READINESS OF NIGERIAN CONSTRUCTION INDUSTRY ON ADOPTION OF BUILDING INFORMATION MODELLING (BIM)

BSTRACT

Previous studies revealed low level of adoption of Building Information Modelling (BIM) in the Nigerian construction industry causing increased wastages, rework, time overruns, cost overruns, and adversarial relationships between project stakeholders. BIM adoption in Nigeria is at its infancy because majority of the knowledge of BIM exists only theoretically as much efforts are not being directed towards its application. This study therefore assessed the level of readiness for the adoption of BIM in the execution of construction projects in Nigeria with a view to enhancing the readiness level of construction stakeholders in the adoption of BIM. The study adopted a quantitative research approach. Data were collected with use of questionnaire survey from 127 construction professionals in Federal Capital Development Authority (FCDA), Abuja, Nigeria. Analysis of data was undertaken to obtain descriptive statistics such as frequency counts, percentage and Meant Item Score (MIS). The study revealed that: the Design phase/stage and Construction phase/stage are the important stages requiring the adoption of BIM (MIS = 4.74 and 4.61 respectively); the important pre-requisites for the readiness of BIM adoption by construction firms in Nigeria are: Model-centric workflows, Collaboration and data management, and Integrated analysis (MIS = 4.53-4.55); the Construction and Design stages are where the level of stakeholders' awareness on the adoption of BIM are high (MIS = 3.76 and 3.73 respectively) and the barriers to the readiness of BIM adoption in the Nigerian construction industry are: Lack of adequate BIM training and inadequate exposure to BIM concept and Low level of BIM technical know-how (MIS = 4.19 and 4.10 respectively). It was concluded that the level of readiness for the adoption of BIM in the Nigerian construction industry is on the average but it is confronted more by the two afore mentioned barriers. It was therefore recommended that the Government and all construction stakeholders should incorporate BIM in the academic curriculum and also provide appropriate technology and infrastructure ready for BIM adoption right from the procurement processes in Nigeria.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

The need for increased productivity and higher return on investments in the construction industry has become a great concern for industry stakeholders (Infocomm, 2011). Such decline in productivity is bred by several factors resulting to increased wastages, rework, time overruns, cost overruns, and adversarial relationships between project stakeholders (Infocomm, 2011; Telaga, 2018; Iyorter, 2019).

Furthermore, the Nigerian construction industry accounts for 70% of fixed capital formation, yet it contributes less to the economy when compared with other industries (Iyorter, 2019). The industry accounts for 4% contribution to Gross Domestic Product and it is a cross cutting or linkage industry which generates employment. The Nigerian construction industry faces problems such as construction delays, time and cost overruns, abandonment of projects, power shortage and corruption among others. In addition, the Nigerian construction industry is stuck in traditional construction processes and fragmentation of work processes which leads to multiple exchanges of information between people, disciplines and project phases. Interestingly, studies such as Iyorter (2019) and Abubakar *et al*. (2014) have shown that Building Information Modelling (BIM) is capable of addressing these problems by promoting better integration of construction processes and enabling project teams to collaborate and exchange project information electronically. BIM is therefore an innovative approach to building design, construction and management which is gradually being implemented by countries such as United

Kingdom, United States, and New Zealand in order to address the challenges facing the industry (Iyorter, 2019).

BIM is described as a set of interacting policies and processes that are being enabled by technologies in generating a methodology to procure building works (Succar, 2009), purely from inception through the construction process to completion and to the entire lifecycle of a building. It aids the visualization of what is to be built in a simulated environment in order to identify potential design, construction or operational problems of a facility. Despite established benefits that BIM offers, the adoption of BIM in the Nigerian construction industry has been relatively slow, which is believed to be associated to low level of awareness and utilization amongst stakeholders (Ryal-Net and Kaduma, 2015). Abubakar *et al*. (2014) reported that many developed economies of the world have recorded impressive outcomes by implementing BIM in their construction practices but the developing countries including Nigeria have not.

Kong *et al*. (2020) reported that many surveys and researches show the effort of using BIM worldwide. However, the challenges still exist since industrial players have certain reasons for not adopting BIM in their projects. For developed countries, it was reported that the lack of adequate training is the greatest challenge while cost of software and required hardware upgrades were reported to be the second greatest challenge (Kong *et al*.,2020). Also, the Smart-Market Report (2014) showed that for the years of 2009, 2012 and 2014, the lack of demand is the top reason for not adopting BIM among non-users in Australia, New Zealand and North America. Developing countries, such as Nigeria, is also faced with similar challenges (Iyorter, 2019). Hence, the need for this study.

1.2 Statement of the Research Problem

The Nigerian construction industry has faced so many criticisms across the globe for its inefficiency and lack of productivity, which have been attributed to its fragmented nature. (Abubakar *et al*., 2014). BIM is one of such innovative processes that promises to bring about

the continuous improvement and desired change in the construction industry and revolutionize the processes of its operation to achieve better collaboration between project parties and ensure successful project delivery (Abubakar *et al*., 2014; Telaga, 2018; Iyorter, 2019).

Hamma-Adama and Kouider (2018), Architecture Engineering and Construction business is developing as a result of digital transition. This development became obvious since development of BIM concept. However, this is yet to be achieved globally due to conventional nature of the industry. BIM is the most recent development of the construction industry's process and a promising concept determined to shape the industry's fragmented culture (Zhao *et al*., 2016).

Improvement of project cost control and conflict reduction are among the numerous benefits associated with BIM (Telaga, 2018). Therefore, BIM has been widely adopted in many countries to increase the productivity of construction projects. However, level of BIM utilization in construction industry varies among countries. While developed countries are among the early implementer of BIM, its implementation in developing countries still poses many challenges.

Nigerian construction industry is besieged with problems such as increased wastages, rework, time overruns, cost overruns, and adversarial relationships between project stakeholders and these problems can be attributed to the low level of BIM adoption (Iyorter, 2019). In order to address these problems, it is necessary to assess the level of readiness of adoption of BIM in the Nigerian construction industry using Abuja as the study area.

1.3 Research Questions

In order to address the problem identified by this study, the following research questions were set:

i. What are the barriers to the readiness of BIM adoption in the Nigerian construction industry?
ii. What is the current level of awareness of stakeholders on the adoption of BIM in the execution of construction projects in Abuja, Nigeria?
iii. What are the pre-requisites for the readiness of the adoption of BIM in the execution of construction works at different stages of a project?
iv. What is the level of readiness for adoption of BIM in the execution of construction projects in Abuja?

1.4 Aim and Objectives of the Study

1.4.1 Aim

The aim of the study is to assess the readiness for the adoption of BIM in the execution of construction projects in Abuja, Nigeria.

1.4.2 Objectives

In order to achieve the aim of the study, the following objectives shall be addressed:

i. Examine the barriers to the readiness of BIM adoption in the Nigerian construction industry.
ii. Determine the current level of awareness of stakeholders on BIM adoption for construction projects in Abuja, Nigeria.

iii. Determine the pre-requisites for the readiness of the adoption of BIM in the execution of construction projects in Abuja, Nigeria.

iv. Examine the level of readiness for adoption of BIM in execution of Construction Projects in Abuja, Nigeria.

1.5 Need for the Study

Previous studies have reported that the adoption of BIM technologies result to impressive outcomes despite some notable challenges in many developed nations of the world such as USA, UK, Australia, Netherlands, Singapore, Hong Kong, Finland, Norway, Denmark, Indonesia, and Malaysia (Yan and Damian, 2008; Isikdag and Underwood, 2010; Nederveen *et al.*, 2010; Telaga, 2018; Kong *et al*., 2020).

Babarinde (2017) found that professionals are willing to adopt BIM but are limited by the various barriers and there is a low level of awareness and usage of BIM among the professionals in the post construction stage with a majority of them just getting to know about it. Babarinde (2017) stressed further that the few studies on BIM and lack of requisite knowledge has served as a major deterrent to BIM adoption. BIM adoption in Nigeria is therefore at its infancy because majority of the knowledge of BIM exists only theoretically, much efforts are not being directed towards the practical aspect of BIM (Babarinde, 2017). This is like putting the cart before the horse. It is therefore imperative to evaluate the readiness for the full adoption of BIM in the Nigerian construction industry in order to address the barriers to effective BIM adoption by the stakeholders.

Considering the reported benefits, Olatunji *et al*. (2010) and Iyorter (2019) stressed the need for the full adoption of BIM technologies across all disciplines and geographical boundaries. This makes it imperative for the Nigerian construction industry, which has been described as a

'sleeping giant' and having no capacity to deliver due to inefficiency and poor service delivery among other problems (Kolo and Ibrahim, 2010), to exploit the widely acclaimed benefits of BIM technologies in order to perform in line with the global best practices and achieve the continuous improvement needed by its players. Studies along this direction have been able to discover that the Nigerian construction industry's awareness and adoption of BIM is still low. This, however, leaves a gap of improving the awareness and adoption level of BIM in the execution of construction projects in Nigeria.

In order to fill the gap identified above, this study assesses the readiness for the adoption of BIM in the Nigerian construction industry with a view to enhancing the readiness level of construction stakeholders in the adoption of BIM. The outcome of this research will clearly make the strategies for improving the level of readiness for the adoption of BIM by construction stakeholders to be known. It will also enable the stakeholders involved make adequate provisions for the adoption of BIM at each stage of a construction projects. These would in the long run solve the problem of increased wastages, rework, time overruns, cost overruns, and adversarial relationships between project stakeholders which have been attributed to the fragmented nature of the Nigerian construction industry.

1.6 Scope of the Study

This research work covers only readiness of the adoption of BIM within construction projects only. Area of my concentration is limited to FCT Abuja. Every stage of Building Construction project was covered.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 The Concept of BIM

Sustainability is a critical issue in global urbanization which has a huge impact on the construction environment. The quest for sustainable processes is changing the way construction is managed globally. The search for better effective tools in construction project management has brought about the use of Building Information Modelling (BIM) in construction project planning. The role of BIM is like that of the project manager, who coordinates the management of construction projects (Opoko *et al*., 2019). Hamma-Adama *et al*. (2018), engineering business is going digital and integrated; there still remain significant move and development to achieving it globally. BIM is therefore most recent paradigm shift in construction industry and the promising concept determined to shape the industry's fragmentation. BIM can therefore be defined as a set of interacting policies and processes being enabled by technologies in generating a methodology to procure building works from inception to completion down to the entire lifecycle of a building in a digital format (Hamma-Adama *et al*., 2018). BIM is also referred to as a form of modelling technology which makes use of computers to achieve holistic information management of a project; it focuses on production information, effective communication and design analysis (Opoko *et al.*, 2019).

According to Opoko *et al*. (2019), the origin of BIM can be traced back to the 1970s in Georgia Institute of Technology where the idea was developed. It quickly grew into an acceptable concept when professionals using BIM for design and construction management got high commendable results. One of the software at that time was ArchiCAD made by Graphisoft back in 1986. ArchiCAD was an introduction into the virtual building interface, which was made of

3-dimensional (3D) components of the given project (Dey, 2010). However, BIM got its major popularity from the Autodesk release of the "Building Information Modelling" (Autodesk, 2013). Now, BIM has been used in various ways, achieving remarkable possibilities in building construction and is seen as an effective tool for sustainable construction. BIM has significantly influenced the standards for construction management in current times, setting new skill requirement for project managers (Baoping, 2011).

BIM is the process of creating a digital parametric model which represents the physical and functional characteristic of a building in full detail and further shared knowledge pool which can be used to form reliable decisions during the design, construction phases and throughout the life cycle of the facility (Eastman *et al*., 2011; Suranga and Weddikkara, 2012). Ruya *et al*. (2018) reported that construction companies are faced with the need to innovatively integrate the construction process and address project development challenges. One way of doing that is the integration of BIM in the building design and development cycles. BIM therefore involves the detailed and complete replication of a building in a digital environment with the sole goal of providing a collaborative platform for managing building information throughout the lifecycle of a facility (Ruya *et al*., 2018).

2.2 Impact of BIM in the Execution of Construction Projects in Nigeria

Fragmentation in the construction industry, being responsible for poor communication between project stakeholders, leads to inefficiency and low productivity in construction project delivery (Latham, 1994). About two-thirds of construction problems are caused by inadequate communication and exchange of information as a result of fragmentation of the construction industry (Mendez, 2006). An increase in maintenance costs can be attributed to faults in the

operations of systems and components as a result of deficiency in design (Mohammad & Mohammed, 2010).

According to Eja and Ramegowda (2020), government projects of any nation are of immense importance to the citizens and residents of that nation as it forms part of the building blocks that support national growth. The successful execution of projects serves as a visible indicator of development in a country (Eja and Ramegowda, 2020). Despite this, in developing countries such as Nigeria, majority of projects embarked on by the government are classified as failed projects.

According to Akerele and Etiene (2016), recent performance studies conducted on building projects by governmental and non-governmental bodies have revealed an alarming rates of client's dissatisfaction concerning time and cost overruns. This usually resulted from the use of inefficient procurement and project delivery, poor project management, incomplete documentation, discord between the design and construction teams, and frequent design change. Hence, leading to the development and subsequent adoption of Building Information Modeling by some countries around the world. However, Alufohai (2012), the level of awareness and adoption of BIM in Nigeria's private, public sector and amongst different building professionals has been very slow considering the numerous benefits enjoyed by the various countries that have adopted it fully. Alufohai (2012) therefore suggested the promotion of BIM's adoption in Nigeria by increasing public awareness on the technique, the tools employed and the benefit associated with its use.

In addition, BIM involves the creation of a digital parametric model which represents the physical and functional characteristics of a building in full detail and further shared knowledge pool which can be used to take reliable decisions during the design, construction and throughout

the lifecycle of the building project. BIM is also an Information Technology solution for the integration of software application and Information Technology tools to design a building in a common platform which affords the diverse professionals involved in the construction of a building the opportunity to make decisions putting into consideration the constructability, build ability and maintainability of the building. Furthermore, Ibrahim and Bishir (2012) opined that the basic premise of BIM is collaboration by different stakeholders during different phases of project life cycle which makes it possible to insert, extract, update or modify information in the BIM process to support and reflect the roles of the stakeholders. Alufohai (2012) further highlighted increased speed of delivery, better coordination, decreased costs, greater productivity, reduction of errors, higher quality of work and better facility operations as the key advantages and benefits of BIM in the execution of construction projects.

2.3 Stages in the Execution of Construction Projects in Nigeria

Building construction is a complex, significant, and rewarding process. It begins with an idea and culminates in a structure that may serve its occupants for several decades, even centuries. Like the manufacturing of products, building construction requires an ordered and planned assembly of materials. It is, however, far more complicated than product manufacturing. Buildings are assembled outdoors by a large number of diverse constructors and artisans on all types of sites and are subject to all kinds of weather conditions. The process by which a building project is delivered to its owner may be divided into the following five phases, referred to as the project delivery phases (Mehta *et al,* 2013). Although there is usually some overlap between adjacent phases, they generally follow the following order: Predesign phase; Design phase; Preconstruction phase; Construction phase; and post-construction phase.

Khaled *et al.* (2005) identified three basic elements or phases noticed during pre-construction period of a project, as follows: planning (pre-design) phase; design phase; and tendering and award phase. The Architects Council of Europe (2013) identified four major stages in the execution of construction projects as:

Stage 1: Preliminary Stage

At this stage, the Architect's advice is often of particular interest to a client or developer, since the Architect will usually have a general understanding of all aspects of the development process, from relatively abstract legal controls to practical construction problems, as well as broader design issues (Architects Council of Europe, 2013).

Stage 2: Design

The design stage is the stage in which the Architect predominates, both as principal designer and as coordinator of other designers. The narratives for this section concentrate on the design task, with a reasonable level of detailed information, including the normal scales used for drawings at this stage and the amount of supporting information required (Architects Council of Europe, 2013).

Stage 3: Procurement

The procurement stage again involves building design, at a more detailed level, and the narratives again concentrate on the design tasks and the level of information required, including drawing scales and other information requirements, this is similar to stage 2 (Architects Council of Europe, 2013).

Stage 4: Construction

During the Construction Stage, the primary role of the Architect may be less clear. In some countries other professions take a leading role in the detailed inspection of the project (such as France and Spain) while in others, the municipality bears a greater responsibility, since the building owner is not obliged to employ qualified professionals such as the UK (Architects Council of Europe, 2013).

Jason (2006) also reported that the project life cycle consists of four phases as: Project initiation; project planning; Project execution; and Project closure.

2.4 Pre-requisites for Readiness of the Adoption of BIM in the Execution of Construction Projects in Nigeria

The basic pre-requisites for the readiness of BIM adoption have been summarized into four distinct stages (Arayici *et al*., 2012). They are Diagnosis Stage; Action Planning Stage; Action Taking Stage; and Evaluation Stage. The Diagnosis Stage consists of detail review and analysis of current practice and identification of the efficiency gains of such practice. The Action Planning Stage involves the design of new business processes and technology adoption path. The Action Taking Stage is comprised of the consideration of possible implementation and roll out of BIM. The Evaluation Stage consists of project review, dissemination and integration into strategy plan. The readiness for the adoption of BIM by any firm in the construction industry is basically determined by these pre-requisites.

Doumbouya *et al*. (2016) also identified four basic pre-requisites for BIM adoption in the construction industry. These are Governance; Model-centric workflows; Collaboration & data management; and Integrated analysis.

Hardin and McCool (2015), regarded another pre-requisite that would facilitate BIM adoption is the change in industrial culture from the conventional, hence a need for behavioral change. This involves change in perception and process which would be possible only when people are aware of BIM Adoption or possess knowledge of the subject matter.

2.4.1 Governance: This is the foundation to the readiness for BIM adoption. It involves the organization and management of the BIM deployment upkeep, compliance and performance.

2.4.2 Model-centric workflows: This involves the deliverable standards that specify the asset models and its downstream use in other lifecycle phases.

2.4.3 Collaboration & data management: This involves accompanying data management framework solution to control the sharing of relevant and accurate information to all project stakeholders.

2.4.4 Integrated analysis: This involves the analyses of integrated asset models with the application of 2D for a start, then proceeding to 3D and finally moving ahead to 4D (cost) and even to greater complexity.

These pre-requisites have been referred to as BIM implementation precedence by Bernstein and Pittman (2004).

Figure 2.1: BIM Implementation Precedence
Source: Bernstein and Pittman (2004)

2.5 Awareness of Stakeholders on BIM Adoption in the Execution of Construction Projects

BIM adoption comes as a result of awareness and persuasion process; it is about perceiving the idea as a new way of doing things. There are three levels of BIM adoption, the Micro (within an organization), the Meso (within a project), and the Macro (market/countrywide). The Micro BIM adoption relates to organizational (firm) adoption with top management of a firm prescribing the BIM usage (Succar, 2010; Papadonikolaki, 2018). The Meso level of BIM adoption is adoption based on projects and their teams, the owner and project manager prescribing that (Succar, 2010; Papadonikolaki, 2018). While the Macro BIM adoption is markets and industries related (country-wide); that involves governments and international institutions (Succar, 2010; Papadonikolaki, 2018). In Nigeria, the application of BIM in property management, especially in the areas of building maintenance, letting, occupation, inspection and repairs of the properties, is rarely embraced among property managers (Anih & Ajiero, 2018). The primary uses include gathering, generating, analyzing, communicating and

realizing. The secondary uses have several items organized under specific heading under the primary uses. Anih *et al*. (2019) stated that the BIM uses and purposes communicate the primary objective of implementing the BIM.

BIM adoption is vital to productivity and the competitive nature of the construction sector. However, BIM implementation has not been generally embraced by many Architecture, Engineering, and Construction (AEC) firms, particularly in developing countries (Babatunde *et al*., 2020). Over the years in Nigeria, various studies have been carried out on BIM implementation and adoption among construction professionals. For example, Alufohai (2012) examined BIM adoption in the Nigerian construction industry and found out that adopting BIM among the Nigerian private and public sector clients as well as among various construction professionals (architects, quantity surveyors, civil engineers etc.) have been very slow. In the same vein, Ryal-Net and Kaduma (2015) also emphasized that BIM is an innovative approach that is gradually being implemented across the globe, because BIM aids the visualization of what is to be built in a simulated environment in order to identify potential design, construction or operational problems of a facility. In spite of the established benefits that BIM offers, the adoption of BIM in the Nigerian construction industry has been relatively slow.

Terreno (2018) reported that Facilities Management (FM) organizations have been lagging in the uptake of BIM, especially in comparison to their project counterparts in design and construction. Challenges such as the lack of demonstrated and recorded examples of successful implementation, and a similar dearth of a structured method for implementation have therefore been vocalized. Owners similarly demand a justification of returns or demonstrated value for their potential investment as reassurance for venturing into the game-changing prospect of BIM implementation. Indeed, the implementation of a new way of working with a different format of

information would have a far-reaching effect on all aspects of managerial strategy, organizational culture and process and on existing technological structures.

Hamma-Adama (2020), BIM is increasingly being adopted in developed countries, but the picture is different in the developing nations. The absence of BIM national implementation program, as well as the scarcity of BIM skilled personnel, are the main reasons for poor adoption and implementation of BIM. In addition to this, Saka *et al*. (2020) reported that the discussion on BIM in the Nigerian context is less than a decade, as the discussion just started in 2012. These early studies stressed the need for adopting and implementing BIM in the Nigerian construction industry and the associated benefits during the design stage, construction, and operation phases of construction projects. Extant studies revealed that the level of awareness and adoption of BIM in the industry is still low and facing many challenges such as lack of knowledge, lack of government support, and lack of implementation guidelines/strategies.

Akerele and Etiene (2016) examined the assessment of the awareness and limitations on the usage of BIM and established that there is low awareness on the usage of BIM. Marcus (2015) examined BIM in the Nigerian construction industry and found that there is a low level of knowledge of BIM which is related to the low utilization among the stakeholders. In a study conducted by Olanrewaju *et al*. (2020), it was reported that BIM has been applied to various aspects of construction processes in developed countries but Nigeria is yet to realize the full potential of BIM. It has greater relevance for the commercial and public subsectors as it enhances construction productivity.

Saka *et al.* (2020), BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its lifecycle; defined as existing from earliest conception to demolition. It is an interrelating set of policies, processes and technologies that enables the life

cycle management of the building data in a digitized format. The information and data made available in the digital format by the BIM can be easily edited, copied, and shared with the project stakeholders, which has improved interoperability between different phases of projects compared to the 2D paper formats. Saka *et al.* (2020) reported further on the significant benefits such as improved productivity and efficiency in construction organizations that have adopted BIM. This has led to an increase in the awareness, adoption, and implementation of BIM in the Architecture, Engineering, and Construction (AEC) industry over the years.

In addition to the above, Olanrewaju *et al*. (2020) reported that BIM is central to the successful management of construction project but most stakeholders in Nigeria are not aware of its uses at the operation stage of a building. It was further reported that BIM awareness level is only high at the design stage of a building. The study concluded that most construction professionals are not very much aware of the use of BIM for sequencing, maintenance schedule, fabrication, asset management, building system analysis, and record modelling.

2.6 Barriers to the Readiness of BIM Adoption in the Nigerian Construction Industry

It is a known fact that all of the perspectives of the BIM model highlight its significance in using it for the entire lifecycle of building projects, though scholars defined BIM differently, but its advantages support its application in project facilities management. The use of BIM is being considerably identified across all phases of project life cycle (Shou *et al*., 2015). While advantages and the beneficial deliverables of BIM has become evident, it is worth mentioning that most scholars had oriented their research on the design-construction phases instead of the entire buildings' life cycle.

Therefore, integrating BIM into pre-contract, contract and post-contract stages is facing certain challenges which act as barriers to BIM adoption as well as the level of readiness to adopt BIM

which is the first step towards BIM effective adoption, particularly in building construction industry. Kassem *et al*. (2015) pointed out the existence of two factors creating difficulties that prevent BIM adoption in the construction industry. First, the various project stakeholders do not intend to collaborate during modelling or in optimum utilization of the BIM model, and second, lack of awareness by clients which is aggravated by the shortage of BIM skills and absence of understanding by finance management professionals. All these, therefore poses major challenge for the building itself, as well as its owners. Hence, BIM processes and models in use, need sustained efforts by the major stakeholders so that they remain effective.

Onungwa *et al*. (2017) discovered that there is low level of awareness and technical know-how of BIM in Nigeria. This was linked to lack of adequate BIM training and inadequate exposure to BIM concept; Inaccessibility to suitable technology and framework; Low level of BIM technical know-how and awareness; Individual perception/ point of view; Absence of appropriate BIM guidelines; Industry/working environment; and Initial BIM huge capital outlays. Furthermore, Aldowayan and Dweiri (2020) identified seven (7) major barriers to the level of readiness of the adoption of BIM. These barriers are highlighted and discussed below:

a) Cost-related factors

During the start of the construction and post-construction phases, the main challenges for professionals are controlling the initial cost, which is the outcome of several other factors.

b) Employee-related factors

Human resource management and creating conducive organizational culture are very critical issues. This required employee training as well as error-free recruitment procedures. Allied to it, remained the major challenge of mobilization which depended on a realistic mobilization plan.

Shortage of skilled personnel was another concern faced by facility managers, especially in technology-based projects.

c) Information-related factors

There were many challenges felt in the beginning of Facility Management (FM) phase, due to the lack of required information which might be due to the underutilization of Building Management System (BMS) and its workflow at the facility. Hence, facility managers face a critical issue of troubleshooting the BMS to restore the missing data; for instance, if they have no as-built data, or the operation manuals is missing.

d) Project Plan-related factors

Proper action plan or implementation plan shows the readiness of operation and maintenance team. Lack of a mature plan for operation and maintenance leads to many errors in the initial phase. Since level of operation remains high at the start of operation and maintenance phase, facility managers are coping with poor coordination in the absence of a practically feasible plan.

e) Equipment and Technology-dependent factors

In the early phase of a facility development, there are hardly any challenges, provided all equipment and system are new but as they start to wear out with the progression of project, the need for maintenance and replacements arises, causing disruption to the project. This becomes a matter of concern for the facility managers. Moreover, the choice of right technology to coordinate between the numerous project players, requires tremendous data which if not provided on time would impact the cost, the deliveries, and the operations.

f) Time-related factors

Most projects require involvement of experienced planners or project managers who can schedule and execute project milestones perfectly. Focusing on the advantages and

disadvantages of various phases of the FM, proper scheduling would impact the designing of the process flow and ultimately the decision-making and customer satisfaction. The whole project is at stake if facility managers are not updated with the right information at the right time.

g) Operation and maintenance- related factors

A professionally coordinated equipment control assisted by qualified technicians can help facility managers to alleviate such concerns. Equipment tagging that reflects database accuracy which would assist in identifying the sources and locating them. To maintain the assets in use, Facility Managers are depended on real-time updated data, which is a matter of concern, in addition to other related issues such as which equipment to use, when to phase out, and what to purchase for the project.

Hamma-Adama (2020) reported that amongst other issues, corruption amongst the construction stakeholders is an issue that has deeply affected the construction industry in Nigeria; quick adoption of BIM in Nigeria has the potential benefit of minimizing corruption in the sector. In view of this, Hamma-Adama (2020) identified the following factors influencing the adoption of BIM in the construction industry of developing nations:

i. Lack of policy and standardization
ii. Lack of case study as a precedent (to demonstrate BIM benefits)
iii. Poor technology infrastructure and high cost of the software tools
iv. Education/training and lack of BIM skilled personnel
v. Non recognition of BIM role by the government and the clients
vi. Resistance by the industry professionals

2.7 Strategies for Enhancing the Level of Readiness of Construction Stakeholders in the Adoption of BIM for the Execution of Construction Projects

The adoption of BIM in AEC firms has attained a level of maturity most especially in developed countries like the United States of America and UK. It has received several strategies to its improvement among professional firms and its adherence has been put to place in several developed countries. For instance, Poole (2014) identified collaboration, training and promotion as the way forward for BIM adoption in Hong Kong. Build Smart (2013) reported the BIM roadmap in Singapore to include public sector takes the lead, regulatory approval, remove impediments, build BIM capability and capacity and incentivize early BIM adopters. Ezeokoli *et al*. (2016) identified strategies to improving BIM usage in the order of importance to include education and training program, incorporation of BIM to academic curriculum, enactment of BIM guideline and regulation, provision of appropriate technology and infrastructure, BIM should be made compulsory for all procurement processes and contracts and finally, setting up BIM council. Alufohai (2012) suggested that software vendors and relevant training institutes should embark on intensive awareness of BIM, BIM tools and associated benefits. The author further proffered that the relevant professional bodies both local and international should keep their member up-to-date by organizing trainings, workshops, and seminars on BIM implementation. Isa (2015) identified strategies for overcoming BIM barriers to include improve BIM awareness and understanding, outsourcing BIM experts, provision of training by employers, provision of BIM education at higher institutions, government legislation supporting the use of BIM, clients demand for BIM, government support, developing BIM guidelines and improved data exchange standards.

Hamma-Adama (2020), in a qualitative study, identified the following strategies for improving the adoption of BIM for FM among AEC stakeholders:

i. Push-pull strategy between the AEC stakeholders;
ii. Build trust between professionals;
iii. Create awareness through conferences;
iv. Proof of BIM benefits through case studies;
v. Consider government and professional societies as a team to lead BIM implementation;
vi. Government provides an enabling environment for BIM-based process;
vii. Mandate BIM on public projects;
viii. Consider six years as a timeline to BIM implementation;
ix. Consider other countries' guide as a starting point, but a national guide is subsequently necessary;
x. Provide incentives for the BIM adopters;
xi. Splits the software cost over projects as well as sharing the cost with a client; and
xii. Customize the local building components for objects libraries.

The current Nigerian situation and the adopters' conviction translate into having a combination of awareness, training, structured guidance, partial mandates, and incentives to encourage BIM adoption, particularly considering the high level of corruption in the industry. In addition, majority of the studies carried out identified BIM mandate as one of the solutions to its resistance. However, a complete mandate is not found to be the one-time solution to the BIM resistance based on the history of the industry. The use of BIM level 0 (CAD tool) is now the norm in the Nigerian construction industry without any mandate, as such partial mandate (with incentives) is concluded as the most appropriate approach (Hamma-Adama, 2020).

It is obvious that several strategies to improve BIM adoption have been identified, but none of these strategies have been investigated, particularly through an empirical approach in Nigeria. Therefore, it becomes imperative to empirically assess the strategies for improving the adoption of BIM among participants and stakeholders in the Nigerian construction industry in order to improve the level of readiness for the adoption of BIM in the industry.

2.8 Summary of Literature Review

The purpose of the review of literature is to put the study into the proper context based on the aim and objectives. Above all, the review of literature will give rise to the main research data required to examine the important constructs or variables required to address the study's objectives. After undertaking an extant review of literature these main constructs have been identified and they are summarized in this section.

2.8.1 Summary of Stages in the Execution of Construction Projects

The stages involved in the execution of construction projects as identified from the review of literature in this study are summarized in Table 2.1:

Table 2. 1: Highlights of Summary of Stages in the Execution of Construction Projects

S/No.	Stages	Source(s)
1	Predesign (planning) phase/ Preliminary Stage	Khaled *et al.* (2005); Jason (2006); Architects Council of Europe (2013); Principles of Construction: Part 2 (2021)
2	Design phase/stage	
3	Preconstruction (tendering and award)/ phase/Procurement Stage	
4	Construction phase/stage	

Source: Researcher's Literature Compilation (2021)

2.8.2 Summary of Basic Pre-Requisites for the Readiness of the Adoption of BIM in the Execution of Construction Projects

The highlights of the basic pre-requisites for the adoption of BIM in the execution of construction projects as identified from literature review is given in Table 2.2.

Table 2. 2: Highlights of Basic Pre-requisites for the readiness of the Adoption of BIM in the Execution of Construction Projects

S/No.	Pre-requisites for BIM Adoption	Source(s)
1	**Diagnosis:** Review and analysis of current practice	Bernstein and Pittman (2004); Arayici *et al*. (2012)
2	**Action Planning:** Design of new business processes and technology adoption path	Doumbouya *et al*. (2016)
3	**Action Taking:** Consideration of possible implementation	
4	**Evaluation:** Project review, dissemination and integration into strategy plan	
5	**Governance:** Organisation and management of the BIM deployment upkeep, compliance and performance	
6	**Model-centric workflows:** Identifying deliverable standards that specify the asset models and its downstream use in other lifecycle phases	
7	**Collaboration & data management:** Accompanying data management framework solution to control the sharing of relevant and accurate information to all project stakeholders	
8	**Integrated analysis:** Analyses of integrated asset models with the application of 2D, 3D, 4D (cost) and even to greater complexity	

Source: Researcher's Literature Compilation (2021)

2.8.3 Summary of level of awareness of stakeholders on the adoption of BIM in the construction industry

Table 2.3 gives the highlights of the level of awareness of stakeholders on the adoption of BIM in the Nigerian construction industry as gathered from literature review in this study.

Table 2. 3: Level of Awareness of Stakeholders on the Adoption of BIM in the Nigerian Construction Industry

S/No.	Level of BIM Adoption	Source(s)
1	In Nigeria, the application of BIM in property management is rarely embraced among property managers	Anih & Ajiero (2018)
2	BIM adoptions have not been generally embraced by many Architecture, Engineering, and Construction (AEC) firms in developing countries	Babatunde *et al*. (2020)
3	Adopting BIM among the Nigerian private and public sector clients as well as construction professionals have been very slow	Alufohai (2012)
4	In spite of the established benefits that BIM offers, the adoption of BIM in the Nigerian construction industry has been relatively slow.	Ryal-Net and Kaduma (2015)
5	FM organisations have been lagging in the uptake of BIM	Terreno (2018)
6	Level of awareness and adoption of BIM in the Nigerian construction industry is still low and facing many challenges such as lack of knowledge, lack of government support, and lack of implementation guidelines/strategies	Marcus (2015); Hamma-Adama (2020); Saka *et al*. (2020)
7	BIM awareness level is only high at the design stage of a building	Olanrewaju *et al*. (2020)

Source: Researcher's Literature Compilation (2021)

2.8.4 Summary of Barriers to the Readiness of BIM Adoption in the Nigerian Construction Industry

The review of literature in this study identified several barriers to the readiness of BIM adoption in the Nigerian construction industry. The highlights of these barriers are given in Table 2.4.

Table 2.4: Barriers to the Readiness of BIM Adoption in the Nigerian Construction Industry

S/No.	Barriers to the Readiness of BIM Adoption	Source(s)
1	Stakeholders do not intend to collaborate in the optimum utilization of BIM model	Kassem *et al*. (2015)
2	Lack of awareness	Kassem *et al*. (2015); Onungwa *et al*. (2017); Onungwa *et al*. (2017)
3	Clients' shortage of BIM skills	Kassem *et al*. (2015); Onungwa *et al*. (2017); Hamma-Adama (2020)
4	Absence of understanding by finance management professionals	Kassem *et al*. (2015)
5	Lack of adequate BIM training and inadequate exposure to BIM concept	Onungwa *et al*. (2017);
6	Inaccessibility to suitable technology and framework	Onungwa *et al*. (2017); Hamma-Adama (2020)
7	Low level of BIM technical know-how	Onungwa *et al*. (2017); Hamma-Adama (2020)
8	Individual perception/ point of view	Onungwa *et al*. (2017)
9	Absence of appropriate BIM guidelines	Onungwa *et al*. (2017)
10	Industry/working environment	Onungwa *et al*. (2017)
11	Initial BIM huge capital outlays	Onungwa *et al*. (2017) Hamma-Adama (2020)
12	Corruption amongst the construction stakeholders	Hamma-Adama (2020)
13	Lack of policy and standardisation	Hamma-Adama (2020)
14	Lack of case study as a precedent (to demonstrate BIM benefits)	Hamma-Adama (2020)
15	Non recognition of BIM role by the government and the clients	Hamma-Adama (2020)
16	Resistance by the industry professionals	Hamma-Adama (2020)

Source: Researcher's Literature Compilation (2021)

2.8.5 Summary of Strategies for Enhancing the Level of Readiness of Construction Stakeholders in the Adoption of BIM for the Execution of Construction Projects in Nigeria

The review of literature in this study identified several strategies for enhancing the level of readiness of construction stakeholders in the adoption of BIM for the execution of construction projects in Nigeria. The highlights of these strategies are given in Table 2.5.

Table 2. 5: Strategies for Enhancing the Level of Readiness of Construction Stakeholders in the Adoption of BIM for the Execution of Construction Projects in Nigeria

S/No.	Strategies for Enhancing the Level of Readiness of BIM Adoption	Source(s)
1	Collaboration	Poole (2014); Ezeokoli *et al*. (2016); Hamma-Adama (2020)
2	Education & Training	Alufohai (2012); Poole (2014); Isa (2015); Hamma-Adama (2020)
3	Promotion (incentivize early BIM adopters)	BuildSmart (2013); Poole (2014); Hamma-Adama (2020)
4	Public sector takes the lead	Poole (2014); Hamma-Adama (2020)
5	Enactment of BIM guideline and regulation	Poole (2014); Isa (2015); Ezeokoli *et al*. (2016)
6	Remove impediments	Poole (2014)
7	Building BIM capability and capacity	Poole (2014)
8	Incorporation of BIM to academic curriculum	Isa (2015); Ezeokoli *et al*. (2016)
9	Provision of appropriate technology and infrastructure	Ezeokoli *et al*. (2016)
10	BIM should be made compulsory for all procurement processes and contracts	Ezeokoli *et al*. (2016)
11	Setting up BIM council	Ezeokoli *et al*. (2016)
12	Software vendors and relevant training institutes should embark on intensive awareness of BIM	Alufohai (2012); Isa (2015)
13	Improved data exchange standards	Isa (2015)
14	Mandate BIM on public projects	Hamma-Adama (2020)
15	Consider other countries' guide as a starting point	Hamma-Adama (2020)
16	Splits the software cost over projects as well as sharing the cost with a client	Hamma-Adama (2020)
17	Customize the local building components for objects libraries	Hamma-Adama (2020)

Source: Researcher's Literature Compilation (2021)

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Research Design

Uji (2009), research design is the program that guides the researcher in the process of collecting, analyzing and interpreting. This study was carried out using the quantitative research approach. This research was broadly divided into two parts; the first part of this work included literature survey undertaken to provide the background information required for this research while the second part comprised of the use of questionnaire to obtain data from construction professionals.

3.2 Target Population

Research population is referred to as a collection of all cases that conform to some carefully chosen set of criteria. The population elements are the unit members of a population: for example, people, social situations, social actions, places, events, time or things. The target population in the study composed of Architects, Builders, Civil Engineers and Quantity Surveyors working in FCDA, Abuja. This is because these professionals are the primary participants who have substantial involvement and responsibilities in the execution of construction projects. There are a total of 286 professionals in FCDA and 194 of them are registered under their respective professional bodies. The population size is therefore 194.

3.3 Sample Frame

The sample frame for this study was made up of the list containing the number and information about the professionals to be considered for this study. It is from this frame that samples of the

respondents were drawn. This sample is made up of the professionals involved in the construction of building and engineering construction works in FCDA, Abuja.

3.4 Sample Size

The sample size for the study was 127 based on Krejcie and Morgan (1970) Table. The representative sample size for a population size of 190 on Krejcie and Morgan (1970) Table is 127. Since the population size of 190 is the nearest number to 194 on Krejcie and Morgan (1970) Table, then the sample size for this population size (127) was adopted for this study.

3.5 Sampling Technique

Sampling is the process of selecting sample groups, it is the process of selecting a group of people or products to be used as a representative or random sample. The goal of sampling is to provide a realistic means of enabling the data collection and processing component of research to be carried out. The sampling technique adopted for the study was the simple random sampling technique. This method of sampling was used because it gives every individual in the population equal opportunity of being selected.

3.6 Method of Data Collection

Data was obtained with the use of structured questionnaire of the close ended response format. The questionnaire was designed on a five-point Likert Scale format. The questionnaire was made up of six sections. The first section addressed issues concerning the general profile of respondents. The other sections addressed issues concerning the research objectives respectively. See Appendix A for a sample of the questionnaire. The questionnaires were administered to 127 construction professionals in Federal Capital Development Authority (FCDA) in Abuja. All the questionnaires administered were returned and used for data analysis.

In order to validate the research instrument used, a reliability test was carried out on the data collected. The result of the reliability test shows that all the items loaded have fairly good inter-item correlation coefficient (r = 0.316 - 0.890). A high Cronbach's Alpha of 0.884 was obtained indicating that the research data are reliable and hence the research instrument is valid. See Appendix B for the raw result of reliability test.

3.7 Method of Data Analysis

The Data collected for this study were analyzed with the use of descriptive statistical techniques. The use of frequency counts and percentage was employed to analyze the profile of respondents. Mean Item Score (MIS) was employed in order to analyze the data collected on the research objectives. The use of Microsoft Excel was employed to aid the analysis of data in this study.

MIS also referred to as weighted aggregate score is defined as the summation of the product of response rating and corresponding number of responses and dividing the figure by the total number of responses in the group. The MIS also known as arithmetic mean or mean score is the measure of central tendency for determining the position of a particular variable among other ones. The mean score for each criterion for analysis of this study based on the Likert scale of 1 to 5 was determined as follows:

$$= \frac{5\ 5+4\ 4+3\ 3+2\ 2+\ 1}{(\ 5+\ 4+\ 3+\ 2+\ 1)} \text{ ---------- (3.1)}$$

Where: n_1 = number of respondents who answered very low n_2 = number of respondents who answer low

n_3= number of respondents who answer average

n_4= number of respondents who answer high

n_5= number of respondents who answer very high

The decision rule to be adopted for the MIS obtained is shown in Table 3.1.

Table 3. 1: Decision Rule for MIS

Scale	Cut-off points	Measures		
	MIS	Importance	Awareness	Effectiveness
5	4.50 -5.00	Very important	Very High	Very Effective
4	3.50 -4.49	Important	High	Effective
3	2.50 -3.49	Fairly Important	Average	Fairly Effective
2	1.50 -2.49	Less Important	Low	Less Effective
1	1.00 -1.49	Least important	Very Low	Least Effective

Source: Adapted and modified from Morenikeji (2006); Agumba and Haupt (2014); Shittu *et al.*, (2016)

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

4.1 Presentation of Respondents' Profile

This section presents the profile of the respondents considered for data collection. The respondents' profile is presented in Table 4.1. Out of the 127 respondents considered for the study, 35 were Architects, 12 were Builders, 18 were Civil/Structural Engineers, 19 were Quantity Surveyors, 37 were Builders/Services Engineers, and 6 were from other related construction professions. This shows that 37% of the respondents, representing the majority, are Builders/Services Engineers. It was also shown from Table 4.1 that 66% of the respondents, representing the majority, are holders of Bachelor's Degree (BTech/BSc). This is followed by Master's Degree holders which represent 25% of the respondents. Holders of Higher National Diploma (HND), representing the minority of the respondents, constitute 9% of the population of respondents. This shows that the respondents have the requisite educational qualification to give reliable response required for the study.

Table 4.1 also indicates that 46% of the respondents have between 1 and 10 years of experience; 53% of the respondents, representing the majority, have between 11 and 20 years of experience; and 1% of the respondents, representing the minority, have between 21 and 30 years of experience. This shows that the respondents are experienced enough to give reliable information needed for the study. It was also revealed that 30 of the respondents have been involved in projects where BIM was used for up to five (5) years, indicating that some of the respondents have actually experienced the usage of BIM to some extent. It was revealed from Table 4.1 that 83 of the respondents, representing 65% are registered members of the professional Associations of their respective professions. Of the 83 professionally registered respondents,

18% are members of the Nigerian Institute of Architects; 60% are members of the Nigerian Society of Engineers; 14% are members of the Nigerian Institute of Quantity Surveyors; while 7% belong to other related professional associations. This indicates that the respondents have the required professional experience to give useful information needed for the study.

Table 4.1: Respondents' Profile

RESPONDENTS' PROFILE	NO	PROPORTION
Respondents' Profession		
Architect	35	28
Builder	12	9
Civil/Structural Engineer	18	14
Quantity Surveyor	19	15
Building/Services Engineer	37	29
Others	6	5
Total	**127**	**100**
Respondents' Highest Educational Qualification		
HND	12	9
BSc/BTech	84	66
MSc/MTech	31	24
PhD	0	0
Others	0	0
Total	**127**	**100**
Respondents' Years of Experience		
1-10 Years	58	46
11-20 Years	67	53
21-30 Years	2	1
Above 30 Years	0	0
Total	**127**	**100**
Respondents' Involvement in projects where BIM was used		
1-5 Years	30	100
6-10 Years	0	0
Never been involved	0	0
Total	**30**	**100**
Respondents' Membership Professional Body		
NIA	15	18
NIOB	0	0
NSE	50	60
NIQS	12	14
Others	6	7
Total	**83**	**100**

Source: Author's Field Survey (2021)

4.2 Pre-requisites for Readiness of BIM Adoption

The MIS obtained on the pre-requisites for the readiness of BIM adoption by construction firms in Nigeria are summarized in Table 4.2. Table 4.2 shows that the very important pre-requisites for the readiness of BIM adoption by construction firms in Nigeria are: Model-centric workflows (MIS = 4.55); Collaboration and data management (MIS = 4.55); and Integrated analysis (MIS = 4.53). Other pre-requisites for the readiness of BIM adoption by construction firms in Nigeria are also important. These range from Governance (MIS = 4.48) to Action Taken (4.23). Averagely, all the pre-requisites for the readiness of BIM adoption by construction firms in Nigeria are important (overall MIS = 4.42).

In support of this finding, Bernstein and Pittman (2004) referred to these pre-requisites as BIM implementation precedence. In addition, the study of Arayici *et al*. (2012) and Doumbouya *et al*. (2016) corroborate the finding of this study by stating that the readiness for the adoption of BIM by any firm in the construction industry is basically determined by some basic pre-requisites which are: Diagnosis Stage, Action Planning Stage, Action Taking Stage; and Evaluation Stage (Arayici *et al*., 2012) and Governance; Model-centric workflows; Collaboration & data management; and Integrated analysis (Doumbouya *et al*., 2016).

Table 4.2: Pre-requisites for Readiness of BIM Adoption

Code No	Pre-requisites for Readiness of BIM Adoption	MIS	Rank	Decision
C6	Model-centric workflows: Identifying deliverable standards that specify the asset models and its downstream use in other lifecycle phases	4.55	1st	Very Important
C7	Collaboration & data management: Accompanying data management framework solution to control the sharing of relevant and accurate information to all project stakeholders	4.55	1st	Very Important
C8	Integrated analysis: Analyses of integrated asset models with the application of 2D, 3D, 4D (cost) and even to greater complexity	4.53	3rd	Very Important
C5	Governance: Organization and management of the BIM deployment upkeep, compliance and performance	4.48	4th	Important
C4	Evaluation: Project review, dissemination and integration into strategy plan	4.42	5th	Important
C2	Action Planning: Design of new business processes and technology adoption path	4.31	6th	Important
C1	Diagnosis: Review and analysis of current practice	4.28	7th	Important
C3	Action Taking: Consideration of possible implementation	4.23	8th	Important
	Average MIS	***4.42***		***Important***

Source: Author's Field Survey (2021)

4.3 Current Level of Awareness of Stakeholders on the Adoption of BIM in the Execution of Construction Projects

The results of MIS employed to rate the current level of Awareness of Stakeholders on the Adoption of BIM in the Execution of Construction Projects, based on the different stages of construction projects, are summarized in Table 4.3. Table 4.3 indicates that the Construction phase/stage and Design phase/stage are the stages of construction projects where the level of stakeholders is most high (MIS = 3.76 and 3.73 respectively). This is followed by the

Preconstruction (tendering and award)/ phase/Procurement Stage which also has a high level of awareness by the stakeholders (MIS = 3.50). The least ranked stage is the Predesign (planning) phase/ Preliminary Stage which has the least level of awareness by the stakeholders (MIS = 3.39). On the average, the stakeholders' level of awareness on the adoption of BIM in the execution of construction projects in Nigeria appears to be high (Average MIS = 3.60).

The current level of BIM awareness as revealed in this study disagrees with the study of Anih and Ajiero (2018) where it was found that in Nigeria, the application of BIM in property management, especially in the areas of building maintenance, letting, occupation, inspection and repairs of the properties, is rarely embraced among property managers. In addition, the studies of Marcus *et al.* (2015) Akerele and Etiene (2016) and Olanrewaju *et al*. (2020) also revealed low awareness on the usage of BIM in Nigeria in contrast with the finding of this study.

Table 4.3: Current Level of Awareness of Stakeholders on the Adoption of BIM for Construction Projects

Code No	Current Level of Awareness of Stakeholders on BIM Adoption	MIS	Rank	Decision
D4	Construction phase/stage	3.76	1st	High
D2	Design phase/stage	3.73	2nd	High
D3	Preconstruction (tendering and award)/ phase/Procurement Stage	3.50	3rd	High
D1	Predesign (planning) phase/ Preliminary Stage	3.39	4th	Average
	Average MIS	***3.60***		***High***

Source: Author's Field Survey (2021)

4.4 Barriers to the Readiness of BIM Adoption in the Nigerian Construction Industry

The result of the analysis on the barriers to the readiness of BIM adoption in the Nigerian construction industry is presented in Table 4.4. The result reveals the MIS for the sixteen (16) identified barriers to the readiness of BIM adoption in the Nigerian construction industry. It was shown that the most important barriers to the readiness of BIM adoption in the Nigerian construction industry are: Lack of adequate BIM training and inadequate exposure to BIM concept; Low level of BIM technical know-how; Inaccessibility to suitable technology and framework; Industry/working environment; Initial BIM huge capital outlays; and Lack of policy and standardization with MIS values of 4.19, 4.10, 4.09, 4.05, 4.03 and 4.03 respectively. On the average, all the identified barriers to the readiness of BIM adoption in the Nigerian construction industry are important (average MIS = 3.87).

Findings from the study of Kassem *et al*. (2015) is in support of the finding of this study by establishing the existence of two factors serving as barriers to the readiness for BIM adoption in the construction industry. These are that the various stakeholders of the project do not intend to collaborate during modelling or in optimum utilization of the BIM model, and lack of awareness by clients which is aggravated by the shortage of BIM skills and absence of understanding by finance management professionals. Also in line with this finding, Onungwa *et al*. (2017) discovered that there is low level of awareness and technical know-how of BIM in Nigeria.

Table 4.4: Barriers to the Readiness of BIM Adoption in the Nigerian Construction Industry

Code No	Barriers to the Readiness of BIM Adoption	MIS	Rank	Decision
E5	Lack of adequate BIM training and inadequate exposure to BIM concept	4.19	1st	Important
E7	Low level of BIM technical know-how	4.10	2nd	Important
E6	Inaccessibility to suitable technology and framework	4.09	3rd	Important
E10	Industry/working environment	4.05	4th	Important
E11	Initial BIM huge capital outlays	4.03	5th	Important
E13	Lack of policy and standardization	4.03	5th	Important
E3	Clients' shortage of BIM skills	3.98	7th	Important
E9	Absence of appropriate BIM guidelines	3.87	8th	Important
E4	Absence of understanding by finance management professionals	3.84	9th	Important
E12	Corruption amongst the construction stakeholders	3.78	10th	Important
E15	Non recognition of BIM role by the government and the clients	3.78	10th	Important
E8	Individual perception/ point of view	3.77	12th	Important
E16	Resistance by the industry professionals	3.72	13th	Important
E2	Lack of awareness	3.71	14th	Important
E1	Stakeholders do not intend to collaborate in the optimum utilization of BIM model	3.52	15th	Important
E14	Lack of case study as a precedent (to demonstrate BIM benefits)	3.49	16th	Fairly Important
	Average MIS	***3.87***		***Important***

Source: Author's Field Survey (2021)

4.5 Strategies for Enhancing the Level of Readiness of Construction Stakeholders in the Adoption of BIM

The result of the MIS obtained on the identified strategies for enhancing the level of readiness of construction stakeholders in the adoption of BIM for the execution of construction projects in Nigeria is summarized in Table 4.5. It shows that seventeen (17) strategies for enhancing the level of readiness of construction stakeholders in the adoption of BIM for the execution of construction projects in Nigeria, Incorporation of BIM to academic curriculum (MIS = 4.59) and Provision of appropriate technology and infrastructure (MIS = 4.52) are the most effective strategies. On the average, all the identified strategies for enhancing the level of readiness of construction stakeholders in the adoption of BIM for the execution of construction projects in Nigeria are effective (average MIS = 4.27).

In line with this finding, Poole (2014) identified collaboration, training and promotion as effective strategies for enhancing the readiness for BIM adoption in Hong Kong. Also, in support of the finding of this study and in the Nigerian context, Ezeokoli *et al*. (2016) identified education and training program, and the incorporation of BIM to academic curriculum as the most effective strategies for improving BIM usage.

Table 4.5: Strategies for Enhancing the Level of Readiness of Construction Stakeholders in the Adoption of BIM for the Execution of Construction Projects

Code No	Strategies for Enhancing the Level of Readiness of Construction Stakeholders in the Adoption of BIM	MIS	Rank	Decision
F8	Incorporation of BIM to academic curriculum	4.59	1st	Very Effective
F9	Provision of appropriate technology and infrastructure	4.52	2nd	Very Effective
F10	BIM should be made compulsory for all procurement processes and contracts	4.45	3rd	Effective
F11	Setting up BIM council	4.44	4th	Effective
F12	Software vendors and relevant training institutes should embark on intensive awareness of BIM	4.39	5th	Effective
F14	Mandate BIM on public projects	4.39	5th	Effective
F2	Education & Training	4.33	7th	Effective
F13	Improved data exchange standards	4.33	7th	Effective
F17	Customize the local building components for objects libraries	4.25	9th	Effective
F15	Consider other countries' guide as a starting point	4.22	10th	Effective
F7	Building BIM capability and capacity	4.20	11th	Effective
F5	Enactment of BIM guideline and regulation	4.17	12th	Effective
F1	Collaboration	4.15	13th	Effective
F3	Promotion (incentivize early BIM adopters)	4.13	14th	Effective
F16	Splits the software cost over projects as well as sharing the cost with a client	4.06	15th	Effective
F6	Remove impediments	3.95	16th	Effective
F4	Public sector takes the lead	3.94	17th	Effective
	Average MIS	***4.27***		***Effective***

Source: Author's Field Survey (2021)

4.6 Summary of Findings

The findings of the analyses carried out in this study revealed the following:

i. The Design phase/stage and Construction phase/stage are the most important stages requiring the adoption of BIM with the MIS of 4.74 and 4.61 respectively. On the average, all the stages of construction projects requiring BIM adoption are important (MIS = 4.42).

ii. The most important pre-requisites for the readiness of BIM adoption by construction firms in Nigeria are: Model-centric workflows (MIS = 4.55); Collaboration & data management (MIS = 4.55); and Integrated analysis (MIS = 4.53). Averagely, all the pre-requisites for the readiness of BIM adoption by construction firms in Nigeria are important (average MIS = 4.42).

iii. The Construction phase/stage and Design phase/stage are the stages of construction projects where the level of awareness on the adoption of BIM in the execution of construction projects in Nigeria is most high (MIS = 3.76 and 3.73 respectively). On the average, level of awareness on the adoption of BIM in the execution of construction projects in Nigeria appears to be high (Average MIS = 3.60).

iv. The most important barriers to the readiness of BIM adoption in the Nigerian construction industry are: Lack of adequate BIM training and inadequate exposure to BIM concept; Low level of BIM technical know-how; Inaccessibility to suitable technology and framework; Industry/working environment; Initial BIM huge capital outlays; and Lack of policy and standardization (MIS = 4.19, 4.10, 4.09, 4.05, 4.03 and 4.03 – 4.19). On the average, all the identified barriers to the readiness of BIM adoption in the Nigerian construction industry are important (average MIS = 3.87).

v. Incorporation of BIM to academic curriculum (MIS = 4.59) and Provision of appropriate technology and infrastructure (MIS = 4.52) are the most effective strategies for enhancing the level of readiness of construction stakeholders in the adoption of BIM for the execution of construction projects in Nigeria. On the average, all the identified strategies for enhancing the level of readiness of construction stakeholders in the adoption of BIM for the execution of construction projects in Nigeria are effective (average MIS = 4.27).

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The study was carried out to address the problem of low level of adoption of BIM in the Nigerian construction industry. The study therefore assessed the level of readiness for the adoption of BIM in the execution of construction projects in Abuja, Nigeria with a view to enhancing the readiness level in the adoption of BIM. Data were collected with use of questionnaire survey from experienced construction professionals in FCDA, Abuja. Analysis of data was undertaken with the use of frequency counts, percentage and Meant Item Score (MIS).

In view of the findings from the data analyzed, it was shown that the Design phase/stage and Construction phase/stage are the most important stages requiring the adoption of BIM in the Nigerian construction industry. The most important pre-requisites for the readiness of BIM adoption by construction firms in Nigeria are: Model-centric workflows; Collaboration & data management; and Integrated analysis. The Construction phase/stage and Design phase/stage are the stages of construction projects where the level of awareness on the adoption of BIM in the execution of construction projects in Nigeria is most high. The most important barriers to the readiness of BIM adoption in the Nigerian construction industry are: Lack of adequate BIM training and inadequate exposure to BIM concept; Low level of BIM technical know-how; Inaccessibility to suitable technology and framework; Industry/working environment; Initial BIM huge capital outlays; and Lack of policy and standardization. The most effective strategies for enhancing the level of readiness of construction stakeholders in the adoption of BIM for the execution of construction projects in Nigeria are Incorporation of BIM to academic curriculum and Provision of appropriate technology and infrastructure. It can therefore be concluded that

the level of readiness for the adoption of BIM in the Nigerian construction industry is on the average but it is confronted with barriers of lack of adequate BIM training and inadequate exposure to BIM concept among other factors which need to be addressed.

5.2 Recommendations

Based on the findings and conclusion of the study, the following recommendations were made:

i. Mechanism should be put in place to encourage and prepare for the adoption of BIM right from the Preconstruction (tendering and award)/ phase/Procurement Stage in order to allow the adoption of BIM throughout the project life cycle covering the Predesign (planning) phase/ Preliminary Stage; Design phase/stage; Preconstruction (tendering and award)/phase/Procurement Stage and Construction phase/stage.

ii. The readiness of BIM adoption should be enhanced by construction firms in Nigeria by focusing more on Model-centric workflows; Collaboration & data management; and integrated analysis as pre-requisite for setting up mechanism for BIM adoption.

iii. Project stakeholders should create more awareness through training and sensitization program on BIM adoption during the Predesign (planning) phase/ Preliminary Stage so as to enhance effective implementation of BIM throughout the project life cycle. This will also assist in addressing the barriers to the readiness for BIM adoption.

iv. In order to set up a mechanism for effective readiness for the adoption of BIM for sustained implementation of BIM in the Nigerian construction industry, the Government and all construction stakeholders should incorporate BIM to the academic curriculum and also provide appropriate technology and infrastructure ready for BIM adoption right from the procurement processes and contracts in Nigeria.

5.3 Contribution to Knowledge

The outcome of this study makes the following significant contributions to the body of knowledge:

i. The study has been able to identify the current level of awareness of BIM at various stages of construction project phases so as to allow Government and construction stakeholders to know how early to start preparation for the adoption and implementation of BIM during the project life cycle.

ii. The outcome of the study has also made known the fact that in spite of the averagely high level of awareness of BIM in the construction industry, there are several barriers confronting the adoption and implementation of BIM due to lack of technical know-how, training and frame work, all these sum up to lack of readiness for BIM adoption.

iii. Finally, the study has revealed the various strategies that would enhance stakeholder's adoption of BIM for construction project.

5.4 Areas for Further Studies

The following areas have been suggested for further research in view of the gap identified from this study and previous studies:

i. Consequences of the Lack of Adoption of BIM in the Nigerian Construction Industry.

ii. Assessment of the Benefits of BIM adoption in the Nigerian construction industry.

iii. Assessment of government contribution in the enhancement of BIM adoption in the Nigerian construction industry.

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APPENDIX A

RESEARCH QUESTIONNAIRE

Department of Quantity Surveying,
School of Environmental Technology,
Federal University of Technology Minna.
Niger State.
Date:_____

Dear Sir/Madam,

RESEACH QUESTIONNAIRE: Readiness of Nigerian Construction Industry on Adoption of Building Information Modelling (BIM)

I am ADELUSI, Caleb Babalola, a Postgraduate student of Quantity Surveying Department, at the Federal University of Technology, Minna. I am undertaking my final year research thesis in partial fulfillment of the requirement for the award of Master of Technology (MTech) Degree.

While appreciating your busy schedule, I humbly request that you spare time to help respond to the attached questionnaire which is pivotal to the success of my on-going research.

Your feedback will be treated with strict confidentiality and used only for the purpose of this research work.

Thank you for your anticipated cooperation

Yours sincerely,

ADELUSI, Caleb Babalola
07062684354
Email: babalolacaleb1@gmail.com
(Researcher)

APPENDIX A

QUESTIONNAIRE SURVEY

READINESS OF NIGERIAN CONSTRUCTION INDUSTRY ON ADOPTION OF BUILDING INFORMATION MODELLING (BIM)

SECTION A: Respondent's Profile

Please kindly respond to the following questions by ticking (√) the appropriate box(s) for each item.

1. **What is your profession?**

a. Architect [ ] b. Builder [ ] c. Civil/Structural Engineer [ ] d. Quantity Surveyor [ ] e. Building Services Engineer [ ]

f. Others: Please Specify_____

2. **What is your highest academic qualification?**

a. HND [ ] b. B.Tech/B.Sc. [ ] c. M.sc/MTech [ ] d. PhD [ ] e. Others [ ]

3. **What is your years of experience?**

a. 1 – 10 [ ] b. 11 – 20 [ ] c. 21 – 30 [ ] d. Above 30 years [ ]

4. **How long have you been involved in construction projects where BIM technology was used?** a. 1 – 5 [ ] b. 6 – 10 [ ] c. Never been involved [ ]

5. **What is your professional qualification?**

a. MNIA [ ] b. MNIOB [ ] c. MNSE [ ] d. MNIQS [ ]

e. Others: Please Specify_____

APPENDIX A

QUESTIONNAIRE

SECTION B: Stages of Construction Projects Where the Adoption of BIM is mostly required

The Table below contains a list of the stages of construction project where the adoption of BIM is mostly required. Please rank these stages in order of importance based on your experience on a five-point Likert's scale by ticking in the blank spaces provided in the Table.

Code No.	Stages of Construction Projects Requiring BIM Adoption	Very Important 5	Important 4	Fairly Important 3	Less Important 2	Least Important 1
B1	Predesign (planning) phase/ Preliminary Stage					
B2	Design phase/stage					
B3	Preconstruction (tendering and award)/ phase/Procurement Stage					
B4	Construction phase/stage					

SECTION C: Pre-Requisites for the Readiness of the Adoption of BIM in the Execution of Construction Works at Different Stages of a Project

Please rank the following pre-requisites for the adoption of BIM in the execution of construction works at different stages of a project in order of importance based on your experience on a five-point Likert's scale by ticking in the blank spaces provided in the Table below.

Code No.	Pre-requisites for Readiness of BIM Adoption	Very Important 5	Important 4	Fairly Important 3	Less Important 2	Least Important 1
C1	**Diagnosis:** Review and analysis of current practice					
C2	**Action Planning:** Design of new business processes and technology adoption path					
C3	**Action Taking:** Consideration of possible implementation					
C4	**Evaluation:** Project review, dissemination and integration into strategy plan					
C5	**Governance:** Organisation and management of the BIM					

	deployment upkeep, compliance and performance					
C6	**Model-centric workflows:** Identifying deliverable standards that specify the asset models and its downstream use in other lifecycle phases					
C7	**Collaboration & data management:** Accompanying data management framework solution to control the sharing of relevant and accurate information to all project stakeholders					
C8	**Integrated analysis:** Analyses of integrated asset models with the application of 2D, 3D, 4D (cost) and even to greater complexity					

SECTION D: Current Level of Awareness of Stakeholders on the Adoption of BIM in the Execution of Construction Projects

Please rank the level of awareness of level of awareness of stakeholders on the adoption of BIM in the execution of construction projects at different stages of a project based on your experience on a five-point Likert's scale by ticking in the blank spaces provided in the Table below.

Code No.	Stages of Construction Projects Requiring BIM Adoption	Very High 5	High 4	Average 3	Low 2	Very Low 1
D1	Predesign (planning) phase/ Preliminary Stage					
D2	Design phase/stage					
D3	Preconstruction (tendering and award)/ phase/Procurement Stage					
D4	Construction phase/stage					

APPENDIX A

SECTION E: Barriers to the Readiness of BIM Adoption in the Nigerian Construction Industry

Please rank the following barriers to the readiness of BIM adoption in the Nigerian construction industry in order of importance based on your experience on a five-point Likert's scale by ticking in the blank spaces provided in the Table below.

Code No.	Barriers to the Readiness of BIM Adoption	Very Important 5	Important 4	Fairly Important 3	Less Important 2	Least Important 1
E1	Stakeholders do not intend to collaborate in the optimum utilization of BIM model					
E2	Lack of awareness					
E3	Clients' shortage of BIM skills					
E4	Absence of understanding by finance management professionals					
E5	Lack of adequate BIM training and inadequate exposure to BIM concept					
E6	Inaccessibility to suitable technology and framework					
E7	Low level of BIM technical know-how					
E8	Individual perception/ point of view					
E9	Absence of appropriate BIM guidelines					
E10	Industry/working environment					
E11	Initial BIM huge capital outlays					
E12	Corruption amongst the construction stakeholders					
E13	Lack of policy and standardisation					
E14	Lack of case study as a precedent (to demonstrate BIM benefits)					
E15	Non recognition of BIM role by the government and the clients					
E16	Resistance by the industry professionals					

SECTION F: Strategies for Enhancing the Level of Readiness of Construction Stakeholders in the Adoption of BIM for the Execution of Construction Projects

Assess the following strategies for enhancing the level of readiness of construction stakeholders in the adoption of BIM for the execution of construction projects in order of effectiveness based

on your experience on a five-point Likert's scale by ticking in the blank spaces provided in the Table below.

Code No.	Strategies for Enhancing the Level of Readiness of BIM Adoption	Very Effective 5	Effective 4	Fairly Effective 3	Less Effective 2	Least Effective 1
F1	Collaboration					
F2	Education & Training					
F3	Promotion (incentivize early BIM adopters)					
F4	Public sector takes the lead					
F5	Enactment of BIM guideline and regulation					
F6	Remove impediments					
F7	Building BIM capability and capacity					
F8	Incorporation of BIM to academic curriculum					
F9	Provision of appropriate technology and infrastructure					
F10	BIM should be made compulsory for all procurement processes and contracts					
F11	Setting up BIM council					
F12	Software vendors and relevant training institutes should embark on intensive awareness of BIM					
F13	Improved data exchange standards					
F14	Mandate BIM on public projects					
F15	Consider other countries' guide as a starting point					
F16	Splits the software cost over projects as well as sharing the cost with a client					
F17	Customise the local building components for objects libraries					

Thank you very much for your co-operation.

ADELUSI, Caleb Babalola
MTech/SET/2018/7975
Tel: (+234) 7062684354
Email: babalolacaleb1@gmail.com

APPENDIX B

RELIABILITY TEST ON DATA AND RESEARCH INSTRUMENT

RELIABILITY /VARIABLES=B1 B2 B3 B4 C1 C2 C3 C4 C5 C6 C7 C8 D1 D2 D3 D4 E1 E2 E3 E4 E5 E6 E7 E8 E9 E10 E11 E12 E13 E14 E15 E16 F1 F2 F3 F4 F5 F 6 F7 F8 F9 F10 F11 F12 F13 F14 F15 F16 F17 /SCALE('ALL VARIABLES') ALL /MODEL=ALPHA /SUMMARY=MEANS CORR.

Reliability

Notes

Output Created		12-Jun-2021 04:01:20
Comments		
Input	Active Dataset	DataSet0
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	127
	Matrix Input	
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data for all variables in the procedure.
Syntax		RELIABILITY /VARIABLES=B1 B2 B3 B4 C1 C2 C3 C4 C5 C6 C7 C8 D1 D2 D3 D4 E1 E2 E3 E4 E5 E6 E7 E8 E9 E10 E11 E12 E13 E14 E15 E16 F1 F2 F3 F4 F5 F6 F7 F8 F9 F10 F11 F12 F13 F14 F15 F16 F17 /SCALE('ALL VARIABLES') ALL /MODEL=ALPHA /SUMMARY=MEANS CORR.
Resources	Processor Time	0:00:00.000
	Elapsed Time	0:00:00.000

APPENDIX B

[DataSet0]

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	124	97.6
	Excluded[a]	3	2.4
	Total	127	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.884	.895	49

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	4.115	3.411	4.734	1.323	1.388	.112	49
Inter-Item Correlations	.148	-.316	.890	1.206	-2.820	.045	49

KEY:

B1	Predesign (planning) phase/ Preliminary Stage
B2	Design phase/stage
B3	Preconstruction (tendering and award)/ phase/Procurement Stage
B4	Construction phase/stage
C1	Diagnosis: Review and analysis of current practice
C2	Action Planning: Design of new business processes and technology adoption path

C3	Action Taken: Consideration of possible implementation
C4	Evaluation: Project review, dissemination and integration into strategy plan
C5	Governance: Organization and management of the BIM deployment upkeep, compliance and performance
C6	Model-centric workflows: Identifying deliverable standards that specify the asset models and its downstream use in other lifecycle phases
C7	Collaboration & data management: Accompanying data management framework solution to control the sharing of relevant and accurate information to all project stakeholders
C8	Integrated analysis: Analyses of integrated asset models with the application of 2D, 3D, 4D (cost) and even to greater complexity
D1	Predesign (planning) phase/ Preliminary Stage
D2	Design phase/stage
D3	Preconstruction (tendering and award)/ phase/Procurement Stage
D4	Construction phase/stage
E1	Stakeholders do not intend to collaborate in the optimum utilization of BIM model
E2	Lack of awareness
E3	Clients' shortage of BIM skills
E4	Absence of understanding by finance management professionals
E5	Lack of adequate BIM training and inadequate exposure to BIM concept
E6	Inaccessibility to suitable technology and framework
E7	Low level of BIM technical know-how
E8	Individual perception/ point of view
E9	Absence of appropriate BIM guidelines
E10	Industry/working environment
E11	Initial BIM huge capital outlays
E12	Corruption amongst the construction stakeholders
E13	Lack of policy and standardisation
E14	Lack of case study as a precedent (to demonstrate BIM benefits)
E15	Non recognition of BIM role by the government and the clients
E16	Resistance by the industry professionals
F1	Collaboration
F2	Education & Training
F3	Promotion (incentivize early BIM adopters)
F4	Public sector takes the lead
F5	Enactment of BIM guideline and regulation
F6	Remove impediments
F7	Building BIM capability and capacity
F8	Incorporation of BIM to academic curriculum
F9	Provision of appropriate technology and infrastructure
F10	BIM should be made compulsory for all procurement processes and contracts

F11	Setting up BIM council
F12	Software vendors and relevant training institutes should embark on intensive awareness of BIM
F13	Improved data exchange standards
F14	Mandate BIM on public projects
F15	Consider other countries' guide as a starting point
F16	Splits the software cost over projects as well as sharing the cost with a client
F17	Customize the local building components for objects libraries