Adoption of Building Information Modelling (BIM) in the Procurement Processes: Nigerian Construction Industry Milieu

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Abstracts

BIM is crucial to building clients and facility managers in terms of increasing building performance, automatic corrections when changes are made to the design, earlier collaboration of multiple design disciplines, automatic extraction of cost estimates during the design stage, discovering design errors and omissions before start of construction and so on. This research was aimed at identifying the imperatives of BIM adoption in the Nigerian Construction Industry and also pin point the most beneficial stage if BIM is embraced in the construction processes so that effort can be concentrated there when adopting the technology in the Industry. A quantitative research approach was undertaken for this purpose, from the Delphi survey conducted using a semi structured questionnaires the study was able to identified twenty-four (24) benefits of BIM within the Industry and with the help of thematic analysis approach they were later categorized into four (4) primary constructs. Thus; are Pre Design Stage Benefit (PDSB), Design Stage Benefit (DSB), Construction Stage Benefit (CSB) and Post Construction Stage Benefit (PCSB). From the analysis, It was observed that Design Stage Benefit (DSB) was ranked highest with 4.35 mean score as it tends toward high and extremely high. This emanated from the respondents' view as a result of the BIM to allow for earlier collaboration of all design disciplines to make inputs in one another's work which subsequently helps minimize errors and omissions. Similarly, BIM enables consistency of all working drawings to the design intent and allows for automatic corrections when changes are made in the design process and provides opportunities to review alternative options.

Keywords: BIM, Construction Industry, Construction Projects, Delphi Survey, Ranking

INTRODUCTION

Across the globe, the Construction Industry faces challenges in relation to construction projects delivery such as lack of efficiency and productivity despite their immense contribution in many countries economy (Oyewobi *et al.*, 2011). This has been attributed to so many factors among which is the; fragmented process of design, not particularly well integrated unjust procurement processes and flawed project delivery system (Khalfan and Anumba, 2000). The consequences are negative regarding value, cost, sustainability, resource depletion and the wellbeing of end-users (Masood *et al.*, 2014; Peng *et al.*, 2016 and Shy 2017). Several attempt by practitioners and documented research by academics within the Industry have indicated the need for continuous improvements in project delivery system. Within academic circle, Latham (1994) in his work asserted that, the disjointed and fragmented nature of the Construction Industry as one of the key factors responsible for creating communication gap among construction project stakeholders which leads to inefficiency and lack of productivity in the project delivery processes. In a similar study carried out by Egan (1998, 2002) further advanced this report by two other researches which affirmed the need for change in the construction processes to ensure more productivity and efficiency. All studies reiterated the need for effective processes throughout the design and construction lifecycle. There are several responses to these calls for continuous improvement in efficiency and productivity of the Construction Industry from different perspectives. These ranges from advancement new procurement arrangements like partnering and integrated project delivery among others (Ibrahim and Price, 2006).

Although, those preceding strategies are held good for improving inefficiency and productivity in the project delivery processes., some researchers understand their shortcomings and emphasized the adoption of Information Technology for better enhancement (Wu *et al*, 2013, Ming, 2015). However, technology was first invented and introduced into the Construction Industry in the early 1980s under the Virtual Building concept by Graphisoft’s ArchiCAD now known as ArchiCAD and this was the start of the software revolution that allowed architects to create virtual, three dimensional (3D) designs of their project instead of the standard two dimensional (2D) (Bataw and Boyd, 2013). Since then, new technologies and updated software were developed and used but they are only limited to the design stage, until the concept of Building Information Modelling (BIM) was introduced.

The BIM process provide platform to set up collaborative work in the Construction Industry and therefore gives the way to enhance the overall quality of the whole value chain. BIM is considering as the speedy and more efficient method for construction project management, it enriches design and construction qualities and reduces rework during construction (Masood *et al.,* 2014). BIM technology allows the creation of an accurate virtual model of a building, that is first digitally constructed. This model can be used throughout the entire life cycle of the building (design to demolition) allowing all the stakeholders to work collaboratively rather than in a fragmented manner (Charef *et al*., 2018).

Egbu *et al*., (1999) asserts that Building information modelling (BIM) is one of such new creative processes that has being recognized to bring about the much needed change and continuous improvement in the Construction Industry where projects are implemented by temporary 'virtual' organizations both within construction organizations and between firms in the supply chain. Succar (2005) advanced that BIM has now proved its position as the reliable approach towards addressing numerous inefficiencies in Construction Industry. Furthermore, existing literature have shown that many countries of the world like USA, UK, Australia, Netherlands, Singapore, Hong Kong, Finland, Norway and Denmark among others have embraced BIM techniques and technologies at different levels and have experienced substantial improvement in construction project delivery (Yan and Damian, 2010; Nederveen *et al*, 2010; Isikdag and Underwood, 2010; Wong *et al*, 2010; Sebastian and Berlo, 2011). Some of the benefits of BIM technologies as claimed by its proponents are that it provides for efficient communication and data exchange (Nederveen *et al*, 2010), auto quantification, improved collaboration, coordination of construction documents, improved visualization of design (Olatunji, *et al*, 2010; Sacks *et al*, 2010), clash detection, and cost reduction (Eastman *et al;* 2011).

Considering the all-important benefits of BIM, Olatunji, *et al;* (2010) stressed the need for its full adoption across all disciplines and geographical boundaries. Consequently, it becomes imperative for the Nigerian construction industry which has been described as a 'sleeping giant' and having no capacity to deliver due to inefficiency among other problems (Kolo and Ibrahim, 2010; Mohammed, 2012), to exploit the widely acclaimed benefits of BIM technologies in order to practice in line with the global best practices and achieve the continuous improvement needed by its players. Adoption of innovations like BIM would bring about the most needed changes in the construction processes and operational procedures in the Construction Industry. It is therefore important now to evaluate the imperatives of adopting BIM technologies in each stage of construction projects processes in the Nigerian Construction Industry with the view to identify the most essential stage so that more effort can be concentrated at that level for achieving meaningful adoption of BIM

METHODOLOGY

Delphi Survey

Based on a comprehensive literature review, an initial list of 21 imperatives of BIM in the Construction Industry was established. Similarly, in the course of survey the respondents were also encouraged to cite additional factors thought to be imperatives for BIM adoption in the Nigerian Construction Industry and at the end of the second round Delphi survey additional three factors were incorporated (see Table 2). To refine this initial list under the context of this study, a two-round Delphi survey was conducted. The Delphi method is a structured communication and consensus approach amongst a group of experts on a complex problem, which has been widely adopted in Construction Industry research (Ameyaw et al. 2016; Xia and Chan 2012). The accomplishment of a Delphi survey depends primarily on the logical selection procedure of panel members. Therefore, to achieve the aforementioned; the following criteria were employed to identify eligible participants for this Delphi survey: All participant must have at least ten years of experience in the construction sector and possessed information and technology knowledge related to Construction Industry ever before. In particular, the latter criterion was highlighted, considering the context of the research.

A total of 43 experts meeting the selection criteria were identified and invited to participate in this Delphi survey. The target experts were from professional consulting firms, contracting companies, government ministries, departments and agencies. The sample for Consultants and Contractors were carefully selected from directory of the Corporate Affairs Commission (CAC) while that of Clients was selected from the government ministries, departments and agencies (MDAs). All the experts hold different positions in their organizations and have enough work experience, especially a sound knowledge of information and technology related to Construction Industry. Additionally, their diversified employer backgrounds (i.e., clients, contractors, consultants) help increase the heterogeneity of the Delphi panel and thus improve the survey validity. Additionally, based on their experience, experts were encouraged to list any new imperatives of BIM in the Construction Industry that were not included in the Delphi survey. The mean score of each imperatives of BIM in the Construction Industry was calculated and then fed back to the Delphi panel. In the second-round survey, experts were asked to re-assess their evaluations in the light of the findings obtained in the previous round. A threshold of 3.0 points was established as a cut-off criterion, as recommended by Jamieson (2004).

The questions were designed to retrieve information on the most important stage for BIM adoption in the construction projects processes in the Nigerian Construction Industry. The questionnaire is divided into two sections (A and B), section A comprises total of five (5) questions aimed at providing information about the respondents' profile whereas section B had twenty-four (24) questions which focused on the subject matter of the study i.e. imperatives of BIM in the Construction Industry and subsequently with the help of thematic analysis approach; the 24 identified variables were categorized into four (4) primary constructs. However, for each question in section B the respondents had been provided with five options in the form of a Likert Scale ranging from 1(Strongly disagree); 2 (Disagree); 3 (Neutral); 4 (Agree) and 5 (Strongly agree).

RESULTS AND DISCUSSION

Respondents' work

The table (1) below present the distribution of the respondents based on the nature of their work. Consultants formed the large group of the respondents with nineteen (19) out of the total fourty five (45) in the entire survey then followed by Clients with fifteen (15). It can also be seen that nine (9) of the respondents were Contractors from various contracting firms.

Table 1: Nature of Respondents' Work

Nature of Work	*Frequency*	*Percent*	*Cumulative Percent*
Consultants	19	44.19	44.19
Clients	15	34.88	79.07
Contractors	9	20.93	100.00
Total	43	100.00	

Distribution of Respondents by Percentages

There were fourty three (43) respondents from the entire survey. According to the result of the analysis, (44.19%) of them were consultants or working with professional consulting firms and they have occupied the largest portion of the respondents, (34.88%) were either clients or clients' representatives working with ministries, departments or government agencies whereas (20.93%) out of the total number of respondents were contractors. These further validate the cogency of the research as the opinions received from the respondents cut across major stakeholders in the Construction Industry.

Benefits of BIM in the Construction Industry

Based on reviews of previous related studies 24 factors were identified thought to be imperatives of BIM for construction projects and the thematic analysis approach was employed to factorized the newly identified variables and the 24 identified benefits were categorized into four (4) primary constructs. A thorough reading and evaluation of each variable was made to find out their main themes so as to aid in the classification procedure. However, at the end of the processes, the four (4) different categories that were developed are Pre Design Stage Benefit (**PDSB**), Design Stage Benefit (**DSB**), Construction Stage Benefit (**CSB**) and Post Construction Stage Benefit (**PCSB**). These variables were adopted in the section B of the questionnaire and the data retrieved from them was further analyzed as shown in the Table (2) below.

Table 2: Benefits of BIM in the Construction Industry

S/No.	Factors	Variables	Code	Mean Score	Categories Mean Score	Rank
	PDSB				3.76	4
1		Better design option from different alternatives with BIM simulation tools	PDSB1	4.13		
2		Feasibility/Development consideration	PDSB2	3.35		
3		Robust information	PDSB3	3.68		
4		Better decision making to all stakeholders	PDSB4	4.53		
5		Probable estimated cost of the project at the onset	PDSB5	3.11		
	DSB				4.35	1
6		Project visualization	DSB1	4.33		
7		Enhance/quality communication	DSB2	4.12		
8		Multi-dimensional integration	DSB3	4.11		
9		Auto-quantification	DSB4	4.53		
10		Clash detection	DSB5	4.33		
11		Time reduction	DSB6	4.62		
12		Better design	DSB7	4.12		
13		Simultaneous access to project database	DSB8	4.63		
	CSB				3.86	3
14		Reduce constructability problems such as change order	CSB1	3.65		
15		Better collaboration of all actors on the job site	CSB2	4.44		
16		Provide for improved planning and scheduling	CSB3	4.30		
17		Proper site coordination among different stakeholders	CSB4	3.78		
18		Reduce waste of effort to the bearest minimum	CSB5	3.13		

PCSB				4.32	2
19	Controlled Whole Life Cost of the projects	PCSB1	3.98		
20	Digital facilities management	PCSB2	4.17		
21	Sufficient project documentation	PCSB3	4.76		
22	Better customer services	PCSB4	4.19		
23	Cost savings/reduction	PCSB5	4.87		
24	Enhanced overall quality of the projects	PCSB6	3.99		

Ranking of Responses

The categories were further ranked based on the mean values of measures of central tendency of statistics. According to Alarape and Agbaje (2010) ranking is a relationship between a set of items such that, for any two items, the first is either 'ranked higher than', 'ranked lower than' or 'ranked equal to' the second. In statistics, "ranking" refers to the data transformation in which numerical or ordinal values are replaced by their rank when the data are sorted. By reducing detailed measures to a sequence of ordinal numbers, rankings make it possible to evaluate complex information according to certain criteria.

For the purpose of explanation; the Arithmetic mean scored “1” depicts extremely low benefit, “2” low benefit, “3” moderate benefit, “4” high benefit and “5” extremely high benefit but if the issue is scored “1.3” then it will consider to be between extremely low benefit and low benefit but tends more towards extremely low. In addition, if the variable was scored “4.6” then it lies within high benefit and extremely high benefit but tends more to the extremely high benefit in line with evaluating the imperatives of the BIM in the Nigerian Construction Industry.

DISCUSSION

The ranking was done based on the mean values of the responses in order to ascertain the most benefit stage from the respondent view point. From the analysis, *Design Stage Benefit (DSB)* was ranked highest with 4.35 mean score as it tends toward high and extremely high. This emanated as a result of the respondents’ perception that BIM enables visualization and analysis of design to the extent of simulating the presumed reactions of the entire building and its individual components to environmental factors. It further, allows for earlier collaboration of all design disciplines to make inputs in one another’s work. This helps minimize errors and omissions. Similarly, BIM enables consistency of all working drawings to the design intent, allows for automatic corrections when changes are made in the design process and provides opportunities to review alternative options.

Furthermore, the analysis revealed that, *Post Construction Stage Benefit (PCSB)* was ranked second with 4.32 mean score value and the means of this category too is tends toward high and extremely high. The respondents opined that BIM provides interactive platforms for streamlined information management from design all through project life cycle and this can be a solution to the problems faced by facility management professionals such as data inconsistency and fragmentation of information management processes. They are also in the view that building information model that has been updated with changes made during construction process provides accurate information about the as-built design and provide a starting point for its operation and management. Similarly, the updated building models are used as rich handing over tools which can be used subsequently by services engineers (mechanical and electrical) to link all the information collected from manufactures of equipment and systems installed in the building for maintenance and facilities management purposes.

In addition, *Construction Stage Benefit (CSB)* was ranked third with 3.86 mean score value and the mean score is tend toward moderate benefit and high benefit. The respondents' perception at this category is that BIM provides for proper site coordination between main contractor and subcontractors to ensure that all items of work are carried out when the appropriate resources are available on site and this often helps to minimize waste of resources and efforts. BIM provides an accurate design model containing information on the material requirements of each segment of the work which serves as a basis for improved planning and scheduling of work and allows for better collaboration of all stakeholders on the job site.

Constructability problems can be easily detected before embark on the project site. Coordination among participating designers and contractors is enhanced and this ensures that errors of omission are significantly reduced. This speeds the construction process, reduces costs, minimizes the likelihood of legal disputes, and provides a smoother process for the entire project team. BIM provides for effective communication and collaboration between all parties to a project and creates a platform for thorough integration of project documentation right from conceptualization through to detailed design, procurement, construction and facility management. *Pre Design Stage Benefit (PDSB)* was ranked least with 3.76 mean score value and the mean is tending toward moderate benefit and high benefit. At this category, the respondent asserted that with the aid of BIM building client can be assisted tremendously in the concept development and feasibility considerations of design at the onset of a project. It further facilitates better decision making on projects. BIM also provides building owner with an idea of the estimated cost of a project before the actual construction begins that is an approximate building model built into and linked to a cost database can assist clients in this regard. In addition, early evaluation of design alternatives using simulation tools increases the overall quality of the building.

From the findings made, it can be concluded that the benefits of BIM at different stages of the construction projects is indispensable in the Nigerian Construction Industry though as revealed from the findings the high or extremely high benefits lies in design phase {*Design Stage Benefit (DSB)}* which was ranked highest with 4.35 mean score value. Similarly, more effort can be concentrated at that level for achieving meaningful adoption of BIM in the Nigerian Construction Industry. In addition, the most important factor for adoption is government's roles and supports such as developing incentives for enhancing professional involvement in BIM-enabled projects and support in the form of complementary training should be provided to inexperienced project teams. Without supports from the government, Nigerian Construction Industry will be ineffective and remain as uncompetitive compared to others.

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