ASSESSMENT OF THE ADOPTION OF BUILDING INFORMATION MODELLING (BIM) IN THE CONSTRUCTION INDUSTRIES IN LAGOS STATE, NIGERIA

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ANYIM, Chigozie Eric
2016/1/64075TI

DEPARTMENT OF INDUSTRIAL AND TECHNOLOGY EDUCATION
FEDERAL UNIVERSITY OF TECHNOOGY, MINNA

MARCH, 2023

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A RESEARCH PROJECT SUBMITTED TO THE DEPARTMENT OF INDUSTRIAL AND TECHNOLOGY EDUCATION, FEDERAL UNIVERSITY OF TECHNOOGY, MINNA IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF TECHNOLOGY DEGREE (B. TECH) IN INDUSTRIAL AND TECHNOLOGY EDUCATION

MARCH, 2023

DECLARATION

I, Anyim Chigozie Eric with Matric N o: 2016/1/64075TI, an undergraduate student of the Department of Industrial and Technology Education, Federal university of technology, Minna certify that the work embodied in this project is original and has not been submitted inpart or full for any other diploma or degree of this or any other university

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Signature & Date

CERTIFICATION

This project titled "Assessment of the Adoption of Building Information Modelling (BIM) in the Construction Industry in Lagos State, Nigeria; its Obstacles and Prospects" has been read and approved as meeting the requirements for the award of B. Tech degree in Industrial and Technology Education, School of Science and Technology Education, Federal University of Technology, Minna.

Dr. Ibrahim Dauda ______________________

(Project Supervisor) Signature & Date

Dr. T.M. Saba ______________________

(Head of Department) Signature & Date

External Examiner Signature & Date

DEDICATION

This project work is dedicated to my beloved parents Mr. and Mrs. Anyim Emmanuel Ndukaku. May God almighty continue to bless them all the days of their lives.

ACKNOWLEGEMENTS

I wish to acknowledge my deepest gratitude to God almighty for seeing me throughout my entire academic journey and through my project work, making it a success. My profound gratitude goes to my project supervisor, Dr Ibrahim Dauda, for all his patience in guiding me to ensure that I follow all the standard practices for a good project work, also for his useful comments, suggestions and resourcefulness to the completion of this project work. I also appreciate the head of department, Dr. T. M Saba, the project coordinator, DR. A.M Hassan and to all my lecturers in the department and all the staff of the department of industrial and technology education for all their contributions to my entire academic journey I say thank you all. Special appreciation goes to my parents Mr. and Mrs. Anyim Emmanuel Ndukaku for their moral, spiritual and financial support all through my program. I am forever grateful to you both and may the lord continue to blessing you. Thank you. To my amazing sister Mrs. Emmanuella Anyim-Ofeimu and her wonderful husband Mr. Ehinomen Ofeimu, thank you for being there for me always, for your financial and moral support I am eternally grateful to you both. May God keep blessing you. To my other siblings Chidinma and Chiemeka Anyim, thank you for all you both do for me.

ABSTRACT

This study was designed to asses the Adoption of Building Information Modelling (BIM) in the Construction Industries in Lagos State, Nigeria. A descriptive survey research design was adopted for the study. Four research questions and four hypotheses were used to guide to guide the study. A structured questionnaire which was developed by the researcher and was used for data collection. The structured questionnaire was validated by three (3) experts from the department of industrial and technology education. The validated instrument was prepared for a population of fifty-nine (59) builders and fifty (50) architects in some selected construction companies around Lagos island local government area of Lagos state. The instrument was administered to the respondent with the help of three (3) research assistant. The research questions answers were analyzed using frequency counts, mean and standard deviation while the t-test was used to analyze the hypothesis at 0.05 level of significance. Findings revealed that there was only a few BIM software that were available or known by builders and architects in the construction industry in Lagos state. Findings of the study revealed that there is a low level of BIM adoption in building construction projects in Lagos state Nigeria. it also revealed that the low BIM adoption rate was as a result of various challenges hindering its adoption rate in Lagos state. Findings were also made on the ways of overcoming these challenges in order to boost the level of BIM use in the construction industry in Lagos state in the coming years.

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CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

The construction industry has undergone a paradigm shift that will maximize performance in terms of effectiveness, quality, productivity, sustainability, cost-effectiveness, and project value. This is consistent with what Azhar, 2018 says about construction industry tends to implement techniques that reduce the cost of the project, increase the productivity and quality of the project and reduce the project time. Building information modelling (BIM), a technological and operational revolution in the construction sector, is one of these techniques. Actually, improvements in procedures connected to most industries have resulted from the advancement of computer science and information technology. Building information modelling (BIM) is an advanced process and tool that combines virtual elements, systems, and ideas with the help of a single environment. It preserves an integrated digital representation of various pieces of information throughout various project stages and incorporates the application. To support constructability, scheduling, analysis, cost estimating, and sequencing, a variety of BIM software are available. Building Information Modeling, as a new paradigm, offers enormous potential for integration into the construction project life cycle. BIM can simulate project timelines and integrate them with traditional design models and in this context according to Naderpour, 2016 the time management can be effective in a project when the project schedule is based on comprehensive time scheduling. The correct geometrical depiction of a building inside an integrated information environment is one of the major benefits of BIM. Additionally, BIM decreases project length and expense, improves maintenance management, and raises the value of the building. Tomek, 2020 pointed out that BIM has impact on both external and internal risks in construction company. This is important according to what Rezakhani, 2017 says that due to unique properties of construction operations, many risk factors are involved in construction project. BIM also enhances communication among project stakeholders. On the other hand, because BIM is a new phenomenon that aspires to update construction industry methods, it faces a number of challenges in its implementation. Appropriate application of BIM by construction professionals (architects, engineers, project managers, and facility managers) allows for benefits relating to five main aspects, namely design, scheduling, documentation, budgeting, and communication (Azhar *et al.*, 2012). However, application of BIM is also subject to several obstacles, including (in order of importance) the high cost of execution, lack of awareness about the utilization of BIM, absence of government support for its application, absence of training facilities, deficient research and innovation, and absence of laws and policies mandating its use (Adebimpe & Etiene, 2016: 232).

The construction industry is a leading sector that has immensely contributed to the growth and development of any nation as a result of its ability to cause a visible change in the urban development of developing countries, globally. In an attempt to meet up with the fast transitioning of the world going digital, the need for a sustainable system that could improve construction operations was stirred up and as such lead to the development of a digital tool called building information modelling (BIM). Building information modelling was developed to provide a basis for resolving the inefficiencies of the previous computer aided drawing (CAD) by providing a working digital environment that incorporates all information about a building in an electronic file and used by various project stakeholder (Abdullah and Ibrahim, 2016). According to Royal Institution of Chartered Surveyors [RICS] (2014), the concept of BIM has no accepted definition due to its ever-evolving nature where new areas and frontiers are creeping into the boundaries of what it could be defined as .Various definition of BIM exists each of them characterized by certain key point such as in referring to BIM as a “product”, a “process”, “technology”, an “innovation” or a “strategy” (Babarinde, 2017). Building information modelling (BIM) is a advance invention in the building sector that is being used in a variety of countries throughout the world. Smith (2007) carefully defined BIM as a digital representation of the physical and functional characteristics of a facility and shared knowledge resource for information about a facility, forming a reliable basis for decisions during its life-cycle, from the earliest conception to demolition. Since the introduction of building information modelling (BIM), the construction industry is evolving towards the new trend of going digital. (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). BIM seeks to revolutionize how modern construction projects are being designed, planned, constructed, managed and delivered. According to Holness (2008), BIM is the assembly of a single database of fully integrated and interoperable information that can be used seamlessly and sequentially by all members of the design and construction team and ultimately, by owners/operators throughout a facility's life cycle.

BIM is often developed at the start of a project, and it will go through a succession of enhancements and updates as the design is continuously enhanced as it is used by the construction team as the project progresses. The input of the team of professionals which include the architect, contractors, clients, building service manufacturers, engineers and other consultants are incorporated into a particular model. (lucas 2017) stated that BIM is a process that acutely increases the ability to collaborate and exchange information throughout a project’s lifecycle from its conception through design, construction, facility management, and decommissioning. (Eastman, *et al.*, 2008) asserted that the use of BIM has provided a means of increasing total project quality, providing accurate scheduling timetable, yielding quality take off and diminishing project cost. BIM helps to reduce information loss which occurs when a design project is transferred from design team, to construction team and to building owner/operator, by allowing each group to add to and reference back to all information they acquired during their period of contribution to the BIM model, which can yield benefits to the facility owner or operator (Srivastava, 2016). Dynamic information about the building, such as sensor measurements and control signals from the building systems, can also be incorporated within BIM software to support analysis of building operation and maintenance as described by (Liu and Akinci, 2009). BIM prevents errors by enabling conflict or 'clash detection' whereby the computer model visually highlights to the team where parts of the building (e.g. structural frame and building services pipes or ducts) may wrongly intersect (Srivastava, 2016). (Ullah *et al.*, 2019) categorized the benefits of BIM into three stages which are pre-construction, construction and post-construction. At the preconstruction stage, BIM enables a more accurate and speedy estimation of cost, leads to sustainable design, improvement in energy efficiency, improved concept and feasibility, and resolve clash issues in designs through visualisation of a model (Eastman *et al.*, 2011; Latiffi *et al.*, 2016). BIM at the construction phase helps to improve resources planning and sequencing (Kjartansdottir *et al.*, 2017), allows for effective management of project resources procurement and storage (Eastman *et al.*, 2011), aids the fabrication of building components offsite (Enshassi *et al.*, 2018), allows for effective and efficient utilisation of site (Deshpande and Whitman, 2014), and improve health and safety performance of projects through reduction of congestion on-site (Khosrowshahi, 2017). The most important post-construction benefits of BIM according to (Kjartansdottir *et al.*, 2017; Husain et al., 2014; Enshassi *et al.*, 2018) are; makes scheduling of maintenance work easy, better access to information during maintenance, the management of assets is improved with faster and more accurate information, and improves decision making at the operation and maintenance of a facility.

BIM possesses great abilities in increasing construction projects quality, productivity and efficiency, based on its capability to reduce mistakes and errors, mismatches, provision of accurate and updated information, and improve building illustration and accessibility (Eastman *et al.*, 2011).

However, BIM has not been fully accepted or used effectively in Lagos State. As a result, collaboration in design and construction has not improved. BIM is used to create a collaborative construction process that covers building design, construction, operation, and maintenance. BIM adoption in Lagos State is gradual; it is largely utilised for schematic design and presentation drawings by architects. Some specialists in the construction business continue to use 2D AutoCAD to create their designs, making collaboration inside BIM-based projects ineffective. In Nigeria, there is a scarcity of study on the usage of BIM. The goal of this research is to investigate BIM adoption in Lagos State and to assess characteristics that encourage collaboration on BIM-based AEC projects during design and construction. The paper addresses the challenges militating against the adoption of BIM.

1.2 Statement of the Problem

Despite the implementation of the adoption of Building Information Modelling (BIM) in building construction, it has encountered a number of challenges, including a high rate of BIM tool implementation, the acquisition of new computer hardware, the training of new BIM operators, and the high cost of these tools. This may be a hurdle for small and medium-sized construction firms to take BIM into their ventures (Ferron & Turkan, 2019). Equally, the inability of a successful strategy to incorporate BIM in an organization may also be due to the slow adoption of BIM by construction stakeholders (Farzad Khosrowshahi, 2012). For instance, the dearth of a complete BIM policy framework and the acceptance of the BIM implementation model (Fadason *et al.*, 2018). No reasonable consensus is reached on how to incorporate BIM in construction projects (Ghaffarianhoseini *et al.,* 2017).

(Gao & Chen, 2017) carried an assessment of "Mechanical, Electrical, and Plumbing (MEP) Implementation Review of BIM on construction firms in Nigeria". According to the report, the primary problems and obstacles in BIM adoption are a lack of professional knowledge in the use of BIM technology, a high cost of training individuals engaged, system reform, and software/hardware updates. As a result, the factors influencing BIM adoption in Nigeria's building industry must be investigated. Also, Ugochukwu et al., (2015) conducted a study on the status of "Building Information Modelling (BIM) framework for better execution of building projects in Nigeria". The study's conclusions showed that professional knowledge of BIM application is very low and that no one is actively using BIM on building projects. Lack of awareness among other professionals continues to be the biggest obstacle to BIM use. Hamada et al, (2016) emphasized that understanding the challenges and barriers to BIM's adoption could improve its acceptance in construction. (Akbar Marefat, Hossein Toosi, (2018), asserted that the main barriers for BIM adoption as may be noticed in some developing countries is lack of awareness and inaccessibility of training skilled personnel. Drivers including BIM software availability and affordability, government and legal backing, technological knowledge, client interest, commitment and cooperation, procurement coordination, and proof of cost savings from its implementation are necessary to guarantee effective adoption of BIM.

Governments all over the world are taking actions to use BIM because of its capacity to minimize rework and boost project value. In the US nearly half of the building industry is using BIM, while the United Kingdom (UK) has prepared a strategy for BIM usage on projects (Farzad Khosrowshahi, 2012). According to (Jensen & Jóhannesson, 2013), the government of Singapore brought a policy on implementing a BIM roadmap via the

Building Construction Authority (BCA) with the objective that by the year 2010 at least 80% of the construction sector will adopt the use of BIM and by 2015 as government plan to advance the productivity of the construction sector by 25% over the next current 10 years. Also, BIM curriculum needs to be adopted in higher education institutions in an effort to increase the adoption of BIM in some developed nations. This will help students learn BIM skills and create programmes that will help them deal with implementation issues. Therefore, In order to reduce project construction delays, rework, and cost overruns, the study recommended tactics to be followed for BIM adoption and identified the optimum BIM integration method to be used in Lagos state, Nigeria's construction industry

1.3 Purpose of the Study

The general purpose of the study was to assess the adoption of BIM in the construction industries in Lagos state, Nigeria. Specifically, the study tends to

i. Find out the various types of BIM software available in the construction industries in Lagos state Nigeria.
ii. Find out the level of adoption of the BIM software in the building construction projects in Lagos State, Nigeria.
iii. Find out the challenges of the adoption of BIM in the construction industries in Lagos State, Nigeria.
iv. Find out ways to overcome the challenges of the adoption of BIM in the construction industries in Lagos State. Nigeria.

1.4 Significance of the Study

Since this study aims at assessing BIM adoption in the construction industries, the results and conclusions will be of immense benefits to, clients, students, AEC professionals, builders and contractors, the construction industry sector of Lagos and the nation at large Clients, owners and contractor would be able to predict costs of their project better and faster Students would be more aware and encouraged to commit into BIM oriented career path and opt in for more trainings on the usage of BIM software packages Builders and contractors would be able to oversee and supervise building constructions effectively from the preconstruction stage to the maintenance of a project Architects and Designers would be able to use BIM from the initial design concept to working documentation - Faster, more accurate and efficient documentation from model Engineers would be able to adopt the more use of BIM model for their calculations, documentation and simulations through 3D models to check for collisions, compromises and errors ion a more effective and efficient way Manufacturers of Building Products would also see the need to use BIM integration systems to work with other professionals in the construction industry by making parametric BIM objects of their products available Quantity Surveyors, Project Managers, Construction Managers and other key actors in the construction industry would be able to use BIM technology to navigate the life cycle of the construction project in an efficient and more productive way.

The Nigerian construction industry would be provided with a deeper insight as to the current level of adoption and implementation on the use of BIM which would help them come up with more efficient strategies to improving the use of BIM and overcoming its barriers thereafter increasing the percentage of its contribution to the nations GDP

1.5 Scope and Limitation of the Study

BIM is a vast subject area and its adoption entails of so many aspects, implementations and applications. The study is limited to adoption of BIM in the construction industries in Lagos state Nigeria. The study hopes to cover, BIM software and their uses, BIM benefits, BIM obstacles, solutions and prospects in the construction industries in Lagos state, Nigeria

1.6 Research Questions

The following research questions will guide the study:

i. What are the types of BIM software available in the construction industries in Lagos State, Nigeria?

ii. What is the level of adoption of BIM software in building construction projects in Lagos State, Nigeria?

iii. What are the challenges of the adoption of BIM in construction industries in Lagos State, Nigeria?

iv. What are ways to overcome the challenges of adoption of BIM in construction industries in Lagos State. Nigeria.

1.7 Research Hypotheses

The following hypothesis where formulated and tested at 0.05 level of significance

H01: There is no significant difference in the mean response between the builder and the architect on the available BIM software in the construction industries in Lagos state

H02: There is no significant difference in the mean response between the builder and the architect on level of adoption of BIM software in building construction projects in Lagos state

H03: There is no significant difference in the mean response between the builder and the architect on the challenges of the adoption of BIM in the construction industries in Lagos state

H04: There is no significant difference in the mean response between the builder and architect on the ways of overcoming the challenges of the adoption of BIM in the construction industries in Lagos state Nigeria

CHAPTER TWO

LITERATURE REVIEW

2.1 Conceptual Framework

BIM is defined as: "a set of technologies, processes and policies enabling multiple stakeholders to collaboratively design, construct and operate a facility". Autodesk (2019) defines BIM as an intelligent 3D model-based process that gives architecture, engineering, construction and operation (AECO) professionals the insight and tools to more efficiently plan, design, construct and manages buildings and infrastructure. According to The National Institute of Building Science, United States, (2019): "BIM is a digital representation of the physical and functional characteristics of a facility, BIM is a shared knowledge resource for information about a facility, forming a reliable basis for decisions during its (facility) life-cycle; defined as existing from earliest conception to demolition".

BIM is more than simply a 3D digital model; it is also an intelligent database from which all building information may be acquired in a collaborative setting. The model comprises the virtual equivalents of intelligent building elements allowing simulation of the facility so as to understand its behaviour in a computer environment before actual construction (Graphisoft, 2019). However it is paramount to understand that building information modeling is not just a digital model but process of creating and applying it to design, planning and execution of construction work (Bernard, 2012)

Several terms have been used worldwide to refer to BIM. Succar, Sher, Aranda-mena, & Williams (2007) states that although the term BIM has been used and is accepted extensively, other terms that have been used include: Asset Lifecycle Information System by Fully Integrated & Automated Technology; Building Information Modelling (BIM) by Autodesk and Bentley Systems; Building Products Models by Charles Eastman a BIM researcher; Building SMARTTM by International Alliance for Interoperability; 4D Modelling by School of the Built Environment the University of Salford; Virtual Building TM by Graphisoft; Virtual Design and Construction & 4D Product Models by Centre for Integrated Facility Engineering Stanford University.

Aouad *et al.*, (2014) described BIM as a virtual demonstration of functional features of a project. BIM is one of such inventive methods that have the potential to bring about the incessant progress and anticipated changes in the construction industry and reform the methods of its operation to accomplish enhanced cooperation among contractual parties and ascertain successful delivery of project (Azhar, 2011). BIM is currently viewed as a rapidly emerging digital technology with the inherent ability to improve information management in construction. However, Alufohai (2012) argued that BIM adoption has not been generally embraced by AEC firms in both developed and developing countries and has experienced stunt growth due to challenges associated with BIM usage. This statement is in accordance with Eadie *et al.*, (2013) who asserted that there are various factors hindering the progress of BIM.

Building information Modeling (BIM) was created to provide a foundation for resolving the inefficiencies of previous Computer Aided Drawing (CAD) systems by providing a working digital environment that incorporates all information about a building in an electronic file and is used by the various project stakeholders. BIM is a computer-generated model used to simulate project planning, design, and construction.. According to Autodesk (2016), "Building information modeling (BIM) is an intelligent 3D model-based process that equips architecture, engineering and construction professionals with the insight and tools to more efficiently plan, design, construct, and manage buildings and infrastructure". Construction firms in Nigeria are implementing Building Information

Modeling programmes. They are, however, usually utilized for sketch and presentation designs. One of the primary benefits of Building Information Modeling is collaboration and improved communication and efficiency throughout development. It is also a serious issue in the Nigerian construction industry.

In Nigeria, the construction industry is more fragmentized that various construction professionals usually generate project information and manage them individually (Onungwa *et al.,* 2017). Hamma-adama *et al.,* (2017) and Kori (2015) claimed that architectural, mechanical, electrical and plumbing designs are still prepared using 2D CAD platform with only few (especially Architects) using 3D CAD platform basically for visualization or demonstration. This is affirmed by Hamma-adama *et al.,* (2017) that the current status of BIM uptake in Nigeria is the predominant usage of 2D and 3D. Smith and Tardif (2009) argued that if BIM is used merely for presentation, detection of clashes and visualization, the numerous inherent capabilities it possesses may remain un-tapped. It can be deduced that these restricted uses of BIM reflect deficiency of BIM knowledge within the Nigerian construction industry context (Ugochukwu et al., 2015). Also, Ibrahim and Bishir (2012) asserted that BIM adoptions and usage in most developed nations are on the increase, however, the extent of BIM adoption particularly in developing countries is best describe as stagnant.

Relevant previous BIM studies in Nigeria were specific to a particular firm. For example, studies on BIM adoption and awareness in architectural firms (Ibem *et al.,* 2018; Kori and Makarf, 2018; Kori *et al.,* 2019). In addition, studies that examined BIM adoption, awareness, and implementation among Architecture, Engineering, and Construction (AEC) firms (see Olugboyega and Aina, 2016; Onungwa *et al.,* 2017; Ganiyu *et al.,* 2018; Olabode and Umeh, 2018). Few studies assessed BIM training gaps among construction professionals (see Oyewole and Dada, 2018). Few other studies examined BIM maturity level among AEC firms comprised architectural firms, facility management firms, quantity surveying firms, and structural engineering firms (Babatunde et al., 2019). It is clear from the preceding research that they are not only focused on a specific firm, but also on BIM awareness and application throughout Nigeria. It is thus necessary to do an explicit study that includes a comparison analysis with a focus on hurdles to BIM implementation in each AEC firm in order to have a balanced knowledge of BIM implementation among AEC firms in Lagos, Nigeria. The need to bridge this information gap is what prompted the necessity for this research. This study is expected to provide a better understanding of the Nigerian BIM environment, which is a true depiction of underdeveloped countries in general. This study would further inform the decisions of the construction stakeholders to make some policy recommendations capable of positively influencing the full BIM implementation in the construction industries in Lagos state

2.2 Review of Empirical Studies

This section covers the BIM framework, dimensions and Noteworthy BIM Publication (NBPs). The BIM framework can be divided into three; BIM field - identifying domain players their requirements and deliverables; BIM stages - depicting minimum capability benchmarks; BIM lenses - represents layers of analysis to field and stage fields to generate necessary knowledge to topic (Succar, 2013). This framework is shown on Figure 2.1

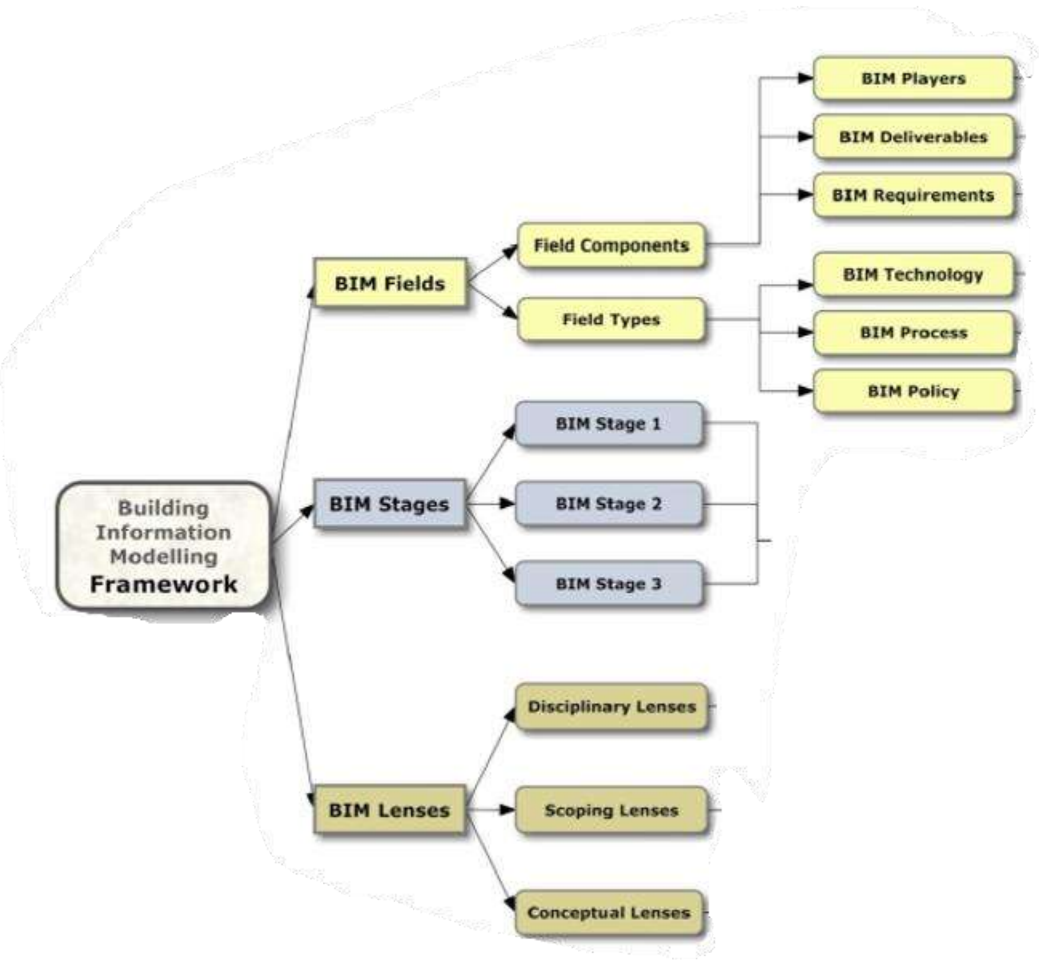

Figure 2.1: BIM Framework.
(Source: Succar, 2010b)**.**

2.3 Summary of Literature Review

BIM field can be divided into three fields: policy field, process field and technology field (Succar, 2009). Kalinichuk (2015) and Azhar *et al.,* (2012) describe the three fields as follows: Technology covers software, hardware, and networks, it ensures project simulation that comprises the 3D parametric model. Leadership, infrastructure, human resources, and services/product are all part of the process. It incorporates a facility's disciplines and systems into a single virtual model, allowing team members to interact properly and efficiently. Contracts, laws, research, and education are examples of policy. The three fields are put in two sub-fields each, namely players and deliverable

(Kalinichuk, 2015). Figure 2.2 illustrates these fields. This study notes that policy, process and technology fields must work together for optimal benefits of the BIM system.

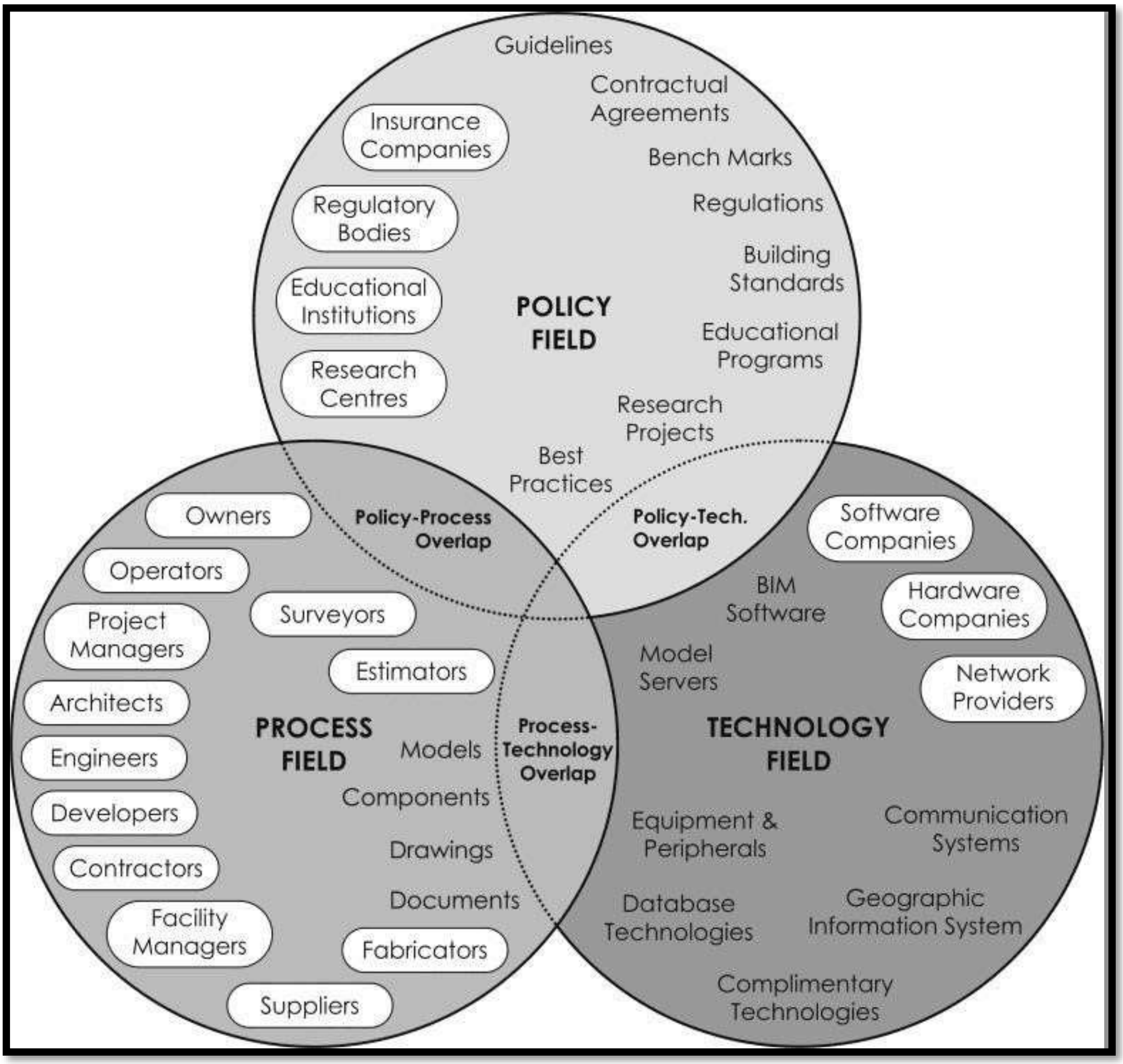

Figure 2.2: Technology, Process and Policy fields with players and deliverables. (Source: Kalinichuk, 2015; Succar, 2010a)**.**

2.4 BIM Software

Autodesk Revit: The architectural, engineering, and construction (AEC) sector is undergoing a digital transition, and BIM is its cornerstone. Autodesk, the industry pioneer in BIM, is a partner in realizing improved working practices and better results for industry and the built environment. From architects and designers to builders and project managers, Autodesk Revit is used by a wide range of people. Data and values are heavily emphasized throughout the software. Users have a ton of flexibility to add new information and edit what is already there. Additionally, "Dynamo," a potent graphical programming engine, is included with Revit. With the help of this engine, even a novice non-IT user may design complex geometries and carry out data-driven operations like import and export as well as parametric modeling based on data.

Autodesk BIM360; Autodesk has developed a cloud-based environment for construction data management called BIM 360 in addition to their well-known BIM Software. It expands upon common elements like conflict track, 3D drawing, and 2D modeling. Additionally, it acts as the main repository for all plans and construction papers. BIM 360 reigns supreme for huge businesses or projects and best-in-class performance. Users have total insight into every area of the project and can access documents via the cloud.

Vectorworks Architect: For staff who focus on design and creativity to think of a better BIM than Vectorworks Architect. This BIM program provides some of the best modeling, drawing, and documentation features available in any BIM. Vectorworks Architect stands apart from the competition thanks to its advanced 3D modeling capabilities, which give architects and design purists tools to unleash creative creativity. While some of the all-inclusive construction and project management software features may not be available elsewhere, Vectorworks does have other solutions that can integrate with Architect. This includes applications for mapping construction sites, commercial lighting, Vectorworks Architect is a great option for architects and designers seeking a BIM that can assist in bringing ideas and projects to life.

Tekla Structure: Tekla Structures performs well in the fields of structural and civil engineering. Software juggernaut Trimble developed Tekla Structures, which was based on XSteel, a program for designing steel structures. Trimble has incorporated glass, wood, concrete, and other building materials into Structures while keeping steel and architectural design at its foundation. For large-scale industrial projects that require BIM to help manage construction resources and materials, Tekla Structures is well suited. It has been applied to the design of everything from megamalls and sports arenas to bridges and airports. Tekla Structures enables structural engineers, contractors, and steel and concrete fabricators to render and manage projects effectively.

ARCHICAD: The user interface of ARCHICAD is basic and practical, making it one of the easier BIM programs for beginners to learn. Since its debut 30 years ago, ARCHICAD has been one of the BIM software programs with the longest lifespan. ARCHICAD can create 3D models of anything, including complete college campuses and landscape projects for office parks. However, one of ARCHICAD's key advantages is that it is an open BIM, which enables it to produce and receive BIM data in a vendor-neutral format (IFC). Regardless of the different design tools used by project partners, this enables smooth data interchange. For building BIM models, ARCHICAD provides enticing and complex tools and functionalities. Its scripting engine enables objects that are flexible and intelligent and go beyond simple data containers. An great selection for a flexible BIM solution that provides useful content generation and visualization tools is ARCHICAD.

BIMx: BIMx is a collection of desktop and mobile software tools for interactively displaying the 3D model and 2D documentation of BIMs developed with ArchiCAD through a simpler, more user-friendly interface than ArchiCAD's intricate BIM authoring environment. BIMx, a mobile BIM communication solution from GRAPHISOFT, enables interactive BIM model exploration of architectural designs on iOS and Android mobile devices. It has a special technology called the "BIMx Hyper-model" for navigating the combined 2D.

Allphan; For rebar detailers, civil and structural engineers, and others, Allplan provides 3D BIM design and detailing software. The platform for architects, engineers, and contractors called Allplan is interdisciplinary and supports and unifies the design and construction process throughout all project phases. Easily exchanged multidisciplinary data, freely move between working in 2D and 3D, superior accuracy and quality of information,.With the help of Allplan, you may construct virtually first, then identify any problems and conflicts early on, even during the design phase, preventing delays in the construction process.

BrisCAD BIM Software: Computer-aided design software called BricsCAD was created by Bricsys nv. Longtime CAD entrepreneur Erik de Keyser established the business in 2002. Using the automatic generation of sections, elevations, drawing views, and sheet layouts, BIM Software produces clear and accurate construction documentation in a flash.

Procore BIM software: Everyone working on your project will have access to everything they require thanks to Procore's platform that connects all of your people, software, and data. You have the option to connect with the Procore App Marketplace's hundreds of integrations using the platform. You can therefore join it even if we don't create it. Give everyone on the job site immediate access to trustworthy BIM data on any device, Outstanding performance, reduce the risk, build what the project's owners expect.

2.5 Application of Building Information Modelling

BIM offers a variety of applications in the construction industry (Shaikh, Raju, Malim, & Jayaraj, 2016: 206). Three-dimensional modelling and rendering can be produced, design drawings and shop drawings can be generated, and construction standards can be reviewed by examining object parameters, while cost estimates and construction schedules can be applied in renovations, maintenance, and operations to make facility management more efficient (Sarkar & Modi, 2015: 54). In addition, various examinations and simulations can be carried out on the model to enhance the overall performance of any project (Azhar, Nadeem, Mok & Leung, 2008). In summary, BIM projects facilitate efficient administration of construction projects and can be applied in all construction project stages: pre-construction stage, construction stage and post-construction stage (Latiffi, Mohammed, Kasim & Fathi, 2013: 3).

2.5.1 Pre-construction stage

The use of BIM during the pre-construction stage is more visible than during the construction and post-construction stages, considering the executions associated with this stage, for example, design, scheduling and estimating (Latiffi *et al.*, 2013). Sarkar and Modi (2015) conclude that BIM can be applied in the pre-construction phase for conceptual design, sketching, space planning, site inventory, and guaranteeing programme consistency with respect to site-related variables. 2.3.2

2.5.2 Construction Stage

Yamazaki, Tabuchi, Kataoka and Shimazaki (2014) note that challenges in the construction procedure are quickly comprehended and tackled by reviewing forms generated by BIM during the construction phase. In addition to creative engineering and enhanced construction innovations, basic investigation in the construction procedure, mechanized crash checking innovation, continuous construction simulation, and 3D estimation innovation are keys to productively utilizing BIM during construction (Yamazaki et al., 2014).

2.5.3 Post-Construction Stage

In the post-construction stage, BIM keeps track of built asset, manages facilities proactively, enables scheduled maintenance, and provides a review of maintenance history (Latiffi *et al.*, 2013: 3). Sarkar and Modi (2015: 55) emphasise that, in this stage, BIM allows facility management to be implemented in relation to renovations, maintenance, operation, cost estimation by investigating the quantities of materials, and construction sequencing to make scheduling more consistent.

2.6 Difference between BIM and CAD

Autodesk (2019) defines CAD as technology for design and technical documentation, which replaces manual drafting with an automated process, either in 2D or 3D. Whereas BIM is a platform with technology, process, and policy. CAD drawings are created independently and modifications done on one of them has to be manually updated on each of the other drawings, whereas BIM is based on 3D parametric model and allows designers to come up with drawings similarly as the actual construction with all data stored within the model (Graphisoft, 2019). BIM includes Geometry (location of points in space), topology (connectivity between the points) and semantics (the meaning, the model has information useful in the lifecycle of the project) whereas CAD includes geometry and topology but lacks semantics (Kumar & Hayne, 2016).

The literature review shows that CAD and BIM are not software. A software supporting BIM should provide: openness, interoperability, simplicity, functionality, accuracy of Data, expandability (3rd party plug-in), time management, clash detection, cost estimation and facility management (Bouška, 2016). CAD is a system that replaced manual drafting and BIM is replacing CAD. Figure 2.4 shows evolution of design processes; from hand drafting to 2D CAD drafting to 3D CAD to BIM which is where the construction industry is currently at or migrating to. While the present research has tried to explain what BIM is through the literature review, the construction industry has a task of training the players thoroughly to eliminate confusion.

Figure 2.3: Evolution of design process.
(Source: Thomas, 2015)**.**

2.7 Comparative review of BIM adoption: global context

The usage of BIM has transformed the construction industry. Increase in profit via cost savings and timely delivery of projects are some of the numerous advantages of using BIM for construction works. United Kingdom BIM Strategy Report (2012); Wong *et al.*, (2009) and BuildSmart (2012) reported that several governments of developed countries including the United Kingdom, United States of America, Australia among others have set up strategies for the implementation of BIM in their construction works which has led to rapid BIM adoption. For instance, Efficiency and Reform Group (2011) established a road map for the adoption of BIM in the United Kingdom to implement BIM and achieve efficacies. In Australia, government had proposed compulsory usage of BIM on public financed projects as from the first phase of year 2016 (BuildSmart, 2012). A survey conducted by Kjartansdottir (2011) on the adoption of BIM in Iceland showed that not less than forty percent of construction professionals use BIM in their practices, especially architects and engineers.

BIPS (2012) reported that Denmark and Norway are among the countries that have developed proficiency in the implementation of BIM, having mandated the usage of BIM on public projects since 2007. The adoption of BIM in the United States of America showed a significant increase in BIM usage from twenty-eight to forty-eight percent which is far more than the percent in other developed countries (McGraw-Hill, 2009; Eadie *et al.*, 2014). McGraw-Hill (2008) found out that sixty-two percent of the respondents showed willingness to use BIM on not less than thirty percent of their project in 2009; eighty-two percent of BIM users admit increase in output of work done and forty-four percent are currently using BIM to ascertain "Return On Investment". According to McGraw-Hill (2009) most BIM users obtained numerous advantages from using it and the percent of BIM usage to find out return on investment has risen to sixty-three percent. The implementation of BIM is fast-growing as building owners and government agencies were prompted to adopt BIM, based on its benefits such as timeliness, reasonability of project cost and high quality among others. It is therefore evident that most nations of the world recognized the inherent capability of such innovative processes for reformation of practices in the construction industry. Lee *et al.,* (2014) stated that BIM processes were made compulsory by the United States of America and United Kingdom government agencies to assist construction professionals' practices in the industry and to satisfy and surpass clients' needs and expectations; they further stated that since 2006, the United States of America general services administration incorporated programme such as spatial arrangement of BIM as one of the least prerequisite for final approval of proposals.

As a result, the United States of America has been recognized as a leading country in the BIM implementation, subsequently the adoption level in North America sky-rocked from twenty-eight percent to seventy-one percent within the period of 2007 and 2012, and similar experiences were reported in the United Kingdom with contractors and architects adoption level amounting to seventy-four and seventy percent respectively (McGraw-Hill, 2014). According to Matarneh and Hamed (2017), the government of the United Kingdom has a foresight of becoming the frontier of BIM in Europe; they further stated that despite the increase in the usage of BIM world-wide, the experience in relation to BIM differs from one construction to another. Singh (2017) investigated BIM adoption in developed nations and found that in Finland, BIM implementation commenced since in 2002 and by 2007, it was established that all design must be IFC certified. In Norway, BIM and IFC data format had been used since 2010; In Denmark, government had mandated the usage of BIM coupled with research and development works in relation to BIM are currently conducted at the organizational and institutional level; In Sweden, BIM is widely adopted without compulsion from the government but are only deficient in BIM research publications when compared to the United States of America; In Singapore, government encouraged the implementation of BIM by making the usage of BIM mandatory for large project and provision of adequate fund for the training and procurement of BIM software and hardware; In France, the government officials in a bit to fully adopt BIM, resolved in 2014 to use BIM in the development of not less than five hundred houses by 2017; South Korean being one of the frontiers of BIM adopters had been making tremendous efforts since 2010 to cause an increment in the number of BIM oriented projects by the provision of funds for the establishment of BIMoriented building design standards and mandatory use of BIM on all government projects over fifty million dollars since 2016.

China Construction Industry (2013) reported that BIM adoption level in China is very low; this is however attributed to government not acting as "role model" in the adoption of BIM. In Hong Kong, Lu *et al.,* (2018) found that BIM maturities of construction-related organizations in Hong Kong vary, with more than half ranging from Stage 0 to 1; and this was attributed to the different developments of their BIM processes and protocols. However, the BIM implementation in Africa differs from one country to another. For instance, in South Africa construction professionals are still confronted with barriers in the adoption of BIM (Succar, 2009). In Nigeria, the BIM awareness is relatively high compared to its usage among AEC firms (Ogwueleka, 2015). This is corroborated by Ugochukwu *et al.,* (2015) that not less than sixty-seven percent of construction professionals are aware of BIM in Nigeria but very few have implemented BIM in their practices. It is surprising that BIM has been rarely used for construction works in Nigeria (Alufohai, 2012). This is affirmed by Olugbenga et al. (2016) that currently BIM usage in Nigeria is been requested mostly by building owners and developers but the government is not showing any interest in the implementation of BIM for the delivery of public projects. Against this backdrop, this study becomes necessary to critically examine the militating factors to BIM full implementation and the ways forward to improving its adoption among AEC firms in Nigeria

2.8 Use of BIM in the Construction Industry

Internationally, a lot of literature is available on Building Information Modeling (BIM), however, literature on BIM in Nigeria is limited. BIM has been in use for some time in Nigeria but its effectiveness and potentials have not been maximized. Benefits of collaborative BIM are well documented, including leveraging the value of good information, enabling better co-ordination, synchronization and sequencing of projects, by allowing all project participants to access and interrogate project information; and, at higher levels of BIM, enabling better clash detection (Chen, Y and Bradley, 2015). Collaboration is often difficult to achieve because the level of adoption of BIM among the different stakeholders in construction industry are not the same.

According to Eastman *et al.,* (2011), BIM can potentially increase the efficiency, quality and productivity of construction projects by reducing the number of mistakes and incompatibilities, providing more accurate and up-to date information, and by giving a more illustrative and accessible exposition of a building. There are many benefits of BIM and they include the ability to reuse information stored in a database, (Egbu and Sidawi, 2012). Automation through BIM also improves time and cost management. It streamlines the design process across the company and facilitates automation of emails via knowledge database.

Other benefits include ability to visualize what is to be built in a simulated environment, higher reliability of expected field conditions, allowing for opportunity to do more prefabrication of materials off site (Rajedran and Clarke, 2011). According to Gordon and Holness (2008), the building design development can continue with the provision of automatic bills of material and generation of automatic shop drawings for everything from structural steel to sheet metal duct fabrication, to fire protection and piping fabrication, to electrical cabling and bus duct layouts.

Benefits of 'GIS-BIM' based site analysis (CICRP, 2009) also include aid in determining if potential sites meet the required criteria according to project requirements and minimizing risk of hazardous materials. The advances in smartphone and tablets technology have allowed contractors and subcontractors to frequently use BIM models at the jobsite for information extraction and coordination. Some of the notable BIM apps include BIMX®, Bentley Navigator®, Buzzsaw®. (Rubenstone, 2012).

2.9 Current state of BIM Adoption in the Nigerian construction industry

Onungwa *et al.,* (2017) asserted that there is low level of awareness and technical know-how of BIM in Nigeria. This can be linked to lack of adequate BIM training and inadequate exposure to BIM concept (Abubakar *et al.,* 2013; Onungwa *et al.,* 2017). In Nigeria, both medium and largesized firms involved in construction activities are predominantly at the foremost in the implementation of BIM (Kori, 2015). However, firms that are relatively small in size rarely use BIM in their practices. Generally, the construction industry in Nigeria is fragmentized, this implies that various construction professionals generate project information and manage them individually. Hamma-adama *et al.*, (2017a) and Kori (2015) found that architectural, mechanical, electrical and plumbing designs are still prepared using 2D CAD platform with only few, especially architects using 3D CAD platform basically for visualization or demonstration. Smith and Tardif (2009) argued that if BIM is used merely for presentation, detection of clashes and visualization, the numerous inherent capabilities it possesses may remain un-tapped. Similarly, these restricted uses of BIM reflect deficiency of BIM knowledge in the Nigerian construction industry (Ugochukwu *et al.*, 2015). Hamma-adama *et al.*, (2017b) opined that change of behavior from the traditional method of procurement is necessary, but change of behavior to successfully implement BIM is often difficult as it requires a complete transition of work processes.

Although BIM implementation in most developed nations are on the increase, however, the extent of BIM implementation in most developing nations such as Nigeria is best described as stagnant (Ibrahim and Bishir, 2012). This is affirmed by Hamma-adama *et al.*, (2017a) that the current status of BIM uptake in Nigeria is the predominant usage of 2D and 3D. However, a more comprehensive and exhaustive examination of the levels of development of BIM in the Nigerian construction industry by Olugboyega and Aina (2018) showed that both two dimensional and various variants of three dimensional building information modeling such as 3D architectural model, 3D architectural and structural model and 3D architectural and building services model were the most widely used in Nigeria. It is quite unfortunate there are no government policies in place to encourage BIM implementation in Nigeria, which is a true reflection of developing countries as whole. Studies have shown that currently BIM implementation in Nigeria is been requested mostly by private building owners and corporate organizations while the governments at all levels (i.e. federal, state and local) are not showing much interest in the implementation of BIM for the delivery of public projects.

2.10 Barriers to the implementation of Building Information Modelling

The implementation of any innovation technology is confronted with difficulties prior to full implementation (Matarneh & Hamed, 2017a: 189). Like with any innovative technology, various challenges impede BIM application in the building construction industry. Azhar et al. (2012: 25) classify BIM application-related challenges in two broad categories: technology-related challenges and process related challenges. The following are some of the most significant technological and process-related hurdles in BIM adoption in the building construction sector.

- ➢ Lack of client demand;
- ➢ Lack of support and incentives from construction policymakers to professionals and experts using BIM;
- ➢ High costs (software, hardware upgrade, training, and time);
- ➢ Lack of awareness about BIM, resulting in professionals comparing BIM to CAD;
- ➢ Lack of standards and codes for BIM application;
- ➢ Lack of a BIM specialist in the region and majority of non-expert staff in architectural firms; Acta Structilia 2018
- ✓ BIM necessitates substantial changes in workflow, methods, and processes, as well as opposition to change on the part of design and construction organisations.
- ✓ Too many legal barriers;
- ✓ Lacking due to exchange and interoperability;
- ✓ Inadequate BIM application research and development;
- ✓ Lack of IT infrastructure to successfully implement BIM.

2.11 Challenges of BIM Adoption In Nigeria

Challenges to BIM Adoption in Nigeria include

- **interoperability risks between different programs used.** (Azhar *et al.,* 20120. In Nigeria, many architects and engineers still use 2D AutoCAD. This has an impact on the collaboration of construction working drawings and limits the usage of BIM, particularly during the post-contract stage. A survey by AECbytes shows that despite each discipline working in 3D environment, collaboration is still primarily based on exchange of 2D drawings (Khemlani, 2007).
- **lack of skilled personnel**: There aren't enough trained workers in the business. Most architects train themselves or learn on the job, therefore they are not aware of all the software's possibilities. Other stakeholders' reluctance to utilise BIM (engineers, contractors, etc.) makes it difficult for architects to adopt BIM because they must transfer their drawings to AutoCAD for the other consultants to conduct their work.
- **Conflit due to ownership of BIM data:** The ownership of the BIM data has yet to be confirmed. It is unclear if the BIM belongs to the client who paid for it or to the architect who created the model. If the client decides to seek assistance from other consultants on his own, this can lead to conflict.
- **Absence of appropriate BIM guidelines:** It is a mere illusion to desire the attainment of purposeful changes without procedure and regulation in place to implement it (Ezeokoli *et al.,* 2016). Inadequate support from the government for BIM implementation and general regulation has been recognized to have a negative impact on the usage of BIM, thus each BIM user adopt their own principle without directive from the vendor which will inevitably result to

differences in the detail level in relation to various firm (Zahrizan *et al.*, 2013; Abubakar *et al.*, 2014).

- **Fear of change:** fear of change is another challenge to adoption of BIM (Hassan and Yolles, 2009). Most people are highly familiar with the software they use and find it difficult to change. Utilizing BIM requires a shift in perspective from generating line drawings to developing three-dimensional drawings with walls, windows, doors, and other building components.
- **Increased cost of production:** Further costs associated with hardware, software, and implementing office procedures are also obstacles to BIM adoption. Implementing BIM necessitates the purchase of software and hardware. It entails training of existing office personnel. This will result in additional expenses for the office. Most of the time, the architect must cover the expense of model revisions during construction because the client is unwilling to pay for additional costs. This raises the production costs for architects**.**
- **Increased risk and liability of parties involved:** Integrated concept of BIM increases risk and liabilities to different parties involved (Azhar *et al.*, 2011). This creates problems when vendors and other consultants make input to the BIM. BIM systems create big files, management and transfer of these files with Nigerian internet and power problems is very difficult big storage space required to store the large amount of information generated by the big number of collaborators (Ding & Xu, 2014), security of data due to pirated software pausing danger to the digital and collaborative BIM, hence exposing data to hackers and viruses (Bui *et al.*, 2016).
- **Lack of BIM object libraries**: According to Farley (2011), "lack of BIM object libraries" affects production of drawings because some products are not vailable

in the software. Most BIM in use do not have object libraries that are used in the Nigerian Market. Standards for drawing presentation have not been developed

- **Low level of BIM technical know-how and awareness:** Zahrizan *et al.*, (2013) argued out that the obscurity of BIM in the construction industry can be traced to the relatively inadequate level of awareness and technical know–how of BIM among construction professionals. Liu et al. (2015) recognized inadequacy of appropriate skills and technical know-how in the usage of BIM as one of the major barriers to the adoption of BIM in their individual nations. Saxon (2013) noted that currently BIM is often utilized and is experiencing instantaneous growth in most developed nations. For example, RICS (2014) reported that BIM was applied on more than seventy percent and thirty-six percent of the construction works in the United States of America and Europe respectively, but this is in contrast to what is prevalent in Africa. Although awareness is growing, the extent to which BIM is being implemented and adopted in building projects appears to remain modest.. For instance, Hosseini *et al.,* (2015) found out that about twenty-nine percent of the construction firms in Iran adopted BIM in their practices and about fifty-six percent have not heard of BIM. Saxon (2013) claimed that only fewer number of BIM applications are recorded in developing countries because construction participants are yet to develop capability to use BIM. Many construction industry personnel are still unaware of the technology. To be effective, BIM must be understood by all experts participating in a project.
- **Lack of constant electricity and internet connectivity**: The lack of consistent electricity and internet connectivity has an impact on office output. The constant usage of generators raises the expense of operating the offices. BIM cannot be utilized effectively without an Internet connection. To obtain drawings from a

vendor site, the Internet must be connected. Internet access is not widely available in Nigeria. The use of the internet raises the cost of production.

- **Initial BIM huge capital outlays:** The adoption of BIM for "first timers" involves initial huge capital outlays which include procurement of BIM computer hardware and software packages, cost of staff training among others (Hong Kong Construction Industry Council, 2013; Memon *et al.*, 2014). Business owners are hesitant to deploy BIM unless they can tie it to long-term benefits for their own enterprises and a significant decrease in the cost of vendor training because the outright move from traditional procedures to new ones, like BIM, has significant financial consequences. Obiegbu and Ezeokoli (2014) argued that BIM technologies available for sale are costly to procure and set-up. Thus, new BIM users might incur excessive expenses which might even affect their profit at the early stage (Hergunsel, 2011)
- **The structure of the construction industry:** BIM implementation usually involves a complete change in practice with respect to procedures and principles (Ezeokoli *et al.*, 2016). Kori and Arto (2015) opined that the attitude of construction professionals to change from an existing process to a new one poses more problems than acquiring the skills. This is because traditional method of procurement has been used long enough that it is extremely difficult to embrace a new process. Zahrizan *et al.*, (2013) argued that managers at the corporate level had been identified as a key factor that brings about incessant incorporation of changes to innovation. Yet, when these managers are properly informed, implementing changes in the businesses is simple. As a result, every company that wants to abandon the traditional methods of procurement must take intentional steps to adopt the implementation of BIM.

2.12 Benefits of BIM in the construction industry

Most obstacles to the sharing of data between project team members that arise during the design and construction process can be solved with the use of BIM in the construction sector. Latiffi *et al.*, (2013: 4) noted that the benefits of implementing BIM in construction projects are related to five main aspects: design, scheduling, documentation, budget, and communication. Generally, BIM technology allows for efficient collaboration of project stakeholders by allowing changes done by members of the design team to be updated in real-time and shared to all project stakeholders (Doumbouya, Gao & Guan, 2016). BIM can reduce rework, design errors, omissions, design conflicts, and revisions during the construction process.

Table 2.1: Illustrates BIM applications for all stakeholders in the building construction industry.

BIM application	Owners	Designers	Contractors	Facility Managers
Visualization	*	*	*	*
Optics analysis	*	*	*	
Sustainability analysis	*	*		
Quality surveying		*	*	
Cost estimation	*	*	*	
Site logistics			*	
Phasing and 4D scheduling		*	*	
Constructability analysis		*	*	
Building performance analysis	*	*	*	*
Building management	*			*

(Source: Azhar *et al.*, 2020)

In summary, the benefits of adopting BIM and using BIM technology on projects in the construction industry are:

- Reduce rework during construction;
- Maximize productivity;
- Reduce conflict/changes;
- Clash detection;
- Enhance collaboration and communication;
- Improve visualization;
- Improve project documentation;
- Enhance design review;
- Faster and more effective method;
- Improve quality;
- Reduced construction time;
- Reduce contingencies, and
- Reduce construction cost

2.13 Prospect of BIM Adoption

BIM encourages integration of the roles of all stakeholders, this ensures efficiency and harmony among players and eliminates adversarial relationships (S. Azhar *et al.*, 2012). Drawings in BIM are informed, the model is information rich (Borjeghaleh & Sardroud, 2016), the client is able to understand the expected product through generative designs that are helpful in decision making and controlling budgets, since the client is interested in maximum profits (Grzyl *et al.*, 2017).

There is limited attention given to BIM implementation in infrastructure projects in developing countries (Bui et al., 2016). Civil Engineers are more comfortable with the traditional methods; they can however use BIM in design, construction, cost and contract management of civil and infrastructure projects, even though Architects are taking the lead in BIM (Asad, 2016; Eadie, 2014). The project and construction manager use BIM in management of: the contract, decision, information, quality, resource, safety, risk, value, time scheduling and cost using the 3D model to plan collaboratively with other professionals hence lowering risks and improving the ROI of the project (Yalcinkaya & Arditi, 2013).

The Contactor uses BIM to price the bills of quantities, schedule work, work on variation and plan a site layout (Grzyl *et al.,* 2017). Occupation health and safety issues are important in construction industry. Since now design and construction planning can be done in one model, safety can be factored in and adequately be planned for (Musyimi, 2016). BIM can also be used to determine and predict the indoor air quality at the construction site before the actual construction work (Altaf, Hashisho, & AlHussein, 2014).

Facility management constitutes over 80% of the total life project cost, hence its imperativeness ought to be acknowledged (Costin, Pradhananaga, & Teizer, 2012). BIM 6D and 7D enables operation & maintenance stage to be treated as equally as the design and construction stages without breaking the flow of information (Nicał & Wodyński, 2016). BIM model provides information about a building and its spaces, systems and components; these data are transferred into facility management operations and can be accessed by clicking on an object of interest (S. Azhar *et al.*, 2012). BIM 6D and 7D application include: Mobile localization of building resources, digital asset with real-time data access, space management, renovation planning, automated maintainability studies, energy analysis control and emergency safety management (Nicał & Wodyński, 2016).

2.14 BIM Education for Architectural, Engineering, Construction & Operation

Universities and colleges should be mandated to teach BIM through established course outline as this will help bring down the cost of BIM implementation to some extent (Asad, 2016; Liu *et al.*, 2017). Today, the difficulty is that most colleges lack understanding of what skills are required in the business, and because BIM is still relatively new, there has been little study on BIM course content. BIM education should not focus on BIM software but, on BIM management, BIM and collaboration, BIM technical skills and knowledge, open BIM, benefits of BIM and ROI (Smith, 2014a). Most developed countries are including BIM as part of the university curriculum for construction related courses (McAuley *et al.*, 2017). The education institutions are well placed to champion for BIM (Musyimi, 2016). This ensures that BIM skills are nurtured early; however, Kenya does not have a BIM curriculum (Mutonyi & Cloete, 2018). The consequences of this gap are transferred to the job market where the employer is forced to train their employees.

2.15 Empirical Reviews of Related Studies

Succar (2010) defined BIM as a set of interacting policies, processes and technologies generating a methodology to manage the essential building design and project data in digital format throughout the building's life-cycle. It is a software that allows the geometrical modeling and the input of information but also Project Management (PM)-related tools and processes (Tarmizi, 2013). BIM has a potential to be used at all stages of the project life-cycle by the owner, design team, contractor and facility manager thereby eliminating waste and reducing errors to the barest minimal (Ibrahim, 2010). In fact, BIM is very essential at all stages of the project life-cycle: from being used by the client to understand and express the project's requirements, to the design team from the conceptual design to the full development of the project, to the contractor to manage the project from site clearing to the commissioning and by the facility manager from operation to decommissioning phases (Cruz, 2008). The future of BIM will lead to virtual project designs and construction approach, with a project being completely simulated before being undertaken for real (Foster, 2008).

BIM will give favourable project outcomes by enabling rapid analysis of various scenarios connected to a building's performance throughout its life cycle. The use of BIM in construction projects is already resulting in projects being built 30 to 40 times faster. According to Aranda-mena (2008), Building Information Modeling (BIM) is revolutionizing the design and construction industry by transforming the way of designing cities, buildings and systems to perform throughout their entire life cycle. BIM has improved the design, construction, and operation of all types of buildings and facilities worldwide, from traditional structures to the most inspirational undertakings of our day. Foreseeing the benefits of using BIM in respect of reduced transaction costs and less opportunity for errors to be made, Great awareness is being created in Lagos towards promoting BIM's use. The efficiency of BIM utilization will depend on the commitment of all the team players to effectively play to the rule of the game. There is hope that the stumbling blocks on the way will be singled out (AGC, 2006). Building information modelling is made up of multiple operators, processes, and communication flows, with each process involving several operators doing their tasks in different locations. The state of operations in each building process, such as architectural and structural construction, can be so vast that BIM will only be required to bring harmony in a specialised sub-sector. Activities in the specialized sectors or in the general context are made possible by the diffused presence of computer-based information technology (Holness, 2008).

The spectrum of tools assisting in the spread of BIM is extensive, ranging from advanced computational support to innovative software that is injected into the market on a daily basis. In the field of built environment with diverse and dispersed activities being facilitated by the rapid development of supporting technologies, it is very difficult to capture current status as new frontiers are emerging continuously (Olatunji, Sher and Ogunseni, 2010). It is hoped that this study will help to highlight the importance of BIM and go to some extent to improve the acceptability of this great innovation in the Construction Industry in Lagos.

2.16 Summary of the Chapter

the literature review on BIM revealed that, the deployment of BIM in the construction industry helps overcome the majority of the issues encountered during the design and construction process relating to data exchange between members of the project team (project owners, designers, contractors, and facility managers).The benefits of implementing BIM in construction projects relate to five main aspects: design, scheduling, documentation, budget, and communication (Azhar *et al.,* 2012; Latiffi *et al.*, 2013: 4). Despite these advantages, the use of BIM still faces a number of challenges, including, in order of importance: the high cost of implementation; lack of awareness of the use of BIM; a lack of government support for its implementation; a lack of training facilities to encourage its utilisation; inadequate research and innovation; and a lack of laws and policies mandating its use. These barriers have contributed to the low level of BIM application and awareness in the construction industry.

The chapter has presented major outline for the research work from the Introduction, conceptual framework, that outlines the detail of the research on approaches of BIM adoption which necessitated the need for the study. From the critical study of BIM adoption, some details such as definition, challenges, benefits, global, Africa and Nigeria view point on adoption of BIM. The chapter also emphasizes on the different phases of acceptance over time among the parties they are intended for. However, the parties need to be sensitized through various means of awareness creation such as education and training. Visionary leadership is also crucial in giving guidelines and enabling technological capacity by putting the right infrastructure in place such as software, hardware, and internet. Awareness and knowledge of benefits of such technologies and how they are likely to solve problems in the old systems create curiosity among the parties leading to the acceptance and adoption.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Introduction

This chapter focuses on the principles and methods of research adopted for this study. The research for this study is discussed under the following sub headings: research design, area of the study population of the study, sampling and sampling technique, data collection instrument, validity of the instrument, method for data collection and method of data analysis.

3.1 Research Design

The descriptive survey research design of correlation was adopted to carry out this study. According to Udoudoh and Usman (2016) the survey research method was described as one of which a large group which can easily be used to make generalization without touching each individual, but just a representative sample of the population. The survey method is adopted by the researcher simply because when studying a large population, it is quite effective and suitable in giving the desired result. In view of the above definitions, the survey research has been considered appropriate for this research and hence it has been adopted.

3.2 Area of the Study

The study will be carried out in, Lagos island local government area of Lagos state Nigeria. This study is being carried in this LCDA of Lagos state because it is currently one of the local government area with the highest number of constructions projects currently running. Examples of construction work ongoing are construction on hotels, malls, schools residential and commercial buildings etc. The Lagos island local Government area is a fast developing LCDA in Lagos state

3.3 Population of the Study

The population of the study comprises of Builders and Architects in the building construction industry in Lagos state, Nigeria. to ascertain the Building information modelling. The total population for this study is one hundred and nine (109) which comprises of fifty-nine (59) builders and fifty (50) architects in Lagos state.

3.4 Sampling

The Study employed random sampling technique which was subjected to a total of ninety-four (94) respondent consisting of fifty-one (51) builders and fourty-three (43) architects.

Table 3.1: Distribution percentage analysis of population of the study

S/N	Respondent	Number received	Percentage received
1	Builders	51	54.3%
2	Architects	43	45.7%
	Total	94	100%

3.5 Data Collection Instrument

The instrument used in this study for data collection is the questionnaire. The questionnaire used is designed into two parts; Part 1 and Part 2. The part 1 consist of the respondent's personal data and also the instructional guide for filling the questionnaire. The part 2 is divided into four sections A, B, C and D consisting of the respondent's views to each item in every section. Section A contains (12) items that deals with the types of BIM software available in the construction industries in Lagos state. Section B contains (12) items which deals with level of adoption of the BIM software in the construction projects in Lagos state. Section C contains (13) items that's deals with the challenges of the adoption of BIM in the construction industries in Lagos state. Section D contains (13) items that deals with the ways to overcoming the challenges of the adoption of BIM in the construction industries in Lagos state

3.6 Validity of the Instrument

The questionnaire is the main instrument used by the researcher for this study. For the purpose of validation of the instrument, the questionnaire was subjected to a face validation by three lecturers in the department of Industrial and Technology Education, Federal University of Technology, Minna. The validators observations, suggestions and corrections on the appropriateness of the items were embraced and reflected in the final copy of the instrument in order to ensure that instrument is efficient enough to provide the necessary information needed for the study

3.7 Administration of Research Instrument

The researcher obtained data from primary sources. The primary source is the questionnaire instrument. The researcher seek permission from the respondents before presenting the instruments to them. The researcher engaged with three (3) research assistants. These research assistants were train by the researcher on how to administer the instruments so as to ensure safe handling and return of the instruments. These research assistants assisted the researcher in both organization and collection of the questionnaire. The researcher explained the questionnaire to the respondents before presenting it to them and assure the respondents of the confidentiality of the information they gave. The researcher waited to collect the instrument as they were filled.

3.8 Method of Data Analysis

Mean and standard deviation (SD) was used to analyze the research questions. A four-point rating scale was used to determine the respondent's level of acceptance of the to each item of the research questions. Mean and standard deviation was used to analyse the items while the t-test was used to test the hypothesis at 0.5 level of significance.

Alternative value		Abbreviation	Rating
Strongly Agree	=	“SA"	4
Agree	=	“A”	3
Disagree	=	“D”	2
Strongly Disagree	=	"SD"	1

Research question 2 was responded to using the following rating scale

Alternative value	Abbreviation	Rating
Very Low level	VLL	1
Low Level	LL	2
High Level	HL	3
Very High level	VHL	4

$$\frac{4+3+2+1}{4} = \frac{10}{4} = 2.5$$

3.9 Decision Rule

To determine the acceptance or rejection of all items on the questionnaire, we will use a mean score of 2.50. hence, responses with mean score of 2.50 and above will be considered accepted and responses with mean score from 2.49 and bellow will be considered rejected. Also, to determine the acceptance and rejection of the hypothesis, t-test calculated will be compared with the critical value. For t-test calculated values below the t-critical value will be considered accepted while those above the t-critical value will be considered rejected.

CHAPTER FOUR

PRESENTATION AND DATA ANALYSIS

This chapter deals with the presentation and the analysis of data collected with respect to the study. The analysis was carried out based on the formulated research questions. the result of this data analysis for the research questions are presented first before those of the hypotheses tested for the study.

4.1 Research Question 1

What are the types of BIM software available in the construction industries in Nigeria?

Table 4.1: Mean response on the types of BIM software available in the construction industries in Lagos state

N_1 =51 N_2 =43

SN	ITEM	X_1	X_2	X_T	REMARK
1	Revit	3.08	3.42	3.25	Agreed
2	Procore BIM	2.94	3.33	3.16	Agreed
3	ArchiCAD	3.27	3.51	3.39	Agreed
4	Vectorworks	2.65	3.09	2.87	Agreed
5	Google sketchup	1.86	2.70	2.28	Disagreed
6	Bricscad	2.76	2.80	2.78	Agreed
7	Digital project	3.18	2.93	3.06	Agreed
8	Lightworks	3.20	3.26	3.23	Agreed
9	Telka structure	2.31	2.27	2.29	Disagreed
10	Allplan	1.86	1.68	1.77	Disagreed
11	Autodesk BIM360	3.22	3.23	3.23	Agreed
12	BIMx	2.82	3.02	2.92	Agreed

KEY
X_1 = Mean of builders
X_2 = Mean of architects
X_T = Average mean of respondent
N_1 = Number of builders
N_2 = Number of Architects

RMK = Remarks

The data presented in the Table 4.1 above shows that the respondents agreed with items 1, 2, 3, 4, 6, 7, 8, 11 and 12, with a mean score above 2.50 and disagreed on item 5, 9 and 10 with a mean score below 2.50. this means that items except items 5, 9 and 10 are the types of BIM software available in the construction industries in Lagos state, Nigeria.

4.2 Research Question 2

What is the level of adoption of BIM software in building construction projects in Lagos state?

Table 4.2. Mean responses on the level of adoption of BIM software in building construction projects in Lagos state **N_1 =51 N_2 =43**

SN	ITEM	X_1	X_2	X_T	REMARK
1	Revit	2.62	2.56	2.59	Utilized
2	Procore BIM	1.80	1.77	1.79	Unutilized
3	ArchiCAD	2.84	2.86	2.85	Utilized
4	Vectorworks	1.80	2.05	1.93	Unutilized
5	Google Sketchup	1.45	1.67	1.56	Unutilized
6	Bricscad	2.29	2.40	2.35	Unutilized
7	Digital Project	2.41	2.33	2.37	Unutilized
8	Lightworks	2.5	2.55	2.53	Utilized
9	Telka Structure	1.67	1.51	1.59	Unutilized
10	Allplan	1.47	2.40	1.94	Unutilized
11	Autodesk BIM360	2.57	2.60	2.59	Utilized
12	BIMx	1.94	2.21	2.08	Unutilized

KEY
X_1 = Mean of builders
X_2 = Mean of architects
X_T = Average mean of respondent
N_1 = Number of builders
N_2 = Number of Architects
RMK = Remarks

The data presented in table 4.2. reveals that the respondents agreed with item 1, 3, 8, and 11 with a mean score above 2.50 respectively as being utilized while item 2, 4, 5, 6, 7, 9, 10 and 12 disagreed with mean score below 2.50 respectively as being unutilized. This goes on to show that item 1, 3, 8 and 11 except item 2, 4, 5, 6, 7, 9, and 10 are highly adopted in building construction projects in Lagos state

4.3 Research Question 3

What are the challenges of the adoption of BIM in construction industries in Lagos state?

Table 4.3 Mean response on the challenges of the adoption of BIM in the construction industry in Lagos State

N_1 =51 N_2 =43

SN	ITEMS	X_1	X_2	X_T	Remark
1	Lack of Constant Power Supply	3.16	3.04	3.1	Agreed
2	Lack of Training Facilities.	3.22	3.14	3.18	Agreed
3	Lack of skilled personnel or experts in the industry	3.08	3.09	3.09	Agreed
4	Lack of readily available access to the internet	3.25	3.26	3.26	Agreed
5	Low level of awareness amongst building construction professionals of the invention of BIM	3.16	3.65	3.41	Agreed
6	High cost of BIM software	3.02	2.93	2.98	Agreed
7	Adaptation to Traditional Method of Work	3.10	3.44	3.27	Agreed
8	Lack of government support on the implementation of BIM in building projects	3.14	3.19	3.17	Agreed
9	Cost of Investment	3.20	3.35	3.26	Agreed
10	Inadequate Supply of Manpower.	3.04	3.12	3.08	Agreed
11	Low level of client demand of the use of BIM in their projects	3.35	3.50	3.43	Agreed
12	Lack of cooperation between stakeholders	3.08	3.19	3.14	Agreed
13	BIM not included in secondary and tertiary curriculum	3.47	3.58	3.53	Agreed

KEY

X_1 = Mean of builders
X_2 = Mean of architects
X_T = Average mean of respondent
N_1 = Number of builders
N_2 = Number of Architects
RMK = Remarks

The result presented in the table 4.4. shows that the builders and architects agreed with the items 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 with mean score above 2.50, indicating that all the respondent agreed with the items on the challenges of the adoption of BIM in the construction industries in Lagos, Nigeria

4.4 Research Question 4

What are the ways to overcome the challenges of adoption of BIM in the construction industries in Lagos, Nigeria?

Table 4.4 Mean responses on the ways of overcoming the challenges of BIM adoption in the construction industries in Lagos state **N_1 =51 N_2 =43**

S/N	ITEMS	X_1	X_2	X_T	Remark
1	Constant Power Supply to motivate the adopting BIM in building construction industry.	3.31	3.35	3.33	Agreed
2	Training Facilities to help in overcoming the challenge of BIM in building construction industry.	3.18	3.14	3.16	Agreed
3	More skilled personnel or experts in the industry	3.20	3.12	3.16	Agreed
4	Reduced cost of internet data to easily and ready use the BIM tools in constructions projects	2.90	3.19	3.05	Agreed
5	BIM taught in schools to increase the awareness amongst students and graduates in the industry	3.35	3.40	3.36	Agreed
6	Affordable cost of BIM software to encourage its use in the building construction industry	3.25	3.49	3.37	Agreed
7	Negligence of old Traditional Method of Work to motivate the adoption of BIM in building construction industry.	3.37	3.51	3.44	Agreed
8	Government policies that encourages the use of BIM in all construction projects	3.43	3.37	3.40	Agreed
9	Affordable Cost of investment to encourage the adoption of BIM in building construction industry.	3.33	3.35	3.34	Agreed
10	Adequate Supply of Manpower motivates the adoption of BIM in building construction industry	2.87	3.07	2.97	Agreed
11	Clients' interest in the use of BIM in their projects	3.28	3.30	3.29	Agreed
12	Increased cooperation amongst stakeholders	3.16	3.19	3.18	Agreed
13	Inclusion of BIM in the education curriculum at secondary and tertiary levels	3.39	3.37	3.38	Agreed

KEY
X_1 = Mean of builders
X_2 = Mean of architects
X_T = Average mean of respondent
N_1 = Number of builders
N_2 = Number of Architects
RMK = Remarks

The result presented in the table 4.4. shows that the builders and architects agreed with the items 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 with mean score above 2.50, indicating that all the respondent agreed with the items on the ways to overcome the challenges of adoption of BIM in the construction industries in Lagos, Nigeria

4.5 Hypothesis 1

There is no significant difference in the mean response between the builder and the architect on the types of BIM software available in the construction industries in Lagos state

Table 4.5. Mean standard deviation and t-test on the types of BIM software available in the construction industries in Lagos state

SN	ITEM	SD_1	SD_2	T-test	REMARK
1	Revit	0.74	0.59	-2.48	NA
2	Procore BIM	0.81	0.75	-0.76	A
3	ArchiCAD	0.78	0.67	-1.62	A
4	Vectorworks	0.91	0.99	-2.23	NA
5	Google sketchup	0.81	1.17	-4.00	NA
6	Bricscad	0.98	0.97	-0.20	A
7	Digital project	0.84	1.18	1.17	A
8	Lightworks	0.63	0.68	-0.44	A
9	Telka structure	0.91	0.90	0.21	A
10	Allplan	0.68	0.76	1.21	A
11	Autodesk BIM360	0.46	0.44	-0.11	A
12	BIMx	0.77	0.83	-1.20	A

KEY

SD_1 = standard deviation of builders

SD_2 = standard deviation of architects

T-test =t calculated

t-critical value = $\pm$1.984

degree of freedom = 92

level of significance = 0.05

NA= Not Accepted

A= Accepted

the data in the Table 5 above indicates that the t-calculated value of all items except items (1, 4 and 5) were less than the t-critical value (±1.984) at 0.05 level of significant. Therefore, the null hypothesis which says that There is no significant difference in the mean response between the builder and the architect on the types of BIM software available in the construction industries in Lagos state is accepted

4.6 Hypothesis 2

There is no significant difference in the mean response between the builder and the architect on level of adoption of BIM software in building construction projects in Lagos state

Table 4.6: Mean standard deviation and t-test on the level of adoption of BIM software in the construction industries in Lagos State

SN	ITEM	SD_1	SD_2	T-test	REMARK
1	Revit	0.63	0.67	0.44	A
2	Procore BIM	0.53	0.52	0.28	A
3	ArchiCAD	0.81	0.77	-0.12	A
4	Vectorworks	1.02	1.17	-1.09	A
5	Google sketchup	0.67	0.68	-1.57	A
6	Bricscad	0.99	0.88	-0.57	A
7	Digital project	0.85	0.83	0.46	A
8	Lightworks	0.93	0.97	-0.25	A
9	Telka structure	0.90	0.67	0.98	A
10	Allplan	0.86	1.17	-4.32	NA
11	Autodesk BIM360	1.03	1.00	-0.14	A
12	BIMx	0.83	0.94	-1.46	A

KEY

SD_1 = standard deviation of builders SD_2 = standard deviation of architects

T-test =t calculated t-critical value = ±1.984

degree of freedom = 92 level of significance = 0.05

NA= Not Accepted A= Accepted

The data in the Table 5 above indicates that the t-calculated value of all items except one item (10) were less than the t-critical value (±1.984) at 0.05 level of significant. Therefore, the null hypothesis which says that There is no significant difference in the mean response between the builders and the architects on level of adoption of BIM software in building construction projects in Lagos state is accepted

4.7 Hypothesis 3

There is no significant difference in the mean response between the builder and the architect on the challenges of the adoption of BIM in the construction industries in Lagos state

Table 4.7: Mean standard deviation and t-test on the challenges of the adoption of BIM in the construction industries in Lagos state.

SN	ITEMS	SD_1	SD_2	T-test	Remark
1	Lack of Constant Power Supply	0.67	0.65	0.88	A
2	Lack of Training Facilities.	0.54	0.51	0.74	A
3	Lack of skilled personnel or experts in the industry	0.82	0.81	-0.06	A
4	Lack of readily available access to the internet	0.93	0.93	-0.05	A
5	Low level of awareness amongst building construction professionals of the invention of BIM	0.88	0.65	-3.10	NA
6	High cost of BIM software	0.65	0.55	0.72	A
7	Adaptation to Traditional Method of Work	0.61	0.63	-2.65	NA
8	Lack of government support on the implementation of BIM in building projects	0.69	0.66	-0.36	A
9	Cost of Investment	0.78	0.75	-0.95	A
10	Inadequate Supply of Manpower.	0.82	0.82	-0.47	A
11	Low level of client demand of the use of BIM in their projects	0.63	0.55	-1.23	A
12	Lack of cooperation between stakeholders	0.72	0.69	-0.75	A
13	BIM not included in secondary and tertiary curriculum	0.62	0.59	-0.88	A

KEY

SD_1 = standard deviation of builders — SD_2 = standard deviation of architects

T-test =t calculated — t-critical value = ±1.984

degree of freedom = 92 — level of significance = 0.05

NA= Not Accepted — A= Accepted

The data in the Table 5 above indicates that the t-calculated value of all items except items (5 and 7) were less than the t-critical value (±1.984) at 0.05 level of significant. Therefore, the null hypothesis which says that there is no significant difference in the mean response between the builders and the architects on the challenges of the adoption of BIM in the construction industries in Lagos state is accepted

4.8 Hypothesis 4

There is no significant difference in the mean response between the builder and architect on the ways of overcoming the challenges of the adoption of BIM in the construction industries in Lagos state Nigeria

Table 4.8: Mean standard deviation and T-test analysis on the ways of overcoming the challenges of BIM adoption in the construction industries in Lagos State.

S/N	ITEMS	SD_1	SD_2	T-test	Remark
1	Constant Power Supply to motivate the adopting BIM in building construction industry.	0.71	0.72	-0.27	A
2	Training Facilities to help in overcoming the challenge of BIM in building construction industry.	0.87	0.86	0.22	A
3	More skilled personnel or experts in the industry	0.83	0.85	0.46	A
4	Reduced cost of internet data to easily and ready use the BIM tools in constructions projects	0.70	0.88	-1.75	A
5	BIM taught in schools to increase the awareness amongst students and graduates in the industry	0.69	0.69	-0.35	A
6	Affordable cost of BIM software to encourage its use in the building construction industry	0.86	0.59	-1.60	A
7	Negligence of old Traditional Method of Work to motivate the adoption of BIM in building construction industry.	0.63	0.59	-1.11	A
8	Government policies that encourages the use of BIM in all construction projects	0.67	0.69	0.43	A

9	Affordable Cost of investment to encourage the adoption of BIM in building construction industry.	0.68	0.65	-0.15	A
10	Adequate Supply of Manpower motivates the adoption of BIM in building construction industry	0.74	0.83	-1.22	A
11	Clients' interest in the use of BIM in their projects	0.85	0.86	-0.11	A
12	Increased cooperation amongst stakeholders	0.64	0.66	-0.22	A
13	Inclusion of BIM in the education curriculum at secondary and tertiary levels	0.82	0.85	0.12	A

KEY

SD_1 = standard deviation of builders
SD_2 = standard deviation of architects
T-test =t calculated
t-critical value = $\pm$1.984
degree of freedom = 92
level of significance = 0.05
NA= Not Accepted
A= Accepted

The data in the Table 5 above indicates that the t-calculated value of all items were less than the t-critical value ($\pm$1.984) at 0.05 level of significant. Therefore, the null hypothesis which says that There is no significant difference in the mean response between the builder and architect on the ways of overcoming the challenges of the adoption of BIM in the construction industries in Lagos state Nigeria is Accepted

4.9 Findings of the Study

Based on the data collected and analyzed, the following findings were made in respect to the formulated research question for this study

Findings related to types of BIM software available in the construction industries In Lagos state

1. There is a high availability of various BIM software around the state that can be purchase they include Revit, Procore BIM, ArchiCAD, Vectorworks, Bricscad, Digital project, Lightworks, Autodesk BIM360, BIMx BIMx in which provides a substantial amount of variant of BIM software for individuals to choose from

Findings related to the level of adoption of BIM software in building projects in Lagos State.

1. The adoption level of BIM software in building construction project is very low even with the fact that there is an availability of various software that will aid its use in building construction projects
2. Although it was noticed that some respondent were aware of these software but only a few BIM software are noticed to be utilized in few building projects these software include Revit, ArchiCAD, lightworks and Autodesk BIM360

Findings related to the challenges of BIM Adoption in the construction industries.

1. There is a relative Low level of client demand of the use of BIM in their projects work which is as a result of unawareness of the benefits of BIM in building construction
2. BIM is not included in the education curriculum at secondary and tertiary level of education
3. Only a few construction professionals and workers are aware of the BIM system and the benefits it brings in the construction process of a project
4. The inconsistent power supply around the state is a high factor affection the adaptation of BIM in the construction industries
5. There is a shortage of BIM skilled personnel or experts in the construction industries in Lagos state that can help in training of more builders on the use of BIM in their projects
6. The government has paid less attention in implementation of BIM in all government approved building project in Lagos state

Findings related to the ways of overcoming the challenges of BIM adoption in the construction industries in Lagos State.

1. The government should formulate and implement policies that will promote the use of BIM in building construction project
2. The government should pay more attention to the construction sector in Lagos state
3. BIM should be included in the secondary and tertiary education curriculum and be taught to technical students to increase its awareness and technical know how
4. construction companies should carry out BIM trainings by experts in the field for workers who are not skilled in it
5. co-operation amongst construction stakeholders should be should be encourage as BIM is a platform that promotes team co-operation

4.10 Discussion of Findings

The result of the findings was presented based on the research question and hypothesis accordingly, posed for the study

The findings of the study on the types of BIM software available in the construction industries in Lagos state revealed that there are various types of BIM software that can be utilized in the construction industries. These software includes Revit, Procore BIM, ArchiCAD, Vectorworks, Bricscad , Digital project, Lightworks, Autodesk BIM360, BIMx BIMx. This revealed that there is a high level of awareness of BIM amongst building construction stakeholders in the building construction industries in Lagos state. The ArchiCAD software has the highest average mean score in the case while allplan has the lowest average mean score. This implies that most clients are only familiar with

ArchiCAD and not allplan software application in the construction industries in Lagos State.

The findings of the study on the level of adoption of BIM software in building projects in Lagos state revealed that majority of the respondent hardly used BIM in their building construction projects. Software which were seen to be mostly utilized was REVIT and ArchiCAD. This suggests a low percentage of BIM adoption in the construction industries in Lagos state. It also suggests that low level of BIM software use can also translates to low level of adoption of BIM in the construction industries in Lagos state. Chan CT (2014) mention that there is still considerably slow adoption of BIM in the industries. Ezeokoli et al. (2016), observed that compatibility between software platforms, level of knowledge awareness, structure/culture of the industries, non-availability of the appropriate technology and infrastructure, and cost of implementation, individual/personal disposition and lack of BIM standards/guidelines are the reasons why most BIM potential remains untapped in Lagos state.

Findings of the study on the challenges of BIM adoption in the building industries shows there are several factors challenging the adoption of BIM in the construction industries in Lagos state these challenges in which all respondent agreed to includes Lack of Constant Power Supply, Lack of skilled personnel or experts in the industries, Lack of readily available access to the internet, Low level of awareness amongst building construction professionals of the invention of BIM , High cost of BIM software,, Lack of government support on the implementation of BIM in building projects, Low level of client demand of the use of BIM in their projects, BIM not included in secondary and tertiary curriculum. This further necessitates a need for immediate solutions to this challenge to enable BIM to be adopted in more projects in the coming future. However, it is important to note that the challenges of BIM are reaped when BIM system is failed to be adopted in totality.

Findings on the study relating to the ways of overcoming the challenges of the adoption of BIM in the construction industries in Lagos state revealed that the respondents all agreed to the items as prospective ways of solving the challenges hindering the adoption of BIM in Lagos state. furthermore, the solution emerged that BIM improves at construction industries; when time, cost, quality, collaboration, power supply improves and becomes effective and efficient. Hypothesis tested showed that there is a relationship between BIM adoption and the solution to challenges. It however showed that these underlying solutions to Challenges of BIM's adoption at construction industries were legal implications, awareness and knowledge, efficiency, versatility, mandate and leadership, and competitiveness

CHAPTER FIVE

SUMMARY CONCLUSION AND RECOMMENDATION

This chapter gives summary of the study, implications, conclusions and recommendations of the research on BIM adoption at construction industries, Lagos State. It also outlines areas for further study

5.1 Summary of the Study

BIM has a great deal of potential to enhance the efficiency of construction projects in terms of design, construction, and maintenance and the adoption of BIM in the construction industries has the ability to address the myriad issues that frequently plague construction projects around the world. Findings from the study revealed that there is a low level of BIM adoption in the construction industries in Lagos state and this may prevent the building industries from fully utilizing the advantages of this cutting-edge technology. The introduction of BIM in the construction industries has the ability to address the myriad issues that frequently plague construction projects around the world. The typical characteristics of construction projects include time and cost overruns, poor quality, rework, waste, disagreements, and a lack of effective communication and teamwork among project participant indicating that there is a huge need to close in on the adoption gap for BIM, which will provide the solution to these issues. One of the hinderance found to BIM adoption was lack of understanding of what BIM is; respondents were still confusing BIM for software; however, BIM is a system. Other hinderances to BIM adoption were found to be, Traditional Procurement System, , training and education challenges rigidity in leadership, fear of corrupt and hidden interest being exposed by transparent BIM cost of implementation, change resistant attitude, complexity of BIM and size of projects, lack of knowledge and awareness, understanding, contractual guidance, BIM skills, case studies, BIM champion, and client’s initiative. The purpose of this study emphasizes on revealing the level of BIM adoption in the construction industries in Lagos state and a need for and more utilization of this technology for a production of better results in all the stages of buildings construction from predesigns stages to maintenance stages of a building project.

Survey approach was taken to develop the study. The questionnaire was the instrument used for data collection for this study and was validated by three lecturers from the department of industrial and technology education of the federal university of technology Minna. A total of fifty (50) validated items were used for this study responded by the respondents who were fifty-one (51) builders and forty-three (43) architects. The data collected from the instrument was analyzed using the mean, standard deviation and t-test for testing the hypothesis at 0.05 level of significance. The study findings showed that there is a need to improve the level of the adoption of BIM in the construction industries in Lagos state

5.2 Implication of the Study

The implication of this study is that construction experts are informed of the barriers, benefits challenges and its solutions associated with BIM adoption, which will have a significant impact on whether clients and management decide to utilize BIM on their projects. Also, the results of this study will be helpful to academicians since they will facilitate the effective and efficient construction of academic curricula for built environment courses that incorporate BIM usage in low-awareness locations. This necessitates further studies using quantitative techniques. Also, a quantitative study to confirm the relationship between the barriers and challenges could reveal the vital few where improvement efforts could be applied (Ahmed and Ahmad, 2011).

5.3 Contribution to knowledge

This study is important in order to know how well BIM has been adopted into the construction industries in Lagos which in turn, would help to critically look at the reasons that could have contributed to its level of use in the industries. This study also impacts the knowledge on us as to how the way of which the issues that have become an obstacle to the expected BIM widespread adoption can be overcome over time so as to start enjoying the benefit of this amazing innovation within the industries.

5.4 Conclusion

From the study carried out, based on the analysis of the findings, it was revealed that the level of the adoption of BIM in the construction industries in Lagos state is low and therefore a high need for its adoption in Lagos state. There is also a low level of use of BIM software packages among the participants of this research. According to the research's findings, professional associations such as Nigerian institute of building (NIOB), Nigerian Institute of Architects (NIA) and Nigerian Society of Engineers as well as other professional bodies in the building industries need to educate their members about the value of BIM in order to reach a critical mass adoption of the technology and maximize its benefits in the construction industries. The study has revealed certain remedies for problems and obstructions to the adoption of BIM, particularly when done collaboratively. One of the biggest obstacles to the adoption of BIM has been recognized as a lack of skilled personnel. This shows just how crucial it is to include BIM instruction in our universities. Lastly if the government at all levels support the industries by providing sound policy framework that favors the adoption of BIM a high rate of BIM adoption will be achieved, producing various benefits in the industries.

5.5 Recommendations

The following recommendations were made based on the findings of the study.

1. Federal Government of Nigeria via the arm of the legislators should enact laws that makes the application of BIM in building construction projects a necessity
2. In order for their employees to gain new abilities and construction techniques like BIM and virtual reality and have a good impact on the construction industries as a whole, Nigerian construction businesses should start training and retraining their workforce abroad.
3. There should be greater collaboration between academia and the construction industry's professional circus in the domain of research-based knowledge in the aspect of recent innovational development in terms of software packages, which can further increase the quality of work done and also the construction industry's professionalism.
4. To qualify for tendering and award for any construction project, a company's proficiency in using BIM should be demonstrated throughout the bidding process for government contracts.
5. Furthermore, development control agencies should incorporate BIM technology into the evaluation of building designs for clearance.

5.6 Suggestion for Further Study

Based on the findings of this research the following suggestions were made for further study

1. Assessment on BIM software brand as a major contributor to the level of adoption
2. the variations in how small businesses, medium-sized businesses, and large organizations approach using BIM.

3. Research on how adoption of BIM affects the work processes in a project and how these can be adapted to streamline practices in the projects.

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APPENDICE I

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA
SCHOOL OF SCIENCE AND TECHNOLOGY EDUCATION
DEPARTMENT OF INDUSTRIAL AND TECHNOLOGY EDUCATION
QUESTIONAIRE

ON

ASSESSMENT OF THE ADOPTION OF BUILDING INFORMATION MODELING (BIM) IN THE CONSTRUCTION INDUSTRIES IN LAGOS STATE, NIGERIA

Dear Respondent,

I am a 500-level student of the department of industrial and technology education of the Federal University of Technology, Minna undergoing a research on **an assessment of the adoption of building information Modeling (BIM) in the construction industries in Lagos state, Nigeria**. The information given shall be used purely for research purposes and nothing else. So please be very honest in answering each of these questions.

PART 1:

PERSONAL DATA

(i) Builder ☐

(ii) Architect ☐

INSTRUCTION

Put a tick (√) below the right columns against the statement. If you strongly Agree with the statement, put a tick under column SA. If you Agree with the statement, tick under column A. If you Disagree with the statement, tick under column D and when you Strongly Disagree with the statement, then tick under column SD.

SA- Strongly Agree	VHL- Very High Level
A- Agree	HL- High Level
D- Disagree	LL- Low Level
SD- Strongly Disagree	VLL- Very Low Level

PART 2
SECTION A
Research Question 1

What are the types of BIM software available in the construction industries in Lagos state?

S/N	**ITEM**	**SA**	**A**	**D**	**SD**
1	Revit				
2	Procore BIM				
3	ArchiCAD				
4	Vectorworks				
5	Google sketchup				
6	Bricscad				
7	Digital project				
8	Lightworks				
9	Telka structure				
10	Allplan				
11	Autodesk BIM360				
12	BIMx				

SECTION B

Research Question 2

What is level of adoption of BIM software in building construction projects in Lagos state?

S/N	ITEM	VHL	HL	LL	VLL
1	Revit				
2	Procore BIM				
3	ArchiCAD				
4	Vectorworks				
5	Google sketchup				
6	Bricscad				
7	Digital project				
8	Lightworks				
9	Telka structure				
10	Allplan				
11	Autodesk BIM360				
12	BIMx				

SECTION C

Research Question 3

What are the challenges of the adoption of BIM in the construction industries in Lagos state?

S/N	ITEM	SA	A	D	SD
1	Lack of Constant Power Supply				
2	Lack of Training Facilities.				
3	Lack of skilled personnel or experts in the industry				
4	Lack of readily available access to the internet				
5	Low level of awareness amongst building construction professionals of the invention of BIM				
6	High cost of BIM software				
7	Adaptation to Traditional Method of Work				
8	Lack of government support on the implementation of BIM in building projects				
9	Cost of Investment				
10	Inadequate Supply of Manpower.				
11	Low level of client demand of the use of BIM in their projects				
12	Lack of cooperation between stakeholders				
13	BIM not included in secondary and tertiary education curriculum				

SECTION D

Research Question 4

What are the ways to overcome the challenges of adoption of BIM in the construction industries in Lagos, Nigeria ?

S/N	**ITEM**	**SA**	**A**	**D**	**SD**
1	Constant Power Supply to motivate the adopting BIM in building construction industry.				
2	Training Facilities to help in overcoming the challenge of BIM in building construction industry.				
3	More skilled personnel or experts in the industry				
4	Reduced cost of internet data to easily and ready use the BIM tools in constructions projects				
5	BIM taught in schools to increase the awareness amongst students and graduates in the industry				
6	Affordable cost of BIM software to encourage its use in the building construction industry				
7	Negligence of old Traditional Method of Work to motivate the adoption of BIM in building construction industry.				
8	Government policies that encourages the use of BIM in all construction projects				
9	Affordable Cost of investment to encourage the adoption of BIM in building construction industry.				
10	Adequate Supply of Manpower motivates the adoption of BIM in building construction industry				
11	Clients' interest in the use of BIM in their projects				
12	Increased cooperation amongst stakeholders				
13	Inclusion of BIM in the education curriculum at secondary and tertiary levels				