

## Assessment of BIM Implementation among MEP Firms in Nigeria

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### ABSTRACT

The purpose of this study is to assess the awareness level and potential challenges for Building Information Modelling (BIM) adoption among the Mechanical, Electrical and Plumbing (MEP) design consultants and contractors in Nigeria, and to get the perspective of BIM in the industry. The research method used in this study was a fieldwork survey using structured questionnaires. The results from the responses were analysed using descriptive statistics, one-way ANOVA test for statistical significant difference, Chi-Square test, and Cross Tab analysis. The findings from the survey show that Nigeria MEP firms have a relatively high level of awareness toward BIM technology. The Most important challenges identified as barriers for BIM adoption are lack of technical expertise on BIM tools utilisation, lack of awareness of BIM technology, and high investment cost in training staff, process change, and software/hardware upgrade.

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## 1. INTRODUCTION

Building Information Modelling (BIM) technology is one of the current collaborative technologies which is effective in three-dimensional (3D) visualization and data storage for planning, constructing and operating/maintaining building construction projects [1]. Korman et al., [2] defines BIM as the process of creating an intelligent and computable 3D data model that can be shared among the various professionals within the design and construction team. BIM is also defined as an intelligent model-based design process that adds value across the entire lifecycle of building and infrastructure projects [3]. The BIM process involves the creation of intelligent building models that carry useful information and integrated data. The BIM models can be shared across different disciplines to help reduce the error or confusion caused by the issues associated with collaboration between architects, engineers, and subcontractors [4]. In fact, BIM has been applied in preplanning, design, and construction and for integrated project delivery of buildings and infrastructure for many years [5]. It has been reported that BIM implementation is being practiced for decades in Canada, France, Germany, UK, and US [6]. Other markets that have recently begun adopting BIM are Australia, Brazil, Japan, Korea, and New Zealand. It was also reported that BIM adoption in North America expanded from 28% in 2007 to 71% in 2012. The National BIM Report (2012) shows that the use of BIM and the awareness of BIM had risen by 58% and 28%, respectively from year 2011 to 2012 [7]. This proves that BIM has gained a wide adoption in the developed nations. However, in Nigeria, there has not been any report of quantitative evidence to justify the adoption rate of BIM. Alufohai [8] stated that the move to adopt BIM in Nigeria's private and public sector (client side) and among different building professionals has been very slow. Architects have adopted BIM but mainly for enhancing the visual quality of their

presentation. This research, therefore, aims to assess the level of awareness of BIM technology among the MEP building services firms in Nigeria, and to determine the challenges for adoption of BIM technology.

## **2. METHODOLOGY**

### **2.1. Literature Review**

The literature review was used for preliminary data gathering about the benefits of BIM and challenges of BIM adoption from previous studies. The review serves as a guide in the development of the research instrument used to assess awareness level, respondents' perspectives on BIM, and the challenges for adoption, and also serves as a baseline to compare the findings from the questionnaires responses with previous researches.

### **2.2. Survey**

A quantitative research approach was used to carry out this research using analytical survey approach. This method was selected because it has more advantages compared to other qualitative approaches in terms of good response rate, wider geographical coverage, privacy protection, not subjective and bias free [9]. The approach used for collection of primary data was a fieldwork analytical survey using structured questionnaire.

#### **2.2.1. Questionnaire Design**

The questionnaire was designed based on the information acquired through the literatures review. It contains a series of closed-ended questions relating to BIM technology awareness and challenges. The questionnaire aims to assess and examine the level of awareness MEP building services firm about the BIM technology, and also to acquire their perspectives and identify those challenges affecting the adoption of BIM technology in the industry. The questionnaire was composed of three sections. The first section was used to obtain demographic information as follows:

1. Classification of firms based on services delivered;
2. Position of respondent in the company;
3. Size of the company;
4. Years of experience of the company; and
5. Years of experience of the respondents in this industry

The second section of the questionnaires contains questions about the BIM awareness comprising 12 numbers of variables. This section intends to assess the level of awareness of respondents on BIM technologies; the extent to which they are aware of the benefits that BIM offers, and to know their perspectives. It assessed the respondents' perception on a five point likert scale, where 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree.

The last section contains questions about the BIM challenges in order to investigate the most important factors that are militating against the BIM adoption in the respective firms. It mainly contains 16 numbers of variables assessing the respondents' perception on a five point likert scale. The questionnaire was reviewed by the experts in the BIM field using their expert knowledge to check for the appropriateness of the questionnaires variables in order to ensure the content validity of the questionnaire.

#### **2.2.2. Questionnaires Administration**

The survey method used for this research was a self-administered survey conducted using an electronics mails with a follow up telephone calls. Total of 25 numbers of MEP firms participated in this survey. The questionnaires were sent *via* e-mail along with the cover letter. The numbers of questionnaire that were able to be administered were 78 and the number of properly filled responses were 47; given a total response rate of 60%.

### **2.3. Method of Analysis**

The responses obtained from the respondents were coded, screened for procedural errors, and inspected for missing data for exclusion from analysis using SPSS software. The reliability of the ordinal variables in the questionnaire was established using the Cronbach's Alpha internal consistency method. The descriptive statistics was used to analyse all the demographic categorical variables and to measure their frequency and percentages of distribution.

The descriptive statistics was also used to identify the most important and weighty factors identified as challenges for the BIM adoption. In order to select the most appropriate inferential statistical method, normality test was conducted for overall BIM awareness variable using Kolmogorov-Smirnov test, Skewness and Kurtosis test, Histogram and box plot. In addition, one-way ANOVA was used to compare the mean of

the MEP groups for any statistical significant differences in their level of awareness. In order to verify any statistical significant relationship between the MEP groups and the overall level of awareness, Chi-Square test and Cross Tab analysis were used.

### 3. RESULT AND DISCUSSION

The results of reliability test, demographic information of respondents, normality test, one-way ANOVA, Chi-Square test, and Cross Tab Analysis are presented and discussed hereunder.

#### 3.1. Reliability Test

The results from reliability test show that the value of Cronbach's Alpha is 0.883, suggesting very good internal consistency reliability for the scale of items used in the questionnaire. The results are shown in Table 1 and 2. The high level of internal consistency value means that the construct the items measuring are closely related. In fact, the values above 0.7 are considered acceptable and values above 0.8 are preferable [10].

Table 1. Reliability Test

	Item-Total Statistics			Cronbach's Alpha if item deleted
	Scale mean if item deleted	Scale variance if item deleted	Corrected item- total correlation	
Building Information Modelling (BIM) is an intelligent model-based design process that adds value across the entire lifecycle of building and infrastructure projects	96.58	185.20	0.49	0.87
Architecture, Engineering and Construction (AEC) companies are using BIM to realize improved productivity and cost-effectiveness	96.84	190.18	0.25	0.88
BIM provide more efficient sustainable design, increased energy efficiency and overall building performance	96.86	189.64	0.29	0.88
BIM improves collaborative working in projects and reduces construction change order	96.88	186.53	0.40	0.88
BIM is a model based workflow that allows the contractors to be integrated right from the design phase	96.98	186.07	0.44	0.87
The use of BIM in construction design can support the implementation and use of LEAN practices by standardizing the work flows, data and file types and providing a centralized documentation and information exchange	97.07	190.40	0.27	0.88
BIM allows constructability issue easily resolve and timely conflict identification and resolution	97.07	187.92	0.32	0.88
BIM allows the project team to make better and more-informed decision across the entire project life cycle	96.93	183.11	0.57	0.87
BIM tools can be used for clash detection between MEP designs and architectural and structural designs	96.95	186.90	0.40	0.88
4D BIM can be used for scheduling, animation, safety analysis and prepare site logistic plans	97.19	191.82	0.25	0.88
5D BIM aids automatic quantification and cost estimate	97.37	193.90	0.14	0.88
BIM Model can be used as As-built Model which serve as the basis for comprehensive facilities and asset management program	97.07	189.11	0.32	0.88
Lack of awareness of BIM technologies	97.14	172.12	0.66	0.87
Lack of technical expertise on BIM tools utilisation	97.07	175.54	0.61	0.87
Non-availability of well trained professional to handle the tools	97.33	180.51	0.46	0.87
Reluctant to change from traditional 2D workflow to new BIM based workflows.	97.86	185.98	0.29	0.88
Benefits from BIM implementation do not outweigh the costs to implement it.	98.14	191.36	0.18	0.88
Effectively implementing the new process and workflow.	97.44	185.30	0.53	0.87
High investment cost on training staff, process change and software and hardware upgrade	97.26	179.33	0.62	0.87
Overcoming the resistance to change, and getting people to understand the potential and the value of BIM over 2D drafting	97.65	182.09	0.53	0.87
Lack of Clients' interest in the use of BIM in their project	98.12	188.58	0.26	0.88
Lack of knowledgeable and experience partner	97.67	187.74	0.29	0.88
Clear understanding of the responsibilities of different stakeholders in the new process	97.60	188.67	0.37	0.88
Software availability and licensing issue	97.40	177.57	0.57	0.87
Lack of cooperation and commitment of professional bodies to its implementation	97.60	177.29	0.62	0.87
Lack of government support through legislation	97.56	174.63	0.58	0.87
Lack of Standards to guide its implementation	97.63	175.62	0.58	0.87
Required collaboration, integration and interoperability between the structural and MEP designer/engineer	97.23	182.70	0.60	0.87

Table 2. Reliability Alpha Value

Reliability Statistics	
Cronbach's Alpha	No. of Items
0.88	28

### 3.2. Demographic Profile of Respondents

The details of the respondents involved in the questionnaire survey are provided in Table 3. The details include the MEP Firm Groups, position of respondent, size of company, years of experience of company, and years of experience of respondents.

Table 3. Demographic profile of respondents ( N = 47 )

Variables	Category	n	%
MEP Firm Groups	M & E Design Consulting Firm	26	55.30
	M & E Contracting Firm	18	38.30
	M & E Design and Build Firm	3	6.40
Position of respondent	Director	3	6.40
	Project Manager	11	23.40
	Project Engineer	25	53.20
	Supervisor	4	8.50
	Site Engineer	4	8.50
Size of company	Small (Less than 36 employees)	15	31.90
	Medium (36-100 employees)	18	38.30
	Large (More than 100 employees)	14	29.80
Years of experience of company	Less than 5 years	2	4.30
	5-10 years	7	14.90
	11-15 years	6	12.80
	More than 15 years	32	68.00
Years of experience of the respondent	Less than 5 years	17	36.10
	5-10 years	21	44.70
	11-15 years	3	6.40
	More than 15 years	6	12.80

#### 3.2.1. MEP Firms Groups

The number of respondents that participated in this survey was 47 from 25 MEP firms. Out of these respondents, 26 (55.3%) came from M&E Design Consulting Firms, 18 (38.3%) came from M&E Contracting Firms, and 3(8.5%) came from M&E Design and Build Firms.

#### 3.2.2. Respondent's Position

A total of 3 (6.4%) of the respondents were Directors, 11(23.4%) were Project Managers, 25(53.2%) were Project Engineers, 4(8.5%) were Supervisors, and 4(8.5%) were Site Engineers.

#### 3.2.3. Size of Company

The respondents have worked for small, medium and large-size companies; out of which 15(31.9%) came from small-size company with less than 36 employees, 18(38.3%) came from medium-size company with 36-100 employees, and 14(29.8%) came from large-size company with more than 100 employees.

#### 3.2.4. Years of Experience of Company

The total of 2(4.3%) of respondents came from the company with less than five years of experience, 7(14.9%) came from company with 5-10 years of experience, 6(12.8%) with 11-15 years of experience, and 32(68%) from company with more than 15 years of experience.

**3.2.5. Years of Experience of Respondent**

The total of 17(36.1%) of the respondents have less than 5 years of working experience, 21(44.7%) have 5-10 years of working experience, 3(6.4%) with 11-15 years of working experience, and 6(12.8%) with more than 15 years of working experience.

**3.3. Normality Test**

The normality test that was conducted for the Overall BIM Awareness score using Kolmogorov–Smirnov test, Skewness and Kurtosis test, Histogram and box plot (Table 4, Table 5, Figure 1, Figure 2). The results show that the scores were normally distributed after removal of one extreme outlier. Thus, the total number of our sample size reduced from 47 to 46. The results of Kolmogorov–Smirnov and Shapiro–Wilk are insignificant (Kolmogorov–Smirnov = 0.20, difference = 46, P>0.05; Shapiro–Wilk = 0.24, difference = 46, P>0.05). A non-significant result (Sig. value of more than 0.05) indicates the normality (Pallant, 2013).The results from Skewness and Kurtosis test also confirmed that the data is normally distributed. The value of Skewness and Kurtosis test are -0.511 and 0.822, respectively. For a data to be normally distributed, the Skewness and Kurtosis values should be in the range of -1.96 to +1.96 [11].

Table 4. Kolmogorov–Smirnov and Shapiro –Wilk Test

	Tests of Normality					
	Kolmogorov-Smirnov <sup>a</sup>			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Overall BIM Awareness Score	0.09	46	0.20 <sup>*</sup>	0.96	46	0.24

Table 5. Tests of Normality

		Statistic	Std. Error
Overall BIM Awareness Score	Mean	47.21	1.09
	95% Confidence Interval for Mean	Lower Bound	45.00
		Upper Bound	49.42
	5% Trimmed Mean	47.53	
	Median	47.00	
	Variance	55.46	
	Std. Deviation	7.44	
	Minimum	25.00	
	Maximum	60.00	
	Range	35.00	
	Interquartile Range	9.50	
	<b>Skewness</b>	<b>-0.51</b>	0.35
	<b>Kurtosis</b>	<b>0.82</b>	0.68

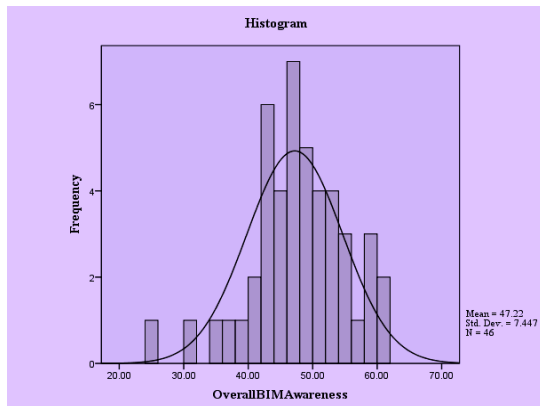


Figure 1. Overall BIM Awareness Scores Displayed on Histogram

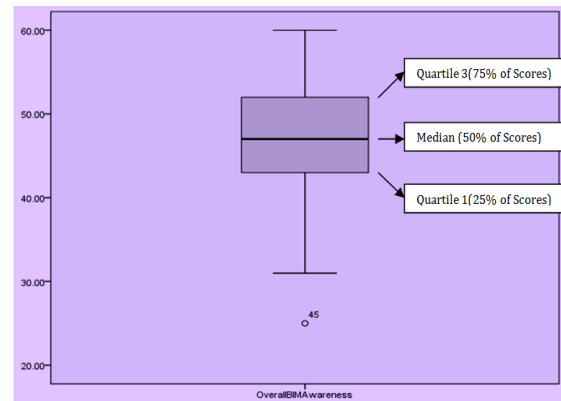


Figure 2. Box Plot showing the distribution of scores

### 3.4. BIM Awareness of MEP Firms in Nigeria

#### 3.3.1. One-Way ANOVA Test for Descriptive and Statistical Significant Difference

The ANOVA descriptive test and test of significant difference for the BIM awareness scores of the MEP firms are presented in Table 6, Table 7, and Table 8, respectively. The item 1 of the questionnaire awareness variables has the highest mean score of 4.33 from maximum score of 5. The item gives definition to BIM as an intelligent model-based design process that adds value across the entire life cycle of Building and Infrastructure project. Item 2 has the second highest mean score of 4.07. The item states that Architecture, Engineering and Construction (AEC) companies have been using BIM to realize improved productivity and cost effectiveness. Item 3 and item 8 have the third highest mean score of 4.02. Item 3 states that BIM provides more efficient sustainable design, increased energy efficiency, and overall building performance while item 8 states that BIM allows the project team to make better and more informed decision across the entire project life cycle. The item which has the least mean score is the item 11 with a mean score of 3.57, which states that 5D BIM aids automatic quantification and cost estimates. The overall BIM awareness variable has a cumulative mean score of 47.2. This is equivalent to 78.7% of the total maximum cumulative mean score of 60. Furthermore, it was observed in ANOVA's descriptive result in Table 7 that the MEP firm groups have different mean score on Overall BIM Awareness. The M&E Design Consulting Firms has an overall mean score of 48.5, M&E Contracting Firms with overall mean score of 46.1, and M&E Design and Build Firms with overall mean score of 42.3. It is difficult to conclude that these differences are due to chance or are real, and whether they are statistically significant. In order to ascertain this, ANOVA test of significant difference was carried out. The result shows that there were no statistical significant differences between the three MEP groups in their Overall BIM Awareness score; [ $f(2, 45) = 1.228$  P = 0.303; P > .05]. Thus, we can conclude that the differences between the groups are due to chance. This also represent a small effect size of 5.44% [ $\{135/(135 + 2361)\} \times 100$ ] which indicates that only 5.44 % of the variance of Overall BIM Awareness score was accounted for by the three MEP groups.

Table 6. Descriptive statistics on BIM Awareness

Items	BIM Awareness	N	Mean	Std. Deviation
1	Building Information Modelling (BIM) is an intelligent model-based design process that adds value across the entire lifecycle of building and infrastructure projects	46	4.33	0.84
2	Architecture, Engineering and Construction (AEC) companies are using BIM to realize improved productivity and cost-effectiveness	46	4.07	0.97
3	BIM provide more efficient sustainable design, increased energy efficiency and overall building performance	46	4.02	0.90
4	BIM improves collaborative working in projects and reduces construction change order.	46	3.98	0.95
5	BIM is a model based workflow that allows the contractors to be integrated right from the design phase	46	3.91	0.91
6	The use of BIM in construction design can support the implementation and use of LEAN practices by standardizing the work flows, data and file types and providing a centralized documentation and information exchange	46	3.87	0.85
7	BIM allows constructability issue easily resolve and timely conflict identification and resolution	46	3.89	0.97
8	BIM allows the project team to make better and more-informed decision across the entire project life cycle	46	4.02	0.88
9	BIM tools can be used for clash detection between MEP designs and architectural and structural designs	46	3.98	0.88
10	4D BIM can be used for scheduling, animation, safety analysis and prepare site logistic plans	46	3.74	0.74
11	5D BIM aids automatic quantification and cost estimate	46	3.57	0.77
12	BIM Model can be used as As-built Model which serve as the basis for comprehensive facilities and asset management program.	46	3.85	0.86
Valid N (listwise)		46		

Table 7. Descriptive Statistics with ANOVA for the Overall BIM Awareness

	N	Mean	Std. Deviation	Std. Error	Minimum	Maximum
M&E Design Consulting Firm	26	48.50	7.25	1.42	25.00	60.00
M&E Contracting Firm	17	46.11	7.21	1.75	35.00	60.00
M&E Design and Build Firm	3	42.33	10.26	5.92	31.00	51.00
Total	46	47.21	7.44	1.09	25.00	60.00

Table 8. ANOVA Test of Significant Differences between the MEP groups on Overall BIM Awareness

Sum of Squares	df	Mean Square	F	Sig.	Effect Size
134.89	2	67.44	1.22	0.30	5.44
2360.93	43	54.90			
2495.82	45				

### 3.3.2. Cross Tab Analysis and Chi-Square Test

The results of Cross Tab analysis and Chi-square test are shown in Table 9 and Table 10. The analysis explores if there is statistical significant relationship between the MEP groups and Overall BIM Awareness. The result of Cross Tab analysis shows that the total response on “Agree” has the highest number of frequency with a total count of 225. It was followed by response “Strongly Agree” with a total frequency count of 162. From the Cross tab analysis, it shows that the M&E design consulting firms has highest frequency count on the responses “Agree” and “Strongly Agree”. This is mainly due to their higher sample size than the other MEP groups. The Design and Build Firms has the lowest total frequency count responses on “Agree” and “Strongly Agree”. This is also due to their lower sample size than the other MEP group. From Cross Tab analysis, it is impossible to tell whether there is statistically significant relationship exists between these groups on Overall BIM Awareness, therefore, Chi-Square test was conducted to ascertain this. The results of Chi-Square show that no significant relationship exists between the MEP groups and the Overall BIM Awareness; [ $\chi^2(46, N=46) = 42.87, P > .05, V=.142$ ]. The Cramer’s V indicates that the effect size is small.

Table 9. Cross tab analysis (the total frequency of responses given by each MEP firm)

Count	Overall BIM Awareness					Total
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	
MEP Groups						
M & E Design Consulting Firm	4	7	69	124	108	312
M & E Contracting Firm	2	5	65	83	49	204
M & E Design and Build Firm	1	6	6	18	5	36
Total	7	18	140	225	162	552

Table 10. Chi-Square Tests test of Association

	Value	df	Asymp. Sig. (2-sided)	Effect Size
Pearson Chi-Square	42.87 <sup>a</sup>	46	0.60	0.14
Likelihood Ratio	36.07	46	0.85	
Linear-by-Linear Association	2.37	1	0.12	
N of Valid Cases	46			

### 3.5. Challenges for Adoption of BIM Technologies

The last section of the questionnaire addressed the challenges for adopting BIM technologies. The result from the analysis shows that item 2 of the BIM challenges variables has the highest mean score of 3.80 which was identified as the most important challenge. The item states that lack of technical expertise on BIM tools utilisation as one the challenges for BIM adoption. Item 1 has the second highest mean score of 3.76, which states that lack of awareness of BIM technologies as one of the challenges for BIM adoption. Item 7 has the third highest mean score of 3.67. The item states that high investment cost on training staff, process change, and software/hardware upgrade as one of the challenges for adopting BIM technology. The fourth and fifth most important challenges were from item 16 and item 3, respectively. Item 16 states that required collaboration, integration, and interoperability between the structural and MEP designer/engineer as one of the challenges for adopting BIM technology while item 3 states the non-availability of well-trained professional to handle the tools. The result also shows the factors that have low mean scores of which indicates that these factors are the least important challenges to the MEP firms for BIM adoption. The item that has the lowest mean score of 2.74 is item 5 which states that the benefits from BIM implementation do not outweighed the costs to implement it. This implies that most of the respondents believe that the benefits from BIM implementation outweighed the costs to implement it. Item 9 and item 4 also have low mean scores of 2.76 and 3.04, respectively. Item 9 states the lack of client’s interest in the use of BIM in their project while item 4 states the reluctant to change from traditional 2D workflow to new BIM based workflow as one the challenges of BIM adoption. The low score of item 4 implies that there are higher possibilities to overcome the resistant to change for BIM adoption in the MEP firms. Table 11 shows the mean scores of the items on BIM challenges.

Table 11. Descriptive Statistics on BIM Challenges

Items	BIM Challenges	N	Mean	Std. Deviation
1	Lack of awareness of BIM technologies.	46	3.76	1.40
2	Lack of technical expertise on BIM tools utilisation.	46	3.80	1.29
3	Non-availability of well trained professional to handle the tools	46	3.61	1.20
4	Reluctant to change from traditional 2D workflow to new BIM based workflows.	46	3.04	1.21
5	Benefits from BIM implementation do not outweigh the costs to implement it.	46	2.74	0.97
6	Effectively implementing the new process and workflow.	44	3.45	0.79
7	High investment cost on training staff, process change and software and hardware upgrade	45	3.67	1.00
8	Overcoming the resistance to change, and getting people to understand the potential and the value of BIM over 2D drafting.	45	3.24	0.98
9	Lack of clients' interest in the use of BIM in their project.	45	2.76	1.06
10	Lack of knowledgeable and experience partner.	45	3.24	1.04
11	Clear understanding of the responsibilities of different stakeholders in the new process.	45	3.33	0.82
12	Software availability and licensing issue.	45	3.56	1.19
13	Lack of cooperation and commitment of professional bodies to its implementation.	45	3.31	1.12
14	Lack of government support through legislation.	45	3.31	1.37
15	Lack of Standards to guide its implementation.	44	3.25	1.29
16	Required collaboration, integration and interoperability between the structural and MEP designer/engineer.	45	3.64	0.88
	Valid N (listwise)	43		

#### 4. CONCLUSION

From the results of this study it can be concluded that;

1. All the surveyed MEP groups have high agreement in the definition of BIM, which indicates that MEP firms in Nigeria are aware of BIM technology.

2. All the surveyed MEP groups have the overall cumulative score of 47.2, an equivalent of 78.7% of the total score. This is a relatively high percentage score which shows the high level of awareness about BIM technology in MEP firms in Nigeria.

3. There are no statistical significant differences between three MEP groups surveyed with respect to their awareness level. This means that the three groups have the same level of BIM awareness.

4. The most important challenge affecting the adoption of BIM by the MEP firms in Nigeria is the lack of technical expertise on BIM tools utilisation. This finding is in line with the findings from survey of Khosrowshahi & Arayici [12].

5. Lack of awareness of BIM technologies and high investment cost in training staff, process change, and software/hardware upgrade are among the most important factors affecting BIM adoption in Nigeria.

6. The factor that has the lowest mean score is “the benefits from BIM implementation do not outweigh the cost to implement it”. This means that most of the surveyed MEP firms believe that the benefits BIM offers outweighed the cost to implement it. This is a good indicator showing that MEP firms in Nigeria have a positive perspective on BIM.

7. “Lack of clients' interest in the use of BIM in their project” has a low mean score. This is also a good indicator that there is high probability to gain the clients' buy-in for BIM technology adoption.

8. “Reluctant to change from traditional 2D work flow to new BIM based work flow” also has a low mean score, which shows that there is higher possibility to overcome resistance to change when BIM technology is introduced to staff of MEP firms in Nigeria.

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