of design and construction techniques, the builder, architect and the land surveyor, were the sources of the variation. In the case of the second variable which is communication between project stakeholders, the engineer was the source of the variation. The builder, quantity surveyor, and the engineer contributed to the variation in the clarification and reduction of risk. The estate and land surveyor were the source of the variation in the reduction of change orders and request for information. The contributing groups to the variation on the linking of quantity take-off to construction drawings are the estate and land surveyors. The engineer and the estate surveyor are the sources of the variation on linking of 3D model to construction drawings. The architect, engineer, town planner and estate surveyor contributed to the variation on clash detection. The contributing group to the variation on improved visualisation for the project stakeholders is the land surveyor. The quantity surveyor, estate and land surveyor are the source of the variation on fast-tracking building process due to virtual building model. For improved productivity due to easy determination of information, the engineer, quantity and land surveyor are the contributing group to the variation. The architect, estate and land surveyor are the sources of the variation on quicker building and system start-up times and personnel training due to the virtual BIM model.

4.4 The Level of BIM Usage in the Study Area

Table 8 reveals the responses of the professionals on their usage of BIM in producing the virtual models for sustainable building projects, as outlined. As shown in Table 8, the most produced model in BIM usage by the respondents is the 3D Building design model (Ranked 1st) with an R.I.I score of 0.691; since the value ranked above the 0.60 R.I.I score, it indicates a high usage of BIM for presentation purposes. However, since the other virtual models ranked below the 0.60 R.I.I score, it can be deduced that there is a low level of BIM usage among the construction industry professionals.

Table 9 also shows the responses of the professionals with regards to the utilisation of the BIM software packages as outlined below. From Table 9, it is observed that the most utilised BIM software is AutoCAD Architecture (Ranked 1st), followed by Revit Architecture (Ranked 2nd) and AutoCAD Civil 3D (Ranked 3rd). For the fact that all these software packages for BIM scored well below the 0.60 R.I.I score, it indicates a very low level of BIM software utilisation among the professionals in the study area.

4.5 Test of Hypothesis Two on the Level of BIM Usage in the Study Area

In order to have a concluding statement on the variation of BIM usage among the professionals for sustainable building projects in the study area, the following hypotheses were tested:

Table 8: The level of BIM usage by the professionals in the study area

	Overall			Builder			Architect			Estate S.			Quantity S.			Land Sur.			Town Plr.			Engineer		
Virtual Model	N*	R.I.I*	Rank	N	R.I.I	Rank	N	R.I.I	Rank	N	R.I.I	Rank	N	R.I.I	Rank	N	R.I.I	Rank	N	R.I.I	Rank	N	R.I.I	Ranl
3D Building Design Model	141	0.691	1	12	0.667	1	22	0.818	1	14	0.443	2	20	0.6	1	8	0.45	2	4	0.8	1	61	0.761	1
3D Engineering Model	141	0.575	2	12	0.467	3	22	0.527	7	14	0.343	9	20	0.47	3	8	0.35	4	4	0.6	3	61	0.728	2
3D Constructability Model	141	0.569	3	12	0.467	3	22	0.673	3	14	0.414	3	20	0.43	5	8	0.6	1	4	0.8	1	61	0.613	4
3D As-Built Model	141	0.563	4	12	0.433	5	22	0.727	2	14	0.357	8	20	0.47	3	8	0.45	2	4	0.6	3	61	0.619	3
3D Phasing Model	141	0.516	5	12	0.433	5	22	0.6	4	14	0.386	6	20	0.48	2	8	0.35	4	4	0.6	3	61	0.561	7
3D Coordination Model	141	0.515	6	12	0.5	2	22	0.564	5	14	0.4	4	20	0.4	7	8	0.3	7	4	0.6	3	61	0.587	5
3D Site Logistics Model	141	0.514	7	12	0.4	7	22	0.545	6	14	0.457	1	20	0.43	5	8	0.3	7	4	0.6	3	61	0.587	5
5D Cost Schedule Model	141	0.468	8	12	0.4	7	22	0.455	9	14	0.4	4	20	0.33	8	8	0.35	4	4	0.6	3	61	0.554	8
4D Time Schedule Model	141	0.461	9	12	0.367	9	22	0.491	8	14	0.371	7	20	0.32	9	8	0.3	7	4	0.6	3	61	0.548	9

* R.I.I: Relative Importance Index; N: Total

Table 9: The level of BIM usage by the professionals in the study area

	Overall			Builder			Architect			Estate S.			Quantity S.			Land Sur.			Town Plr.			Engineer		
BIM Software	N	R.I.I	Rank	N	R.I.I	Rank	N	R.I.I	Rank	N	R.I.I	Rank	N	R.I.I	Rank	N	R.I.I	Rank	N	R.I.I	Rank	N	R.I.I	Rank
AutoCAD Architecture	141	0.494	1	12	0.639	1	22	0.742	1	14	0.357	1	20	0.358	1	8	0.208	4	4	0.833	1	61	0.467	1
Revit Architecture	141	0.395	2	12	0.583	2	22	0.606	2	14	0.274	4	20	0.35	2	8	0.208	4	4	0.667	4	61	0.331	7
AutoCAD Civil 3D	141	0.389	3	12	0.5	3	22	0.182	5	14	0.214	8	20	0.333	3	8	0.583	1	4	0.667	4	61	0.456	2
ArchiCAD	141	0.353	4	12	0.333	5	22	0.394	3	14	0.321	3	20	0.267	5	8	0.208	4	4	0.833	1	61	0.366	4
Revit Structure	141	0.305	5	12	0.5	3	22	0.242	4	14	0.274	4	20	0.3	4	8	0.208	4	4	0.167	7	61	0.319	8
AutoCAD MEP	141	0.289	6	12	0.278	7	22	0.167	6	14	0.25	6	20	0.158	6	8	0.417	3	4	0.833	1	61	0.336	6
Orion	141	0.226	7	12	0.306	6	22	0.03	10	14	0.155	12	20	0.017	7	8	0.125	11	4	0.167	7	61	0.383	3
Land Desktop Development	141	0.209	8	12	0.083	12	22	0.061	9	14	0.238	7	20	0.008	9	8	0.542	2	4	0.333	6	61	0.295	9
Staad Pro	141	0.209	9	12	0.25	8	22	0.03	10	14	0.19	9	20	0	10	8	0.167	8	4	0.167	7	61	0.347	5
Navisworks	141	0.168	10	12	0.139	9	22	0.091	7	14	0.19	9	20	0.017	7	8	0.167	8	4	0.167	7	61	0.246	10
FM Desktop	141	0.147	11	12	0.111	10	22	0.03	10	14	0.333	2	20	0	10	8	0.167	8	4	0.167	7	61	0.197	12
Tekla	141	0.135	12	12	0.111	11	22	0.076	8	14	0.19	9	20	0	10	8	0.125	11	4	0.167	7	61	0.191	13
Catia	141	0.123	13	12	0.056	13	22	0.03	10	14	0.119	13	20	0	10	8	0.125	11	4	0.167	7	61	0.208	11

* R.I.I: Relative Importance Index; N: Total

H_O*: *There is no significant variation on the level of BIM usage among the construction professionals for sustainable building projects in the study area.

H_1*: *There is significant variation on the level of BIM usage among the construction professionals for sustainable building projects in the study area.

The H-test was carried out on the hypothesis and the decision rule is such that if the p-value is less than 0.05, it means the null hypothesis is rejected and the alternative hypothesis is accepted. Otherwise, the null hypothesis is accepted and the alternative hypothesis is rejected.

From Table 10, almost all the variables are with p-values less than 0.05, which by indication means they are significant. This means that the null hypothesis is rejected, while the alternative hypothesis is accepted for the variables. However, one of the variables (3D site phasing model) returned a p-value greater than 0.05; this means that for this variable, the null hypothesis is accepted, while the alternative hypothesis is rejected. Hence, due to the significant variation of eight variables, a post hoc test was carried out on these variables using Mann-Whitney U test to determine the variations' contributing respondents.

The estate and land surveyor are the sources of the variation in the responses for 3D building design model. The contributing groups to the variation of the responses on 3D engineering model are the architect, engineer and estate surveyor. The builder, land surveyor and engineer are the sources of the variation in the responses for 3D site logistics model. For the 3D constructability model, the architect, quantity surveyor, town planner and engineer are the sources of the variation. The land surveyor and engineer contributed to the variation on the 3D coordination model. The architect and estate surveyor are the sources of variation in the 3D as-built model. For the 4D time schedule model, the builder, quantity surveyor and the engineer are the sources of the variation. The quantity surveyor and the engineer are the contributing groups to the variation in the 5D cost schedule model.

Table 10: Variation on the level of BIM usage by the professionals in the study area

Virtual Model	Designation of Respondent	N	Mean Rank	Chi Square	D/f	Sig.	Remark
3D Building Design Model	Builder	12	63.42	26.275	6	0.000	S
	Architect	22	90.32				
	Estate Surveyor	14	36.14				
	Q.S	20	65.13				
	Land Surveyor	8	37.38				
	Town Planner	4	78.00				
	Engineer	61	79.40				
3D Engineering Model	Builder	12	55.00	35.593	6	0.000	S
	Architect	22	63.50				
	Estate Surveyor	14	39.93				
	Q.S	20	57.80				
	Land Surveyor	8	41.38				
	Town Planner	4	69.50				
	Engineer	61	92.30				
3D Site Logistics Model	Builder	12	57.17	14.851	6	0.021	S
	Architect	22	74.14				
	Estate Surveyor	14	61.71				
	Q.S	20	57.68				
	Land Surveyor	8	40.38				
	Town Planner	4	86.50				

Table 10: *Continued*

	Engineer	61	82.09				
3D Phasing Model	Builder	12	62.58	9.057	6	0.170	N.S
	Architect	22	80.82				
	Estate Surveyor	14	53.57				
	Q.S	20	66.90				
	Land Surveyor	8	49.00				
	Town Planner	4	81.00				
	Engineer	61	76.69				
3D Constructability Model	Builder	12	59.33	14.689	6	0.023	S
	Architect	22	84.18				
	Estate Surveyor	14	50.79				
	Q.S	20	52.90				
	Land Surveyor	8	76.50				
	Town Planner	4	99.00				
	Engineer	61	76.56				
3D Coordination Model	Builder	12	70.42	14.982	6	0.020	S
	Architect	22	76.59				
	Estate Surveyor	14	55.11				
	Q.S	20	55.08				
	Land Surveyor	8	41.25				
	Town Planner	4	82.50				
	Engineer	61	81.11				
3D As-Built Model	Builder	12	55.33	18.904	6	0.004	S
	Architect	22	92.27				
	Estate Surveyor	14	45.71				
	Q.S	20	60.08				
	Land Surveyor	8	55.25				
	Town Planner	4	69.50				
	Engineer	61	77.96				
4D Time Schedule Model	Builder	12	58.92	20.615	6	0.002	S
	Architect	22	75.86				
	Estate Surveyor	14	53.82				
	Q.S	20	51.20				
	Land Surveyor	8	46.63				
	Town Planner	4	93.50				
	Engineer	61	83.78				
5D Cost Schedule Model	Builder	12	62.00	16.394	6	0.012	S
	Architect	22	69.05				
	Estate Surveyor	14	58.82				
	Q.S	20	51.65				
	Land Surveyor	8	52.75				
	Town Planner	4	92.00				
	Engineer	61	83.63				

N.S = Not Significant; S = Significant; N = Number of Respondents
D/f = Degree of freedom; Sig. = Significant Level

4.6 Discussion of Major Findings

The findings emanating from the study are discussed as follows:

4.6.1 The Awareness Level of BIM in the Study Area

The study on the awareness level of BIM by construction professionals in the study area revealed that there is a high level of BIM awareness for sustainable building projects among the professionals. It can be asserted that since the professionals are much aware of the relationship between BIM and the sustainability of building projects, its usage and adoption can be much anticipated. This outcome is in agreement with a study in North America by McGraw-Hill (2012), where it was seen that there is a high level of BIM awareness among project stakeholders. It also agrees with a study by Bernstein (2010) in Europe where it was observed that the project stakeholders are much aware and have enjoyed the benefits of BIM in building projects. This supports the study by Alabdulqader, Panuwatwanich and Doh (2014) in Australia that reflected a high level of BIM awareness. It also agrees with the study by Enegbuma and Ali (2011) that the awareness of BIM importance and benefits in the Malaysian construction industry is high. It also supports a study by Kiprotich (2014) in South-Africa which reflected that there is a high awareness level of BIM and its benefits among project stakeholders. Ugochukwu, Akabogu and Okolie (2015) in South-Eastern Nigeria, also asserted that the level of BIM awareness in the Nigerian construction industry is high, which corresponds with the findings of this study.

The results from the hypothesis on the variation of BIM awareness among construction professionals revealed a significant variation in their awareness level for eleven variables, and the null hypothesis was rejected while the alternative hypothesis was accepted for these variables; but three of the variables (facilities and asset management for owners, linking of project budgets & schedules to construction drawings, production of as-built drawings) revealed a not significant variation, meaning that the null hypothesis was accepted for them while the alternative hypothesis was rejected. This shows that though the professionals are aware of BIM and its concept in the study area, some group of professionals are more aware of BIM than the other groups. This implies that some professionals are still lagging behind in equipping themselves with the current trends in technology advancements as it relates to the construction industry. This was also ascertained from the post hoc test, and it was seen that most of the professionals were appearing as the source of the variation in the awareness level of BIM in the study area. In a situation like this where some professionals are not fully aware of BIM’s benefits, the movement for its adoption and the quest for sustainable buildings in the construction industry, will be slackened.This supports the study by Akerele and Etiene (2016) which asserted that the professionals’ level of BIM awareness varies a lot in the different stages of construction project.A respondent made a comment on areas that the professionals ought to be aware of, as regards the concept of BIM for sustainable building projects in the construction industry:

> *Minimization of waste on site, design of large-scale complex project and simulate /analyse potential impacts for sustainable construction (**Builder**)*

4.6.2 The Level of BIM Usage in the Study Area

From this study, it was clear that there is a low level of BIM usage by the professionals in the study area. It was also obvious that BIM is mainly used at the design or pre-construction stage to produce 3D design models. This outcome shows that the level at which BIM is used in building projects in the study area, does not measure up in any way to the concept of sustainability practices even in the planning stage; this is because the 3D presentations only give a pictorial representation and do not put into consideration, sustainable concepts. This supports a study carried out in Europe by Bernstein (2010), where it was observed that there is a slow implementation of BIM in building projects. This is in agreement with the study by Hosseini, Azari, Tivendale and Chileshe (2015), who asserted that BIM has never been used and its implementation is at a slow rate in the Iranian construction industry. It also aligns with a study in the South Australian construction industry by Newton and Chileshe (2012) that there is a very low level of BIM usage in projects. The studies carried out in the Nigerian construction industry by Ugochukwu, Akabogu and Okolie (2015) and Ryal-Net and Kaduma (2015) also agrees with this study that there is a very low level of BIM usage by professionals in the Nigerian construction industry.

The results from the hypothesis on the variation of the professionals' BIM usage level revealed that there is a significant difference among the professionals in their usage of BIM for eight virtual models, and the null hypothesis was rejected while the alternative hypothesis was accepted for them; meanwhile, one of the variables (3D phasing model) revealed no significant variation, and the null hypothesis was accepted for it, while the alternative hypothesis was rejected. This clarifies the findings as shown in Table 8 that BIM is majorly used for the 3D design model and presentation purposes, while other areas are not been exploited. In order to attain sustainable buildings in Nigeria, there is need for the application of all aspects of BIM; but from this study it is obvious that the level of BIM usage by some professionals is far below the level of its usage by other professionals, especially the architects that present 3D models using some software packages. This shows that the professionals are lagging behind in the move for sustainable building projects in the Nigerian construction industry.

5. Conclusion and Recommendations

The study investigated the usage of BIM in building projects delivery in Akwa Ibom state, Nigeria, with a view to achieving sustainable building projects through effective collaboration among building professionals. The study assessed the awareness and usage level of BIM in the study area and concluded that there is a high level of awareness of BIM and its concepts. However, there is a low level of usage among the professionals in Nigeria's construction industry. The study therefore recommends that there is need for professionals to brace up to the current trend in information management on construction sites for improved project delivery, and for sustainable building projects, by making good use of BIM in their projects. This can be achieved through relevant legislation by the government.

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