# IMPERATIVES OF BUILDING INFORMATION MODELLING (BIM) IN THE NIGERIAN CONSTRUCTION INDUSTRY FOR SUSTAINABLE DEVELOPMENT

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## Abstracts

*BIM proves to be beneficial 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 approach was undertaken for this purpose, from the 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, Mean Score, Ranking*

## Introduction

There has been a great concern about the lack of efficiency and productivity in the Construction Industry worldwide 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, unjust procurement processes and flawed project delivery system (Khalfan and Anumba, 2000). The need for change and continuous improvement to the conventional design and construction process in the industry has been well established from the Industry actors. Several documented research by academics and practitioners within the Industry have indicated the need for continuous improvements in project delivery system.

Within the research community, Latham (1994) considered the fragmented nature of the Construction Industry as one of the factors responsible for poor communication between parties working on a construction project which leads to inefficiency and lack of productivity in the construction project delivery. The report also reiterated the need for effective processes throughout the design and construction lifecycle. Egan (1998, 2002) further supported this report by two other researches which affirmed the need for change in the construction processes to ensure more productivity and efficiency. Similarly, Olatunji *et al* (2010) in their study reiterated that the Construction Industry is in dire need of more logical improvements.

However, Nigerian Construction Industry is not also free from such problems and even more. It has severally been characterized as inefficient with low productivity and lack of capacity to deliver and satisfy its clients. Oyewobi *et al.*, (2011) ascribed the decline of the Nigerian Construction Industry's contribution to GDP between 1980 and 2007 to poor performance and low productivity within the sector. Similarly, Idrus and Sodangi (2007) opined that the Nigerian Construction Industry produces nearly 70% of the nation's fixed capital formation yet its performance within the economy has been, and continues to be very poor. Among other criticisms facing the industry are time and cost overruns (Kuroshi and Okoli, 2010; Ameh, 2011; Ogwueleka 2011), inadequate planning and budgetary provisions, contract sums inflation, inefficient and poor service delivery (Kolo and Ibrahim, 2010; Mohammed, 2012). Hence Aibinu and Jagboro (2002) and Oyewobi *et al.*, (2011) emphasized the need for improved performance and efficiency if the industry is to deliver value for money and effectively satisfy the needs of the clients.

Furthermore, there are several responses to these calls for continuous improvement in efficiency and productivity of the Construction Industry from different perspectives. These range from new procurement arrangements like partnering (Ibrahim and Price, 2006), integrated project delivery etcetera. 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. This system was designed and developed to assist all Construction Industry professionals in storing and communicating relevant information such as the building geometry and spatial data as well as the properties and quantities right from the inception of early stages throughout to demolition.

Bryde *et al*, (2013) asserts that BIM is currently the most essential option for a new way of approaching the design, construction and maintenance of buildings. Similarly, 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 (Egbu *et al*., 1999).

Succar (2005) advanced that BIM has now proved its position as the reliable approach towards addressing numerous inefficiencies in Construction Industry. Furthermore, literature review have shown that many countries of the world like USA, UK, Australia, Netherlands, Singapore, Hong Kong, Finland, Norway, Denmark and etcetera 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) among others.

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.

In addition, adoption of innovations like BIM would bring about the most needed changes in the construction processes and operational procedures in the Nigerian 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.

## Research Methods

The sample of the study was randomly selected for Consultants and Contractors from directory of the Corporate Affairs Commission (CAC) while that of Clients was selected from the government ministries and agencies. Total of 71 questionnaires were distributed to the entire respondents; 25 each to Clients and Consultants while 21 to Contractors. 43 questionnaires were successfully retrieved representing (60% of the total), i.e. 19 Consultants (76%), 15 Client (60%) and 9 Contractors (36%) which were valid and used in the analysis. The data obtained in the returned questionnaires was analyzed using the Statistical Package for Social Sciences (SPSS) software.

Quantitative research approach was systematically employed for the purposes of this study were semi structured questionnaires were designed and administered to professionals in the Nigerian Construction Industry. 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. These imperatives were derived from the review of previous studies from related works and with the help of thematic analysis approach; the 24 identified variables were categorized into four (4) primary constructs.

However, the variables highlighted may not cover all but commenting effort was made to identify the substantial imperatives of BIM in each stage of construction projects. 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). In addition, the respondents were also encouraged to cite additional factors thought to be imperatives for BIM adoption in the Nigerian Construction Industry.

## Results

### Description of 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 19 representing (44.19%) out of the total in the entire survey then followed by Clients with 15

(34.88%). It can also be seen that 9 representing (20.93%) 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** | |

**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 aforementioned 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 of Result**

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 tends 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 tends 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.

## Conclusion

From the findings made, it can be concluded that the benefits of BIM in 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.

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