Correlation Analysis of Benefits of Building Information Modelling and Clients' Requirements

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Abstract The demand for BIM by clients has significant implications on the widespread adoption of BIM and clients may not be demanding for BIM because they were not aware of the correlation of BIM benefits to their project goals and objectives. This study surveyed construction clients in order to examine the correlation between BIM benefits and clients' requirements in the Nigerian construction industry. A total of fifty-seven questionnaire was administered to the respondents with a response rate of 80%. The data obtained were analyzed using exploratory factor analysis, frequency distribution, single factor analysis of variance, z-score and mean score. The findings of the study revealed that extra cost to support usage of BIM is highly responsible for the lack of demand for BIM by clients, and that presentation and visualization of the building design was the only significant benefits of BIM. The findings also revealed that the benefits of BIM translate to performance, value, statutory, productivity, and innovation requirements for construction projects by clients. The study concluded that AEC firms and construction professionals should influence clients to be demanding for BIM by making BIM services available, advertising BIM services, and providing BIM services at an affordable cost.

Keywords Clients' requirements, Demand for BIM, BIM, Benefits of BIM, Implementation of BIM

1. Introduction

Clients are the primary beneficiaries of Building Information Modelling (BIM), and yet studies show that they are not demanding for BIM. NBS-National BIM Report [1] and McGraw-Hill Construction [2] noted that lack of demand for BIM by clients is the major barrier to BIM adoption. The government of United Kingdom, Australia, Hong Kong, Canada, France, Germany, Japan, Korea, New Zealand, Norway, and Singapore have asked for BIM for publicly-funded projects [3-4]. However, NBS-National BIM Report (2014) and Chartered Institute of Building [5] reported that private clients are still not demanding BIM for their projects, owing to their opinions that their projects are too small to warrant BIM. Some believe that BIM is not relevant to their projects and their requirements. This is distressing, for the reason that demanding for BIM helps clients to achieve their projects' objectives with few problems [6].

NBS-National BIM Report (2013) specifically indicated that clients demand for BIM would be the major drive for BIM adoption, since clients are the major beneficiary from BIM. The problem, however, is that clients don't understand nor are aware of BIM or of its benefits. Even few who are aware, believed that BIM is only for complex projects [6]. However, contractors and consultants are reluctant to adopt BIM, claiming that they need the commitment and participation of clients in BIM processes and also need the clients to push the envelope for the cost of BIM. While some professionals attribute their demotivation to adopt BIM to lack of demand for BIM by clients, others see BIM predominantly as a technical solution and not as a business opportunity [7]. On the other hand, Kymmell [8] accused the majority of professionals in the construction industry of lacking a genuine understanding of BIM and that this has affected the awareness and understanding of clients on BIM.

Demand is a function of awareness [9-10]. Clients need information and reasons to demand for BIM and it is the duty of construction professionals and that of the construction industry to provide these information, through the creation of awareness for BIM and its benefits. Although, those that are aware of BIM may be refraining from demanding for it with the fear that demanding for BIM requires them to be responsible for the cost of BIM. Clients may be wondering if the benefits of BIM are tangible enough to warrant its demand or if most of the information derivable from BIM are for them or if the existing computer-aided tools, which pose no extra cost, are not capable of fulfilling their information needs.

It is a fact that clients' demand for a service provides strong motivation for provision of the service; but it is also true that a well-informed client will know what they want out of BIM. Clients cannot demand for BIM when they are not aware of it. The demand for BIM by clients can be achieved by creating awareness of BIM.The benefits of BIM and their correlation to the clients' requirements should be used as the basis for creating awareness for BIM. Consequently, it can be presumed that the demand for BIM by clients has significant implications on the widespread adoption of BIM and that clients were not demanding for BIM because they were not aware of BIM, nor of its benefits, or the correlation of its benefits to their project goals and objectives. For this reason, this study examined the correlation between BIM benefits and clients' requirements; so as to find effective ways to create clients' awareness about BIM and its benefits.

2. Literature Review

Barriers to BIM adoption and implementation have been documented in literature (Table 1). The lack of demand for BIM by clients emerged as the most important barrier to widespread adoption and implementation of BIM. In a survey of early adopters of BIM in Canadian construction industry, Centre Facilitating Research and Innovation in Organizations (CEFRIO) [11] reported the reluctance of clients to demand for BIM as a serious barrier to BIM adoption and implementation.

Yan and Damian [12] analysed the benefits and drawbacks of BIM in AEC industry, and found that demand for BIM is lacking because of the unawareness of the benefits of BIM and that BIM was only popular among professionals and not among clients. The conclusion of the study was that, even with the benefits of BIM, complete adoption cannot be achieved without complete demand. Becerik-Gerber and Rice [13] evaluated the perceived value of BIM in the United State building industry. The study elicited that BIM has benefits but these benefits were unknown and unproven. The study also found that firms were the ones covering the cost of BIM. In few cases where clients were covering the cost of BIM, this was done indirectly. The study claimed that the adoption of BIM will be widespread, if clients embrace BIM and the value of BIM to clients is investigated.

Table 1: Barriers to BIM implementation

Barriers to BIM implementation	Source(s)
Lack of demand for BIM by clients	[3, 6, 14-15]
Problems of client expectation	[1, 15]
Problems of training staff on new process and technology	[1, 3, 15]
Problems of implementing new process of work	[1, 14]
Realising financial value	[3, 6]
Copyright ownership of the model information	[16, 17]
Changes in construction practice and use of information	[15, 16]
Problems of scaling BIM in large projects	[16, 18]
High cost of training and learning BIM	[3, 16, 18]
Difficulty of getting the required reaction from the public	[16, 19]
Legal barriers	[3, 14, 20]
Undefined BIM standards	[17, 20]
Non-adoption of BIM by professionals	[3, 17, 21]
Interoperability problems between software platforms	[3, 18, 22]
Drawbacks in developing component libraries and details	[14-15]
Problems of establishing office standards	[3, 15]
Steep learning curve to build up BIM expertise	[19]

Lack of ready pool of skilled BIM manpower	[14, 19]
Establishment of protocols in the project programming stage	[20]
Contractual and organizational risks	[20, 22]
Lack of legal framework for allocating risk among the project stakeholders	[17]
Cost of BIM	[16, 20]
Late return on investment in BIM	[22]
Lack of knowledge about BIM	[1, 3, 14]
BIM is not required by other team members	[3]

McGraw-Hill Construction [2] investigated the business value of BIM in South Korea in comparison with North America and Western Europe. The study reported that only 26% of owners demanded for BIM in South Korea in 2009 and 37% in North America in 2009. The study concluded that lack of demand by clients was the prime obstacles to BIM adoption. These studies did not investigate the significance of BIM benefits and their interrelationship with clients' requirements. The level of awareness of BIM and level of demand for BIM by clients were not studied.

A study by McGraw-Hill Construction [23] focused on why AEC firms were not using BIM and what could convince them to adopt BIM. The study found that clients were not even aware if the AEC firms working for them were using BIM or not. The conclusion of the study was that demand for BIM by clients is the single most important way to make AEC firms adopt BIM. This study also did not explore ways to make clients demand for BIM. In 2010, McGraw-Hill Construction repeated its study of 2009. This study also reported lack of client demand for BIM as the primary reason for non-implementation of BIM in Europe. Other findings of the study were that 55% of respondents surveyed indicated lack of understanding of BIM benefits by clients had delayed the widespread adoption of BIM by AEC firms. The study was of the opinion that if the benefits of BIM can be demonstrated, clients will be convinced to be demanding for BIM. Awareness will surely create demand, but awareness cannot be created without knowing the factors causing unawareness; and the alignment of the benefits of BIM with the requirements of clients should be demonstrated before demonstrating the benefits of BIM. Zahrizan *et al.* [3] reported that countries like United Kingdom, Australia, Hong Kong and Singapore have implemented BIM by public clients; at the same time, Kiviniemi [24] studied how clients can drive BIM adoption and how to persuade clients that BIM is worthwhile. The study found that government is the major construction client and this influence can be used to drive BIM adoption through policies. It was also found that clients will be impressed by the visualization properties of BIM, but more importantly they will be more impressed by better and more value for their investments. The study concluded that public clients or government should make BIM a key part of the procurement of public buildings and that clients should be made aware of the benefits that they will achieve with BIM. This study addressed the shortcoming of the previous study; but the study confused the power of policies with that of desire and also overlooked the influence of private clients. Without putting BIM policies in place, clients will demand for BIM if they are aware of the benefits of BIM and its alignment with their requirements. Also, few AEC firms work for public clients owing to prequalification requirements. Majority of the firms in the construction industry survive on the patronage of private clients and not on public clients. The visualization properties of BIM and its capability of giving more value to investments as found by Kiviniemi [24] were not linked to clients' requirements.

In order to cover the influence of private clients that was left out by Kiviniemi [24], Chartered Institute of Building [5] investigated why some private clients were still holding back from demanding for BIM in spite of BIM adoption by the United Kingdom government. Prior to this study, it was erroneously believed that adoption and policies by government were all it required to ensure widespread adoption of BIM. Construction projects have various stakeholders with different requirements and motives. This means that each of the stakeholders can only decide for themselves on what their demands would be and when to make those demands. As found by Chartered Institute of Building [5], private clients indicated the cost of demanding for BIM as the major reason why they were not demanding for BIM. Also majority of them were sceptical about realizing their investments through BIM. This shows that awareness of BIM and its benefits won't be sufficient to motivate clients to

demand for BIM. There were factors that could militate against demand for BIM in spite of awareness of BIM; and there are some benefits of BIM that are not significant.

BIM was described as having enormous benefits and yet it is striving for adoption and implementation globally. This prompted Salleh and Fung [25] to attempt an understanding of the reasons for the poor implementation of BIM in Malaysia. The answer remains the same, as the study also identified BIM demand by clients as the key strategy for enhancing BIM implementation. Likewise, Building and Construction Productivity partnership [26] sought to identify barriers to realizing the full potentials of BIM on projects in New Zealand. The study agreed that the role of public clients is critical to BIM implementation; but argued that private clients need to see the value that BIM can offer them before they start demanding for BIM. The study added that private clients won't go through pre-design stages of construction with BIM until they have knowledge of the value of BIM to their requirements. The study by Abubakar et al. [24] on the factors affecting BIM implementation in Nigeria, also identified government support through legislation and clients' interest as the drivers of BIM implementation in the Nigerian Construction Industry. Although clients can make their choices based on their awareness, but only value can influence their demands. Thus, clients have to be familiar and comfortable with a BIM before they can demand for it. However, the interpretation of value depends on each clients and if these value contents were not found in BIM, there won't be any demand for BIM from the clients. All the more so, the existence of value doesn't equate to its awareness. Barroso and Llobet [10] affirmed that advertising becomes crucial in making clients aware of the existence and benefits of new innovation, for the reason that advertising can influence clients' decisions beyond the effects of their preferences. Autodesk (2014) reported that those who have implemented BIM in their work processes were forced to do so owing to clients' requirements on a project. It was further noted that clients are in need of education on getting the benefits of BIM and that AEC firms and professionals should provide insights into the benefits that BIM provides for clients. Similarly, Joseph and Parameswari [28] pointed out that marketing of services is important for creating demand, as it connects the service providers to the clients and promotes demand for the advertised service. Chen *et al.* [29] determined the challenges for BIM adoption in the Nigerian construction industry. The study identified lack of awareness of BIM as the most important factors affecting BIM adoption in Nigeria. The study further claimed that lack of demand for BIM by clients has low impact on BIM adoption in Nigeria and that this showed a level of interest by client in BIM which could be leveraged to ensure the widespread adoption of BIM in Nigeria. This study did not investigate why the interest of clients in BIM has not translated into widespread adoption of BIM. It also did not investigate ways to leverage clients' interest in BIM for widespread adoption of BIM. The satisfaction of clients is of interest to the construction professionals; and clients cannot be satisfied without meeting their interests. It could be that the personal interest of clients in BIM does not align with their projects' requirements; or it could be that they are not aware of the relationship between BIM and their projects' requirements.

Ezeokoli et al. [30] examined the factors affecting the adaptability of BIM by the construction professionals in Anambra State, Nigeria. The study reported that 43% of project stakeholders that were aware of BIM were not using nor demanding for BIM. Although, the study did not investigate why this is so, but the findings show that beyond BIM awareness, there are factors responsible for lack of demand for BIM regardless of BIM awareness. The study failed to include 'lack of demand for BIM by clients' among the items it used to study factors affecting BIM usage; therefore, it couldn't be ranked by the respondents.

Education or awareness can be created using traditional methods as well as new media such as newspaper, magazines, billboards, print advertising, TV, radio or internet [31]. Lee [32] suggested that clients' demand should be managed by carefully selecting the right marketing instruments and working closely with them so that the overall incoming demand will give rise to maximum values for all parties concerned. Nevertheless, Karam and Saydam [31] believes that clients can be tempered psychologically through media, though they are distinctive in their behaviours and routine marketing has changed as clients have also changed. TV, newspapers and magazines were identified by Bakhshi et al. [33] as the most effective media of creating awareness for a service.

There are lots of successful scenarios on BIM adoption and implementation around the world. One of the underlying causes of success in BIM adoption has been the use of BIM-based pilot projects. In Russia, the government is using twenty-five BIM-based pilot projects to ensure that BIM implementation penetrates the

Russian construction industry [34]. Also, the use of three BIM-based pilot projects have been reported in Canada [11]. In a study of the BIM-based pilot projects in the Canadian construction industry, CEFRIO [11] highlighted the establishment of BIM implementation strategy at the organizational level, improvement on the client's level of knowledge about BIM, and alignment of the BIM needs of the project stakeholders, as some of the lessons learned in BIM implementation. This shows that emphasis is still on the need to ensure that project stakeholders are aware of the need for BIM, as a way of achieving widespread usage of BIM [35]. Among the project stakeholders, only the needs of the client are not negotiable; therefore, if the client imposes the use of BIM, its usage would be binding on the other stakeholders. According to Chan [14], the major reason for the implementation of BIM in Hong Kong is the demand for BIM by clients. Hence, the implementation of BIM still boils down to the knowledge of clients about BIM and relationship between BIM and the clients' project needs.

3. Methodology

Questionnaire survey was adopted in order to meet the objective of this study. The first section of the questionnaire used for the study, was used to elicit information on the profile of the respondents. The other sections of the questionnaire elicit information on the extent of awareness of BIM, rate of demand for BIM, underlying reasons for the lack of demand for BIM by clients, relationship between the rate of demand for BIM and extent of awareness of BIM, effect of extent of awareness of BIM on the rate of demand for BIM, significance of BIM benefits, influence of benefits of BIM on demand for BIM, and the relationship between the benefits of BIM and clients' requirements. If demand can be influenced by awareness, the factors militating against demand for BIM regardless of BIM awareness by clients and the factors influencing BIM unawareness among clients would explain the underlying reasons for the lack of demand for BIM by clients.

In order to ensure that the respondents are aware of BIM and knowledgeable enough to complete the questionnaire; the respondents were asked to indicate their extent of awareness. The extent of awareness was measured by requesting the respondents to evaluate their extent of BIM awareness on a 5-point scale ranging from '1= not aware of BIM', '2= neither aware nor demanding for BIM', '3= just aware of BIM', '4= aware but not demanding for BIM', and '5= aware and demanding for BIM'. Where the respondents indicated 'not aware of BIM' or 'neither aware nor demanding for BIM' or 'just aware of BIM', the next question for those kinds of respondents was 'if unaware of BIM, kindly indicate the factors influencing unawareness of BIM'. The respondents who indicated 'aware of BIM and demanding for BIM', were required to indicate the number and size of projects where they have demanded for BIM and forms of BIM they were demanding for. Those who indicated 'aware but not demanding for BIM' were required to indicate the 'factors militating against demand for BIM regardless of BIM awareness'.

The 5-point scale for questions on relationship between the level of demand for BIM and effect of level of awareness of BIM on the level of demand for BIM among clients, ranged from '1= Very Low', '2=Low', '3=Average', '4=High', and '5= Very High'. Factors militating against demand for BIM regardless of BIM awareness by clients, significance of BIM benefits, and influence of benefits of BIM on demand for BIM were measured on a 5-point scale that ranged from '1= Less Significant', '2= Fairly Significant', '3= Significant', '4= Highly Significant', and '5= Most Significant'.

The target population for the study composed of construction clients in Abuja and Lagos State, being the Federal Capital Territory and commercial capital of Nigeria. The study focused on clients in order to get their perspectives on ways to create demands for BIM and achieve construction project objectives through BIM awareness and benefits. Construction clients are majorly classified as public and private clients. However, there are sub-groups within these two major classification of construction clients; therefore, this study adopted stratified sampling method. The construction clients surveyed were grouped into: Ministries of works, Tertiary institutions, Public funds and trusts, Public liability companies, Commercial banks, and Property developers and managers. The selection of respondents within the sub-groups was done using simple random selection technique.

The sub-groups were taken as the sample frame to give a population of sixty-three (63). From the population, the sample size was calculated as fifty-seven (57) respondents using the formula given by Glenn (2013). A total

of fifty-seven (57) questionnaires were administered to the respondents. The information obtained from the respondents on the interrelationships among the benefits of BIM and the relationships between the benefits of BIM and clients' requirements was analysed using exploratory factor analysis (EFA). EFA was used to model the common dimensions of clients' requirements in relation to the benefits of BIM. Frequency distribution (formed into bi-polar characteristics of responses), z-score, and mean score were used to analyse the factors militating against demand for BIM regardless of BIM awareness, factors influencing BIM unawareness among clients, and the significance of BIM benefits. The effect of level of awareness of BIM on the level of demand for BIM was analysed using a single factor analysis of variance. The examination of the relationship between the level of demand for BIM and level of awareness of BIM was done using Spearman's rank correlation.

4. Results

4.1. Profile of Respondents

Forty-five valid responses were received, representing 80% response rate. Among the respondents (Figure 1), Ministries of works represented 24% of the total respondents, 33.3% were property developers and managers, and commercial banks accounted for 22.2%. Public funds and trusts, tertiary institutions, and public liability companies accounted for 4.4%, 6.6%, and 8.8% of the total respondents. This shows that both the private and public clients were adequately represented in the survey. Only 4.5% of the total respondents had executed 30 projects and above in the last five years. 31.8% had executed 11-20 projects in the last five years; while 45.5% had executed 1-10 projects in the last five years. This is as shown in Figure 2, and it shows that the respondents have had enough working experience to provide the required information for this study.

A Cronbach Alpha analysis was carried out to validate the appropriateness of the research instrument. Coefficient alpha value of 0.83 was gotten for questions on the level of awareness and demand for BIM, 0.965 for questions on factors militating against demand for BIM regardless of BIM awareness by clients, 0.79 for questions on factors influencing BIM unawareness by clients, and 0.94 for questions on correlation between clients' requirement and benefits of BIM. The items in the groups of questions were considered to have high internal consistency given that the coefficient alpha values were higher than 0.7.
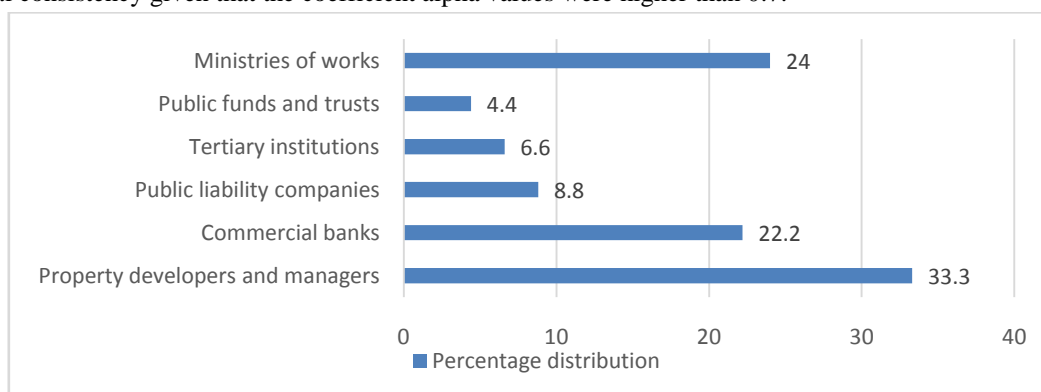

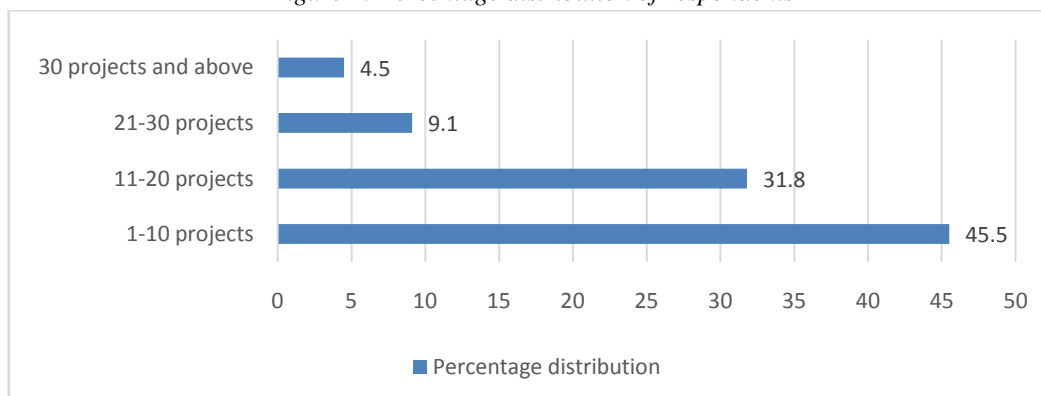*Figure 1: Percentage distribution of respondents*

Figure 2: Percentage distribution of projects executed in the last five years

4.2. Extent of BIM Awareness

Among the forty-five respondents, 15.5% were not aware of BIM, 8.8% were neither aware nor demanding for BIM, 11.1% were just aware of BIM, and 35.5% were aware but not demanding for BIM, while 28.8% were aware and demanding for BIM. To further examine the extent of awareness of BIM among the respondents; respondents who indicated that they were aware of BIM were asked to indicate what they were aware about as regards BIM. There was no single respondents that was not aware of BIM software technologies. Only 17.64% indicated that they were aware of BIM processes and protocols, 58.8% had knowledge of the collaboration requirement in BIM, and 67.6% had knowledge of building information models, while 29% were aware of the benefits of BIM.

4.3 Rate of Demand for BIM

The respondents who were demanding for BIM were requested to indicate the rate at which they demand for BIM. The rate of demand for BIM was measured by the number and size of projects where BIM was demanded and forms of BIM that were demanded. About 12% of the respondents had demanded for BIM in less than five projects; while 2.3% had demanded for BIM in 5-10 projects. Only 6.8% had demanded for BIM in 11-15, 16-20, and 21 projects and above. Less than 3% had demanded for BIM in projects worth 10-20million naira, 7.3% had demanded for BIM in projects worth 20-50million and 50-100million naira; while 77.3% had demanded for BIM in projects worth 100million naira and above. About 93% had demanded for usage of BIM software technologies and development of building information models. Only 46.15% had requested for collaboration in their construction projects; while 23.1% had requested for adherence to BIM processes and protocols in their construction projects.

4.4. Relationship between the Rate of Demand for BIM and Extent of BIM Awareness

A Spearman's correlation was conducted to determine the relationship between the rate of demand for BIM and extent of awareness of BIM among the surveyed clients. The correlation between extent of BIM awareness and rate of demand for BIM was found to be very strong and positive (R= 0.823 [82%]). Although the R-value of 0.823 suggests a very strong positive relationship between extent of BIM awareness of BIM and rate of demand for BIM among clients; a test of significance was carried out to confirm if the relationship was a product of chance. From the Spearman Rank Significance Table, the R-value of 0.823 at degree of freedom of 42 gives a significance level of above 0.1% significance level. This means that the probability of the relationship being a product of chance is about 0.1 in a 100 and shows that we can be 99.9% confident that the correlation has not occurred by chance. For further confirmation, a single factor analysis of variance was conducted to determine the significance of the correlation analysis and to test for the effect of extent of awareness of BIM on the rate of demand for BIM among the surveyed clients (Table 2).

Table 2: Effect of level of awareness of BIM on the level of demand for BIM

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	28.58333	2	14.29167	8.032422	0.000657	3.109311
Within Groups	144.119	81	1.779248			
Total	172.7024	83				

SS = sums of squares, df = degrees of freedom, MS = mean squares

At $p<0.05$ level of significance for the conditions [$F_{(2, 81)} = 8.0324$, $p = 0.000657$], extent of awareness about BIM has a significant effect on the rate of demand for BIM among the surveyed clients.

4.5. The Influence of Benefits of BIM on Rate Demand for Bim

The influence of benefits of BIM on rate of demand for BIM was determined using the same Likert item. *Presentation and visualization of building design* was the only benefits of BIM that was rated as having high influence on demand for BIM (mean score = 4.0). All other benefits of BIM were rated as having significant influence on demand for BIM, with the highest mean score being 3.92, and no more than 60% of the respondents agreeing that these other benefits of BIM have influence on demand for BIM. About 70% of the

respondents agreed and less than 3% of the respondents disagreed that *presentation and visualization of building design* had influence on demand for BIM.

This study determined the significance of the benefits of BIM using a six-sigma technique. One hundred and thirty (130) point Likert item on a 5-point scale was used. The scale was benchmarked to 80%. The benchmark was used to determine the z-score of the Likert item by subtracting the benchmark from the mean for each of the item and dividing the answers by the standard deviation; while the z-score was used to decide the significant and insignificant items. As a result, *presentation and visualization of building design* was the only significant benefits of BIM as indicated by the respondents.

4.6. Factors Influencing BIM Unawareness By Clients

A proportion of the surveyed clients indicated that they were unaware of BIM. The reasons for this was investigated by requesting the respondents to indicate and rate on a Likert scale, the factors influencing their unawareness of BIM. Table 4 shows the results of the fifty-five (55) Likert item measured on a 5-point scale to show the factors influencing BIM unawareness by clients. Lack of information on BIM (mean score = 4.71) and lack of BIM awareness program from the construction industry (mean score = 4.19) were rated as having high influence on BIM unawareness among the clients. More than 79% of the respondents agreed that these factors were influencing BIM unawareness among clients. As agreed to by about 70% and disagreed with by about 25% of the respondents, factors such as BIM does not involve clients (mean score = 3.66), BIM is only for construction professionals to know (mean score = 3.66), lack of usage of BIM (mean score = 3.53), lack of advertisement for BIM by construction professionals bodies (mean score = 3.14), and lack of advertisement for BIM by construction professionals (mean score = 3.14) were indicated by respondents to have significant influence on BIM unawareness among clients. Lack of advocacy and campaigning for BIM (mean score = 2.62), lack of relationship between clients and consultants (mean score = 2.62), lack of marketing for BIM (mean score = 2.57), and lack of use of BIM in tendering and bid presentations (mean score = 2.09) were found to have fair influence on BIM awareness among clients. About 56% of the respondents agreed; while less than 46% of the respondents disagreed that these factors were influencing BIM unawareness among clients.

Table 4: Mean score and bi-polar characteristics of responses on factors influencing BIM unawareness by clients

Factors influencing BIM unawareness by clients	Mean score	Agree (%)	Disagree (%)
Lack of information on BIM	4.71	79.5	20.5
Lack of BIM awareness program from the construction industry	4.19	88.9	11.1
BIM does not involve clients	3.66	77.8	22.2
BIM is only for construction professionals to know	3.66	77.8	22.2
Lack of usage of BIM	3.53	75.0	25.0
Lack of advertisement for BIM by the construction professional bodies	3.14	66.7	33.3
Lack of advertisement for BIM by construction professionals	3.14	66.7	33.3
Lack of advocacy and campaigning for BIM	2.62	55.6	44.4
Lack of relationship between clients and contractors/consultants	2.62	55.6	33.3
Lack of marketing for BIM	2.57	54.5	45.5
Lack of use of BIM in tendering and bid presentations	2.09	44.4	55.6

4.7. Factors Militating against Demand for BIM Regardless of BIM Awareness by Clients

Respondents who indicated aware but not demanding for BIM were asked to indicate and rate on a likert scale, the factors militating against demand for BIM regardless of BIM awareness (Table 3). One hundred and fifteen (115) point Likert item on a 5-point scale were used to measure the factors militating against demand for BIM regardless of awareness of BIM by clients. The scale ranged from 'Less Significant' to 'Most Significant' with weight value of 1-5 respectively. None of the Likert item was rated as having a very high influence on the lack of demand for BIM regardless of awareness of BIM. The influence of extra cost to support usage of BIM on

lack of demand for BIM was rated as highly significant with a mean score of 4.18. Only 63.2% of the respondents agreed that extra cost to support usage of BIM was militating against demand for BIM regardless of BIM awareness. Factors rated as having significant influence on lack of demand for BIM regardless of BIM awareness were shortage of BIM proficient professionals (mean score = 3.59), requirement to demand for BIM are unknown (mean score = 3.50), benefits of BIM have not been proven (mean score = 3.38), unawareness of the benefits of BIM (mean score = 3.28), BIM is not affordable (mean score = 3.20), and lack of standards and regulations for BIM (mean score = 3.07). About 70% of the respondents agreed that these factors were militating against demand for BIM regardless of their awareness of BIM. Fifteen factors were indicated to have had fair significance on lack of demand for BIM regardless of their awareness of BIM. these factors were lack of understanding of BIM (mean score = 2.98), unsupportive organizational policy for BIM (mean score = 2.91), BIM is not necessary (mean score = 2.76), unpopularity of BIM in the construction industry (mean score = 2.69), lack of interest in BIM (mean score = 2.69), BIM is not a proven project delivery system (mean score = 2.69), lack of political and corporate will (mean score = 2.63), lack of policy and BIM roadmap by the government (mean score = 2.56), complexity of BIM supportive procurement (mean score = 2.52), legal issues and copyright ownership (mean score = 2.39), lack of information on the BIM capacity of contractors and consultants (mean score = 2.39), BIM is not part of contract documents (mean score = 2.39), lack of advice from consultants to demand for BIM (mean score = 2.33), lack of BIM-based pilot projects by the federal government (mean score = 2.15), and adequacy of the existing project delivery system (mean score = 2.03). More than 72% of the respondents agreed that these factors were militating against demand for BIM regardless of their awareness of BIM. Less than 26% of the respondents disagreed.

Table 3: Mean score and bi-polar characteristics of responses on factors militating against demand for BIM regardless of BIM awareness by clients

Factors militating against demand for BIM regardless of BIM awareness by clients	Mean score	Agree (%)	Disagree (%)
Extra cost to support usage of BIM	4.18	63.2	36.8
Shortage of BIM proficient professionals	3.59	68.4	31.6
Requirement to demand for BIM are unknown	3.50	69.2	30.8
Benefits of BIM have not been proven	3.38	70.3	29.7
Unawareness of the benefits of BIM	3.28	71.1	28.9
BIM is not affordable	3.20	71.8	28.2
Lack of standards and regulations for BIM	3.07	73.0	27.0
Lack of understanding of BIM	2.98	73.7	26.3
Our unsupportive organizational policy for BIM	2.91	74.4	25.6
BIM is not necessary	2.76	75.7	24.3
BIM is not yet popular in the construction industry	2.69	76.3	23.7
Lack of interest in BIM	2.69	76.3	23.7
BIM is not a proven project delivery system	2.69	76.3	23.7
Lack of political and corporate will	2.63	76.9	23.1
Lack of policy and BIM roadmap by the government	2.56	77.5	22.5
Complexity of BIM supportive procurement	2.52	77.8	22.2
Legal issues and copyright ownership	2.39	78.9	21.1
Lack of information on the BIM capacity of contractors and consultants	2.39	78.9	21.1
BIM is not part of contract documents	2.39	78.9	21.1
Lack of advice from consultants to demand for BIM	2.33	79.5	20.5
Lack of BIM-based pilot projects by the federal government	2.15	81.1	18.9
Adequacy of the existing project delivery system	2.03	82.1	17.9
BIM is not acceptable for obtaining building permit	1.79	84.2	15.8

4.8. Relationship between the Benefits of Bim and Clients' Requirements

In order to determine the interrelationships among the benefits of BIM and the relationships between the benefits of BIM and clients' requirements, twenty-six (26) benefits of BIM were identified so that respondents rated the extent to which they are related to the requirements of clients on a 5-point scale. The ratings ranged from '1= Very Low Relevance', '2= Low relevance', '3= Average Relevance', '4=High Relevance', and '5= Very High Relevance'. Exploratory factor analysis was conducted on the responses using principal component analysis as the method of extraction and Varimax as the method of rotation. The appropriateness of the sampling accuracy and the strength of relationship among the variables were determined by calculating the Kaiser-Meyer-Olkin (KMO). The KMO value was 0.61, slightly above the recommended value of 0.60. Also, the Bartlett's test of sphericity was significant (x^2 (325) = 913.11, p<0.05). As shown in Table 6, the communalities of the variables were all above 0.30 (30%). This shows that each variable shared some common variance with all other variables and interrelationships exist among the variables. The analysis yielded five factors explaining a total of 73.304% of the variance for the entire set of variables. The factors were labelled as follows: Factor 1 = Performance requirements, Factor 2 = Value requirements, Factor 3 = Statutory requirements, Factor 4 = Productivity requirements, and Factor 5 = Innovation requirements. With preference to items with high loadings, the factors were given names that best represent the variables within the factors.

Only two variables ('faster client approval cycles' and 'better cost control') were eliminated because they did not contribute to the factor structure and failed to meet a minimum criteria of having a primary factor loading of 0.50 or above and cross-loading of 0.30 or above. Also, Table 6 shows the correlation coefficient between the variables and the factors. Factor 1 which was labelled as 'performance requirements' explained 20.515% of the variance and has Eigenvalue of 5.334. The benefits of BIM that correlate with 'performance requirements' by clients were presentation and visualization of building design (63%), improved collective understanding of design intent (60%), spatial coordination (73%), integration of design and construction process (74%), improvement in construction processes (63%), improved communication among project team members (86%), improved operations, maintenance and facility management (61%), simulation and scheduling of construction process (57%), better understanding of project (57%), and better collaboration among the project team members (56%). Value requirements (variance = 10.228%, Eigenvalue = 4.219) has high degree of correlation with the following benefits of BIM: improved project value and quality (63%),elimination of delay, cost overruns and conflicts (82%), reduction of errors, omissions and rework (80%), improved budgeting and cost estimating capabilities (66%), simulation and scheduling of construction process (54%), and improved safety and productivity of personnel (55%). The variance explained by statutory requirements was 13.789%. It has an Eigenvalue of 3.585 and the following benefits of BIM correlate with statutory requirements to the following degree: allows sustainability and maintainability analysis (51%), improved tender process (76%), faster regulatory approval processes (74%), and better collaboration among the project team members (67%). The fourth factor was labelled productivity requirements' owing to the degree of correlation it shared with the following benefits of BIM: reduced changes during construction (90%), reduced construction costs and time (81%), and fewer claims and litigation (80%). The factor had an Eigenvalue of 3.407 and explained 13.103% of the total variance. Innovation requirements had only three benefits of BIM that correlated with it. Reduced numberof field coordination problems, increased prefabrication, and fewer requests for information, with 63%, 83% and 72% degree of correlation respectively. Figure 4 further explains the relationship between the benefits of BIM and clients' requirements.

Table 6: Correlation coefficients between the benefits of BIM and clients' requirements (Rotated Component Matrix)

Benefits of BIM	PER	VAR	STR	PRR	INR	Communality
Presentation and visualization of building design	0.632					0.636
Improved collective understanding of design intent	0.601					0.658
Spatial coordination	0.731					0.746
Reduced changes during construction				0.905		0.846

	PER	VAR	STR	PRR	INR	
Integration of design and construction process	0.743					0.758
Improvement in construction processes	0.636					0.719
Improved project value and quality		0.638				0.741
Elimination of delay, cost overruns and conflicts		0.823				0.761
Improved communication among project team members	0.864					0.779
Reduction of errors, omissions and rework		0.808				0.777
Improved budgeting and cost estimating capabilities		0.661				0.784
Improved operations, maintenance and facility management	0.619					0.670
Reduced number of field coordination problems					0.635	0.666
Simulation and scheduling of construction process	0.595	0.541				0.769
Reduced construction costs and time				0.817		0.838
Increased prefabrication					0.831	0.725
Fewer requests for information					0.727	0.740
Allows sustainability and maintainability analysis	0.570		0.510			0.771
Improved safety and productivity of personnel		0.552				0.561
Fewer claims and litigation				0.803		0.780
Faster client approval cycles						0.699
Improved tender process			0.765			0.859
Faster regulatory approval processes			0.748			0.723
Better cost control						0.860
Better understanding of project	0.570					0.670
Better collaboration among the project team members	0.560		0.679			0.783
Eigenvalue	5.33	4.21	3.58	3.40	2.77	
% of total variance	20.5	16.2	13.7	13.1	10.6	
Total variance					74.3	

PER= Performance requirements; VAR= Value requirements; STR= Statutory requirements; PRR= Productivity requirements; INR= Innovative requirements

5. Discussion

5.1. Getting Clients to Demand for BIM

The extent of awareness about BIM has a significant effect on the rate of demand for BIM. Previous studies by McGraw-Hill Construction [6], Zahrizan *et al.* [3] and Chartered Institute of Building [5] have also reported a strong relationship between awareness and demand for BIM. Nevertheless, what the clients know about BIM is affecting what they are demanding for in BIM. This study found that most of the clients were not aware of the whole concept of BIM; and this affected what they demanded for about BIM. BIM is not just a terminology or a software technologies, its concept is broader than computer aided-design or 3D models. In spite of this, clients were only demanding for BIM software technologies because they were only interested in 3D models.

The few clients that were knowledgeable about the collaboration requirements in BIM were only demanding for them in large projects. This findings support the survey results obtained in 2012 by McGraw-Hill Construction; which indicated that clients believed that BIM is only for large projects. This fact explains why the extent of awareness about BIM does not equate to the rate of demand. The gap between the extent of awareness and the rate of demand can be attributed to clients' lack of knowledge about the benefits of the whole concept of BIM.
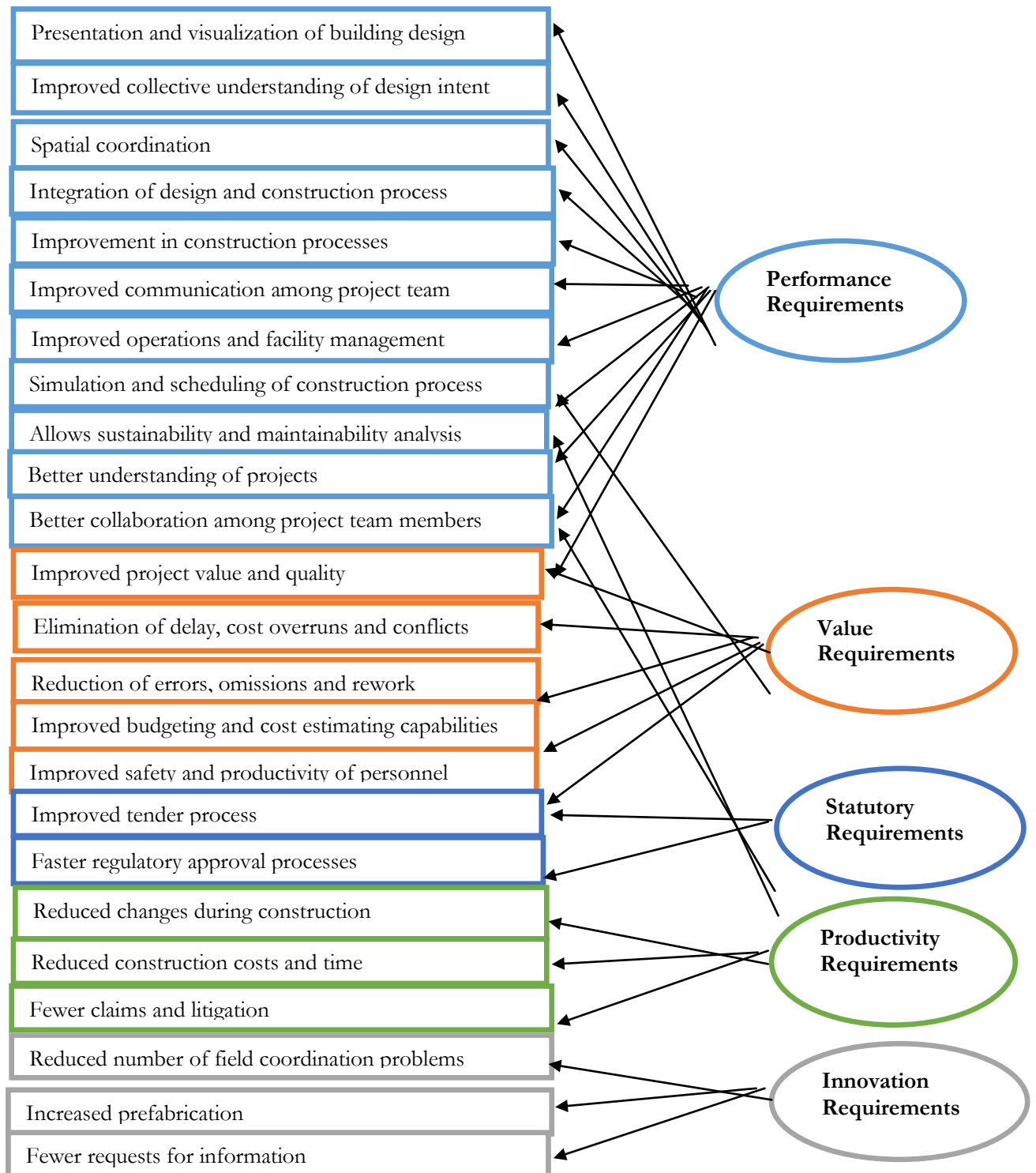
Figure 4: Relationships between the benefits of BIM and clients' requirements

Construction professionals, therefore have to educate and demonstrate the benefits of BIM to the clients so as to encourage clients to demand for BIM. Similar findings were reported in the United State building industry by Becerik-Gerber and Rice [13].

Educating and demonstrating the benefits of BIM to the clients provides an opportunity for construction professionals to market their services to the clients, and give themselves a competitive edge in the construction industry. In order to achieve this, construction professionals will have to implement BIM in their firms and

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working processes. Clients might not want to put in their money on BIM without seeing the value BIM is going to give to their investment. This means that construction professionals and AEC firms would have to find ways to cover the cost of BIM implementation. Chen *et al* [29] claimed that clients are interested in BIM but not demanding BIM. Also, this study found that some clients were aware of BIM but not demanding for BIM. The significant factors militating against demand for BIM regardless of BIM awareness as found by this study include: extra cost to support usage of BIM, shortage of BIM proficient professionals, ignorance about BIM requirements, unproven benefits of BIM, unawareness of benefits of BIM, and lack of BIM standards. It could be inferred that professionals and AEC firms that wants to be competitive and enjoy high patronage from the clients should not wait for clients to demand for BIM before they implement BIM. As an alternative to waiting for clients to demand for BIM, construction professionals and AEC firms should capitalize on clients' interest in BIM by offering BIM as a service. However, offering BIM as a service requires the AEC firms and construction professionals to look for an innovative ways to cover the extra cost to support BIM usage, train their workers on the usage of BIM, enlighten clients about BIM requirements and benefits, demonstrate the value of BIM other than presentation and visualization, and adopt a BIM standard.

Clients' demand for BIM could be influenced when BIM services are available in the AEC firms, when clients are made aware of the availability of BIM services, and when clients are not being charged for BIM services or when the cost of BIM services is moderate enough as not to exceed the benefits of BIM. If this is not done, clients won't be demanding for BIM. As noted by Farris *et al*. [36], decisions made by clients on a cognitive level are influenced significantly by their awareness of the available services and their benefits. Therefore, a new service or innovation such as BIM needs advertising and promotion to create and increase awareness among the existing and potential clients. The demand for a service may be limited if the service is expensive to provide, but demand can be increased if the benefits of the service exceed the cost and if it can be demonstrated [9]. This assertions corroborates the findings of Sawant [37] which indicated that awareness develops a positive attitude that will culminate demand in clients and that it educates them about their needs, provides information on their requirements, and assists them in comparing the available alternatives.

As indicated in the findings of this study, lack of information on BIM, lack of BIM awareness program from the construction industry, unawareness of clients' role in BIM, non-usage of BIM by construction professionals, and lack of advertisement for BIM by the construction professionals and industry, were the factors influencing BIM unawareness by clients. This shows that majority of the clients did not understand the concept of BIM owing to unavailability of BIM services in AEC firms and lack of advertisement for BIM services, if at all it is available in the AEC firms. Awareness of BIM by clients can only be ensured by making BIM services available for them and by informing them about the availability of BIM services via the media. Similar finding is observed in Barroso and Llobet [10] and Bakhshi *et al* [33] which suggested advertisement as a way to create awareness about the existence and benefits of an innovative service.

5.2. Achieving Clients' Project Requirements in BIM

Majority of the respondents indicated the presentation and visualization benefits of BIM as the only significant benefits of BIM. This shows that the limitation of their awareness to only BIM software technologies made them to associate the benefits of BIM to 3D models that could be produced using BIM software technologies. On the other hand, BIM is more than a software and its benefits go beyond presentation and visualization. Studies by Eastman *et al*. [16] and BIM International Report [1] have shown that BIM has good benefits and that these benefits are responsible for the adoption and implementation of BIM across the world.

Construction projects characterize investments for clients; and clients' requirements for their projects have always been interpreted as time savings, cost savings and quality improvements. As indicated in Figure 4, this study identified five distinct dimensions of clients' requirements in the benefits of BIM, which include: performance, value, statutory, productivity, and innovation requirements. This shows that the conventional requirements of time savings, cost savings, and quality improvements can be achieved in BIM. BIM will provide the conventional value and added value for clients' investments. Also, the ever increasing complexities and diverse requirements of projects demand that clients should demand for BIM for their projects. This findings similar to the earlier published report which posited that BIM is for every projects that want to be successful and for every clients that want to achieve his project requirements.

5.3. Implications for Construction Professionals, AEC Firms and Policy Makers

Construction professionals and AEC firms in Nigeria that would like to be offering BIM services require a level of financial investment, which will cover the cost of training workers, creating BIM environment, and advertising BIM services. BIM implementation requires more than a declaration or legislation, public clients in Nigeria that would like to demand for BIM must back up BIM adoption with legal and regulatory framework, BIM standards and protocols, educational standards, and pilot projects. Agencies of the Nigerian construction industry should be at the fore-front of BIM advocacy. At the same time, the professional institutions should collaborate with BIM vendors and tertiary institutions on BIM training for construction professionals and undergraduate students. This will help reduce the cost of BIM implementation in AEC firms, as they will have a ready pool of BIM competent workers and graduates to employ from.

6. Conclusion

This study only revealed the perceptions of construction clients in the Nigerian construction industry; and did not investigate the types of construction projects where the respondents had demanded for BIM and the types of BIM models and software technologies they were demanding for This study has shown that the extent of BIM affects the rate of demand for BIM. Some clients were not aware of BIM owing to the fact that the construction industry, construction professional bodies and construction professionals were not providing information on BIM usage for clients through advertisements in the media. This has made the clients to believe that BIM is only for construction professionals to know and that BIM does not involve them. A shift in clients' demand requires advertising and marketing. The requirements and priorities of clients and the impact of BIM on those priorities and requirements should inform the advertisement.

Clients that were aware of BIM and its benefits were demanding for BIM in their projects mainly because BIM helps them to visualize the intended building design. Although all the other benefits of BIM have significant influences on demand for BIM by clients; but the building presentation and visualization benefits of BIM was considered as the only unique benefit of BIM. All other benefits of BIM can be achieved through other project delivery methods and control systems. However, BIM offers an all-in-one solution to all the challenges of construction project delivery and the problems of the construction industry.

The benefits of BIM translate to performance, value, statutory, productivity, and innovation requirements for construction projects by clients. By meeting the value requirements of clients, BIM would deliver construction projects to time, cost and quality. These three fundamental requirements have been used to measure the success of projects and to interpret clients' requirements. The complexities of modern projects are pushing the success criteria of projects beyond time savings, cost savings, and quality standards. Also, two projects cannot have the same requirements and the requirements of clients may differ; but with BIM, any projects and clients' requirements can be met.

Construction professionals and firms should leverage BIM as an investment and opportunity for marketing their services; because it will be difficult to convince clients to demand for BIM if it means covering the cost of BIM. This is compulsory because the benefits of BIM are not only for the clients; although clients benefits more from BIM; but BIM also increases the competitiveness of construction professionals and helps them to meet clients' requirements with fewer problems.

AEC firms and construction professionals should not wait until clients demand for BIM before they implement BIM in their firms and working processes. Preferably, they should influence clients to be demanding for BIM by making BIM services available, advertising BIM services, and providing BIM services at a reasonable or affordable cost.

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