CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of Study

Building has evolved through many centuries from dwelling in caves to skyscrapers and recently to intelligent structures that can smartly respond to stimuli in its environment (Azhar, 2010). This view was corroborated by Kiviniemi, Fischer and Bazjanac (2005) that building practice has also undergone a great deal of metamorphosis in response to the dynamic nature of human needs and development. Hence, the submission of Grillo (2010) that building design and construction are processes which traditionally involve several professionals collaborating for relatively short periods to develop a facility for use over a long period. However, most of the building designs have failed to meet user's requirements and functionality leading to inefficiencies in terms of performance of the construction industry.

However, construction industry has been noted for lagging behind other industries in terms of project delivery for the past decade (Eastman, Teicholtz, Sacks and Liston, 2008). This could be adduced to non-collaborative efforts of stakeholders and the fragmented nature of the building processes. This view was in line with Sommerville, Craig and McCarney(2004) that the construction industry is highly inefficient and relies heavily on traditional means of delivering its products and services. Furtherance to this assertion, the report of the study undertaken by the National Institute of Standards and Technology (NIST, 2004) in America assessed the cost of these inefficiencies. The study revealed that the price of new construction was increased by $6.12 per square meter due to inefficiencies within the industry.

However, in 2004, a study was carried out by Lean Construction Institute suggested that as much as 57% of time, efforts and material investment in construction projects does not add value to the final product delivery in comparison to a figure of only 26% in the manufacturing industry.

Moreover, project owners are becoming increasingly focused on deriving more value on their investment; they are aware of the consequences of late delivery, low productivity issues, technological advancement and the demand changes. Furtherance to this concern the Construction Users Round Table (CURT, 2007) generated two white papers urging significant changes throughout the construction processes and recommended the need for consideration of new methods of building project delivery.

Many building owners as well as other institutions and corporate organizations shared these frustrations associated with the traditional methods of construction. This is evident in the increase in the number of projects completed using alternative delivery methods. This implied that building owners are dissatisfied with the traditional Design-Bid-Build process. This view was corroborated by CURT (2007) on the difficulties experienced on typical projects as artifacts of a construction process fraught by lack of cooperation and poor information integration. The submission highlighted typical problems as design errors, omissions, inefficiencies, coordination problems, cost overruns, delay and productivity loses. The study attributed historical reasons for this dysfunctionality to be multiplicity of participants with conflicting interests, incompatible cultures among team members and limited access to timely information.

Tam, Tam, Zeng and Ng (2007) submitted that building process can be grouped into three major phases as: the conception/design phase, construction phase and operation or user phase. The conception/design phase could be described as the period when most of the decisions that influence the performance of the building are conceptualized; the construction phase represents the actualization stage when the capital cost of construction is incurred; and the operation or user phase account for the greatest proportion of time period of the building life span relative to earlier two phases. These phases resulted into the fragmentation of the construction industry. This fragmentation process inhibits widespread change in the building industry. However, Building Information Modeling (BIM) technique replaces this fragmented process with an interdisciplinary approach that consolidates the team efforts (Bernstein and Pittman, 2005).

Tertiary institutions are the third tier of educational system in Nigeria. It is the highest level of education for the development of human capital resources through high level manpower training as contained in the Nigerian Policy on Education (Nigerian Educational Research and Development Council; NERDC, 2004). However, Ofide and Jimoh(2010) noted the consistent increase in the population of students on a yearly basis. The study stressed the need to ensure that higher institutional buildings perform not only optimally but are functional throughout their life-cycles.

Olatunji, Aghimien, and Oke (2016) noted that the appearance of these buildings and infrastructure have implication on the performance of the institution as a citadel of learning. The study posited the need for a high level of maintenance culture in tertiary institutions in Nigeria so that its buildings and infrastructure can perform its function efficiently and effectively. The Committee on Needs Assessment of Nigerian Universities (CNANU, 2012) reported the inadequacy, dilapidated, over-stretched and improvised state of physical facilities for teaching and learning in the South West universities in Nigeria. This assertion underscores the need for tertiary institutional buildings in Nigeria to adopt the policies and practices of building information modeling into building and infrastructural development.

Moreover the costs of financing higher education coupled with dwindling national income according to Bogoro (2015) poses a great challenge for sustainability of high quality higher education in the country.

Construction projects by nature are capital intensive. To meet its infrastructural needs, Nigeria will have to invest $33billion dollar (5.95 trillion naira) annually for the next thirty (30) years (Tsokar, 2015). The National Planning Commission (NPC) projects that a sum of 60billion US dollars would be required for the next five(5) years to drive the national economic development plan of the country. This submission was attested to by Afolayan (2015) that a sum of #522,206,727,294.11 was invested in funding tertiary education in Nigeria between 2009 to 2013 through the Tertiary Education Trust Fund (TETFund). The fund was expended on project development, academic staff training, library development and other high impact projects. Within the same period of report, another sum of #94,129,527,348 was released to federal universities through National University Commission (NUC) for Direct Teaching and Laboratory Cost (DTLC) and for Teaching and Research Equipment (T&RE). This report does not only attest to the high capital outlay required in funding higher institutions in Nigeria. It brings to the fore the need to judiciously utilize the financial resources through the adoption and implementation of BIM principles.

The construction industry is a fragmented sector and it functions in an environment that is full of uncertainty and fast changing in its knowledge management as documented by (Dave and Koskela, 2009).There is always the need for organizations to move in the direction of new knowledge to improve various businesses in the construction industry. However, this does not depict the reality of the state of buildings in the South West Nigeria Federal Universities that were procured through conventional traditional methods.

Summarily, BIM allows multi-disciplinary information to be superimposed within one framework, such that it creates an opportunity for sustainable development and performance analysis throughout the project lifecycle. Therefore, this study intended to appraise the prevalence of BIM with a view to developing a framework for effective public building projects delivery in Nigeria.

1.2 Statement of the Problem

Arayici, Khosrowshahi, Ponting and Mihindu (2009) described Building Information Modeling as lifecycle evaluation concept that seeks to integrate processes throughout the entire lifecycle of a construction project. Hence, the focus of BIM is to create and re-use consistent digital information by the stakeholders throughout the project lifecycle. However, the traditional construction project delivery approach of Design-Bid-Build fragments the roles of participants during design and construction phases. This hinders the collaborative involvement of the general contractor or the construction manager during the design phase. Furthermore, the traditional practice of two dimensional drawings at the design phase does not promote a true collaborative approach in such that the Architects and Engineers produce their own fragmented drawings to relay design information to the owners and the contractors. These drawings are not integrated and usually pose conflicts of information which result in inefficiency in project delivery.

Traditionally, the inter-disciplinary collaboration in the Architecture, Engineering, and Construction (AEC) industries has revolved around the exchange of Two-Dimensional drawings and documents. Amor, Jiang and Chen (2007) noted that even though the separate design disciplines have been using Three-Dimensional models and applications for visualization and design development, the collaboration practices have remained more or less Two-Dimensional-based until recently. The widespread use and proliferation of object-oriented Computer-Aided Design (CAD) packages and increased constructability and level of automation in Tertiary Institution construction processes provides and encourages motives for the exchange of Three-Dimensional data in the collaboration process (Sacks, Treckmann, andRozenfeld 2009).

However most contractors complain about poor design works which lacks better understandingand details. The consequence of this effect call for several meetings with the design teams and it slow down the workflow of all trades undertaken on the said project. Sometimes, the building owner's wishes are not well documented during the beginning of the project. Lack of documenting the important information in the tender documents affects the various construction phases and at the same time the profit margin of the construction company in question is also affected.

According to Abolore (2012), construction project delivery has not received the necessary attention it requires to positively impact on the way construction projects are executed just like other developing countries. Hence, the construction industry in Nigeria has been wasteful and inefficient in its activities of creating human habitat who highlighted some of the problems of traditional method of construction that lead to project delivery and productivity as Design problems, Managerial and supervision of contracts, financial issues, politics, complex problems procedures. The foregoing are pointers to the wide gap that exists in the level of knowledge required for effective implementation of Building Information Modeling (BIM) in south-west universities in Nigeria.

Succar (2009) has been the leading voice in the implementation of BIM thereby establishing the difference between conventional (method) of construction and Building Information Modeling

(BIM). However,most contractors complain of poor design works which lack betterunderstandingand details. The consequence of this effect call for several meetings with the design teams and it slows down the workflow of all trades undertaken on the said project. Sometimes, the building owner's wishes are not well documented during the beginning of the project. Moreso, lack of documenting important information in the tender documents also affects the various construction phases and at the same time the profit margin of the construction company handling the project in question is also affected.

Also, there is lack of construction professional with thetechnical know-how on project managementand execution, due to this most of the tradesmen (artisans) on the sites failed to go for further training in order to acquire more knowledge for project performance.

One of the biggest problems that contractors do encounter day in and day out in the execution of project in terms of projecst handled in the universities iscash flow. Most of the interviewed contractors handling projects expressed their frustration in payment of project execution most especially from governmental projects. Any time there is delay in payment, banks find it difficult to offer contactors funds for their project and sometimes, these cash come with high interest because the banks consider these contractors as higher risk.

Moreover, the method of construction of projects in the construction industry and Universities is Traditional method and this has led to non-delivery of project to time, cost and quality. Also so many projects have been delayed, abandoned not delivered to time in the Federal Universities in the south west such as four blocks of hostel for students, postgraduate buildings in Federal University of Technology, Akure, Faculty Lecture Theatre Hall and Museum at Obafemi

Awolowo University, Ile-Ife, laboratories and offices in Federal university of Agriculture, Abeokuta and Federal university, Oye. But BIM is envisaged to play a significant role in this transformation. However, the adoption of BIM brings with it several barriers, some involving technological, sociological or legal issues. This has brought about reluctance within some firms to adopt BIM as a strategy.

Summarily, as a result of non-collaboration and fragmentation nature of Architect and the Engineer used to design for their clients at the design phase, this has led to non-delivery of projects to time and to quality. the requirements for the deployment of BIM demand a whole paradigm shift in working relationship among professionals in the physical planning units of the study area this will necessitate the need to explain the implementation and adoption of BIM among stakeholders for the selected projects, with a view to developing a framework to enhance effective public building project delivery in the study area.

1.3 Aim and Objectives

1.3.1 Aim

The aim of the study is to appraise the prevalence of BIM with a view to developing a framework to enhance public building projects delivery in the south west, Nigeria.

1.3.2 Objectives

In order to achieve the aim of this research, the following were the specific objectives:

(i) To create awareness of Building Information and Communication in the construction industry,

(ii) To evaluate the problems that could emanate from the adoption of ICT to effective delivery of public building projects,

(iii) To assess the requirements for the implementations checklist of BIM software in public building projects delivery,

(iv) To assess BIM as a management tool for effective public building projects delivery.

(v) To establish the relationship between Traditional 2D (conventional method) and Building Information Modeling (BIM); and

(vi) To develop a framework for BIM for adoption in the physical planning units to enhance effective delivery of public building projects in South-West, Nigeria.

1.4 Research Questions

Based on the three major phases of project lifecycle, the following questions were derived from the statement of problem as:

(i) What is the concept of Building Information and Communication in the construction

(ii) What are the problems that could emanate from the adoption of ICT to effective delivery of public building projects?

(iii) What is the requirement for the implementation of BIM software in public building project?

(iv) How can BIM Management toolbe used for public building project delivery?

(v) Is there any relationship between Traditional 2D (conventional method) and Building Information Modeling (BIM)?;

(vi) How coulda framework of BIM be developed for adoption in the physical planning units to enhance effective public building projects delivery in Federal Universities in South-West, Nigeria?

1.5 Research Hypotheses

Based on objective 4 and 5 respectively, the following hypotheses were formulated as:

H_{o1}: There is no significant relationship between BIM management tool and effective public building project delivery.

H_{o2}: There is no significant relationship between traditional 2D (conventional method) and effective implementation of BIM.

1.6 Significance of the Study

The development of a nation is hinged on its human capital capacity. As a developing nation, Nigerian Bureau of Statistics (NBS, 2014) indicated that Nigeria has a higher percentage of its population (about 60%) to be less than forty-five years old. This implies that a larger percentage of the population is in need of good quality tertiary institutional buildings for human capacity development. This figure is worrisome going by the NEEDS assessment report that majority of higher institutional buildings in Nigeria are in sorry state (CNANU, 2012). It also poses a big challenge to the future of the country considering the huge investment that has been made by the Federal Government in recent years, especially through the TETFUND allocation to educational infrastructure in federal institutions in Nigeria.

Therefore, developing Building Information Modeling as a management tool for effective public building projects delivery in selected federal universities in southwest Nigeria will not only guarantee availability of quality buildings and infrastructure to support the aim of tertiary institutions in Nigeria but will also ensure the sustainability of new buildings and retrofitting the existing buildings for future generation to use.

Construction projects are capital intensive requiring huge capital outlay, as a result of high volume of wastes that are associated with the conventional construction process, up to 25% of the materials are wasted (Hussin *et al*, 2013).The problem of inadequate, poor quality institutional buildings and facilities and environmental degradation due to the increase use and consumption of environmental and natural resources in the provision of buildings and infrastructural facilities will be minimizes if the principles and adoption of Building Information Modeling development is embraced. Arayici, Khosrowshahi, Ponting, and Mihindu (2009) noted that the construction industry has been facing a paradigm shift to increase in productivity, efficiency, infrastructure value, quality and sustainability and also to reduce; lifecycle costs, lead times and duplications**.**

Literature has shown that most of these can be obtained through BIM (Building Information Modeling) implementation and adoption. However, Building information modeling (BIM) is a technology that is currently gaining momentum within the construction industry. It allows buildings to be modeled virtually and stores information about the building in a central coordinated model.

The purpose of implementing BIM in tertiary institutions and in Architectural, Engineering and Construction industry (AEC) is to improve the construction activities, provide the necessary information that will guide the professionals/ stakeholders in the decision making especially in the development/ formulation of policy such as building codes/standards/regulations that will address project delay, abandonment, cost overrun, wastage that arises from the use of traditional method of construction in the south-west Nigeria, it will also reiterate the significance of environmental sustainability, architectural design, and wider content of societal need.

Moreover, in Nigeria content, the implementation of BIM will increase awareness on matters relating to the environment, sustainability and construction techniques. Utilization of BIM and implementation in AEC techniques has numerous advantages to the building industry in the South West of Nigeria. However, the advantages of BIM include increase productivity, quality and sustainability, reduce lifecycle crusts, reduce duplications and reduce time of construction and also consolidate the team effort.

Furthermore, ten critical tertiary facilities issues which BIM will improve are resource scarcity and affordability, performance measurement and accountability, customer service, information techniques, developing the laboratory and classroom of the future, facility reinvestment and total cost of ownership, Workshop issues, Sustainability, Energy resource management, Safety, security and business continuity. Hence, the purpose of this study is therefore, to develop a framework of BIM for effective public building project delivery.

1.7 Scope and Delimitation of the study

The study will center on the application of BIM to public building project delivery. However, since it is absolutely impossible in a given topic of research to exhaust all the issues relating to the topic. The research was thereafter limited to some specific areas of the topic. For this purpose, the scope of this study would be limited geographically and contextually.

By geographical and contextual scope, the study intends to cover South-West, Nigeria. The study shall focus on the impact of BIM on public building project delivery in South-West of Nigeria. However the study shall be limited to the six Federal Universities in South-West, Nigeria. Educational building projectshall entail Tetfund construction projects in the six tertiary institutions in Lagos (University of Lagos), Ogun (Federal University of Agriculture Abeokuta), Oyo (University of Ibadan), Osun (Obafemi Awolowo University Ile-Ife), Ondo (Federal University of Technology Akure), and Ekiti States (Federal Univrsity Oye-Ekiti). The study focused on completed and on-going educational buildings on campus that is meant for teaching and learning only.

The study shall seek information from the professionals in the physical planning units of the universities on how they have been making use of BIM tools and BIM software in planning, design, engineering, quantifying and construction of educational facilities and infrastructures in the delivery of projects.

1.8 The Study Area

The Southwest Nigeria is made of the following states:

(i) Lagos State

University of Lagos,

Lagos State is located in south west geopolitical zoneofNigeria. It is smallest in area out of Nigeria's 36 states. Lagos State is the most viable economical state of the country. However it is the nation's largest urban area. Lagos lies between longitude 6° 31' 0"and latitude 3° 22' 10".It is bounded on the North and East by Ogun State.In the West it shares boundaries with the Republic of Benin while its southern borders lay theAtlantic Ocean. Twenty two percent (22%) of its 3,577 km^2areas are lagoons and creeks. When the colony and protectorate of Nigeria was established in 1914, Lagos was declared as capital. Lagos experienced rapid growth throughout the 1960s and 1970s as a result of Nigeria's economic oil boom prior to the Biafran War. This continued through the 1980s and 1990s up to the present date.

The University of Lagos is located within the terrain of Lagos State. UNILAG was founded in October 22, 1962. The University of Lagos has provided qualitative and research-oriented education to Nigerians and all those who have entered its domain in search of knowledgefor over 5 decades. The University has built a legacy of excellence and has been instrumental in the production of top rank graduates pand academia that have had tremendous impact, directly or indirectly, on growth and development in Nigeria. UNILAG comprises of 1,123 Academic staff and 1,065 Administrative staff and 57,183 students. It is located in Akoka area of Yaba in Surulere local government of Lagos state.

Fig 1.1: Map of Nigeria Showing 36 states of the Federation

Source: National Space Research and Development Agency (2013).

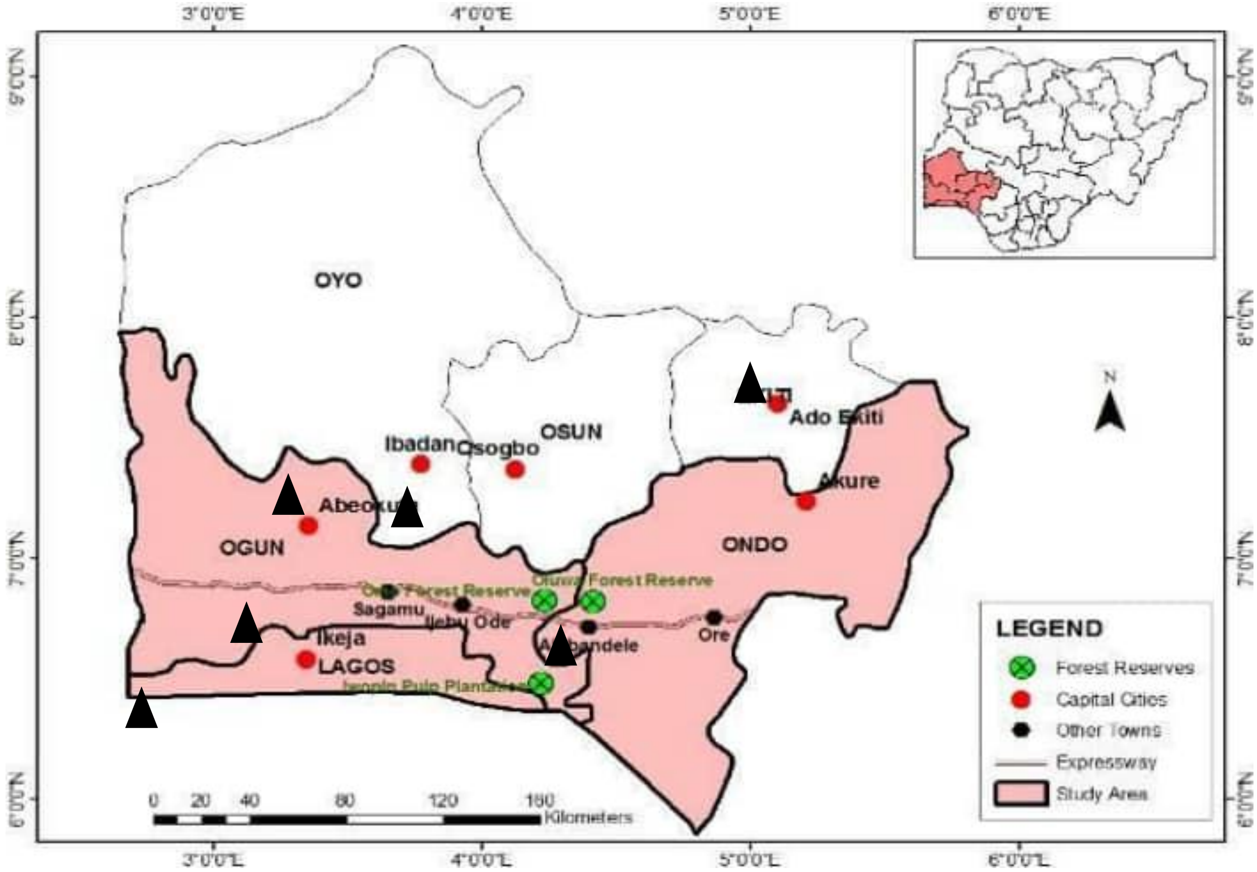


Fig 1.2: Map of South-West showing the Location of Tertiary Institutions in the Study Areas.
Source: National Space Research and Development Agency (2013).

(ii) Ogun State

Federal University of Agriculture, Abeokuta

The Federal University of Agriculture, Abeokuta, Ogun State is a Public University. Itwas established on 1st January, 1988 alongside with other four universities of technology.On the same date, Professor NurudeenOlorun-NimbeAdedipe was appointed as the pioneer Vice-Chancellor of the university. Professor Adedipe officially assumed duty on 28 January, 1988. The university started from Abeokuta Grammar School, Isale-Igbehin near the city centre when the permanent site was completed the school moved to its permanent site in December 1997 on a 10,000-hectare which is located next to the Ogun-Osun River Basin Development Authority along Abeokuta-Ibadan road.

In October 1988 five colleges were introduced in the university as follows: College of Agricultural Sciences, College of Natural Sciences,College of Agriculture Management, Rural development and Studies, which was later changed to College of Agriculture Management and Rural Development,College of Animal Science and Livestock Production,College of Environmental Resources Management,College of Plant Science and Crop Production.

In March, 2002two additional Collegeswere introduced as College of Engineering and College of Veterinary Medicine. Also in 2008/2009 session, the College of Agricultural Management, Rural Development and Consumer Studies were spitted into two, with two new colleges emerging as follows: College of Food Science and Human Ecology,College of Agricultural Management and Rural Development. The newest college is College of Management Sciences.

(ii) Oyo State

University of Ibadan

University of Ibadan originated from Yaba College in 1932 in Yaba, Lagos state as the first tertiary educational institution in Nigeria. In 1948It was moved to its permanent site and named University College of Ibadan. In 1963, Rt. (Hon.) Sir AbubakarTafawaBalewa became the first Chancellor of the university. The first Nigerian Vice-Chancellor of the university was Kenneth Dike, after whom the University of Ibadan's library was named.

It is the oldest and one of the most prestigious universities in Nigeria. It is located 8 kilometers from the centre of Ibadan in South West,Nigeria.Besides College of Medicine, there were eleven other faculties: Arts, Science, Agriculture and Forestry, Social Sciences, Education, Veterinary Medicine, Technology, Law, Pharmacy, Public Health, and Dentistry.

In September 2016, UI became the first Nigerian university to top 1000 of Higher Education rankings. Prior to that, it had always made top African 10 in Webometrics Rankings. However, the vision of the management is that UI becoming one of the top 100 universities in the world in the nearest future.

(iii)Ondo State

Federal University of Technology,Akure

The Federal University of Technology, Akure (simply called FUTA) was founded in 1981by AlhajiAliyuShehuShagari to create universities that specialised in producing graduates with practical as well as theoretical knowledge of technologies.

The University has Seven Schools: School of Agricultural and Agricultural Technology,School of Science,School of Earth and Mineral Sciences, School of Environmental Technology, School of Engineering and Engineering Technology, School of Management Technology. The school runs pre-degree science programs and university diploma programs. By August of the same year, government appointed the pioneer chancellor, HRH AlhajiZulkarnainiGambari Mohammed, Emir of Ilorin along with other 13-membersGoverning Council. While Late Chief (Dr) Gabriel Akindeko was appointed as the pioneer pro-chancellor and chairman of the Governing Council in October of the same year.

On November 19, 1981, late Professor Theodore Idibiye Francis was appointed as the Vice-Chancellor of the University.FUTA has over 15,000 students while 13,000 were undergraduates and 2000 as Postgraduates, the colour of the school is purple and the motto of the school is ‘‘technology for self-reliance’’. Federal university of technology Akure has been ranked the 8th best university and firstuniversity of technology in Nigeria by Webometrics ranking as at 2015.

(iv) Osun State

Obafemi Awolowo University,Ile-Ife.

ObafemiAwolowo University (OAU) is a public and federal government owned university. It is located in ancient city of Ile-Ife, Osun State, Nigeria. The university was founded in 1961 and academic activities commenced in October 1962 as the University of Ife by the regional government of Western Nigeria, led by late Chief Samuel LadokeAkintola, and was renamed ObafemiAwolowo University on 12 May, 1987 in honor of Late Chief ObafemiAwolowo (1909–1987).

The University started with five faculties namely: Agriculture, Arts, Economics and Social Sciences, Law and Sciences. Another five faculties were added to the existing one as: Faculty of Education, Faculty of Pharmacy, Faculty of Administration, Faculty of Environmental Design and Management and Faculty of Health Science.

The motto of the university is "For learning and culture". University of Ife is ranked as the most productive university in Nigeria by the National Universities Commission (NUC). It has more than 20,000 undergraduates’ students and 6,000 postgraduate students. OAU Ile-Ife lies on longitude 7^o 31 06$^{''}$ N and latitude 4^o 31$^{'}$ 22$^{''}$ E. The color of the school is Midnight Blue and Gold. The campus has an eye-catching landscape built on about 5,000 acres (20 km^2) out of a total of 13,000 acres (53 km^2) of the land owned by the university.

(v) Ekiti State

Federal University Oye-Ekiti

Federal University Oyeis a public and government ownedNigerian university. It is located in the ancient city of Oye-Ekiti, Ekiti State, Nigeria. The university was founded in 2011 by the federal government of Nigeria, led by President GoodluckJonathan.Federal University Oye-Ekiti offers undergraduateprograms in different fields of specialization. The university has 5 faculties: Agriculture, Arts and Humanities, Social sciences, Engineering and Pure sciences and The school had its first graduating students in 2016.

The Motto of the University is ‘‘Innovation and Character for National Transformation”. The pioneer Vice Chancellor, was Professor ChineduOsitadinma Nebo, (OON), while the present Vice Chancellor Professor Kayode Soremekun was appointed by President Muhammodu Buhari (GCFR). It has two campuses, one at Oye-Ekiti and Ikole-Ekiti and 30 academic departments. The vision of the University is to become an academic giant, pacesetter among universities of the World, in terms of quality scientific research and innovative teaching.

1.9 Structure of the Thesis

The thesis consists of six chapters, which have been organized in a logical manner in order to enable the reader to appreciate the thought of the author in achieving the objectives of the study, the chapters are organized as follows:

Chapter One: Introduction

This is a general introduction of the research theme and the nature of the problem investigated. The chapter made a brief review of previous works on Building Information Modelling and identified the research gap, which the present study focuses on. The aim, objectives and benefits of the research are also stated in this chapter.

Chapter Two: Literature Review, Theoretical and Conceptual Framework.

Chapter two explains the theoretical perceptions and facts about Building Information Modeling. It identifies theories relating to BIM and empirical studies by earlier researchers or BIM. It also reviewed the philosophy of information management system in the construction industry within the content of educational system in Nigeria.

Literature review: examines Building Information Modeling (BIM) within environmental planning, design and development, optimization, safely and code checking construction and its benefits and overview of BIM for project delivery. Also particular considerations were given to physical planning units of the institutions.

Chapter Three: Research Methodology

Chapter three discussed the methodological issues such as research design, research population, sampling frame and sampling techniques, data collection and analysis couple with the reason for the choice. The chapter also dealt with important issues of questionnaire for data collection, measurement of scales and questionnaire administration. Statistical methods employed and justifications for its use were also substantially dealt with.

Chapter Four: Data Presentation, Analysis and Discussion of Results

Chapter four presented the findings of the research from the survey analysis. It presents data obtained on general views of respondents on Building information and communication, requirements for the implementation of BIM, as a management tool for project delivery; and relationship between traditional method and BIM in Federal Universities in South West, Nigeria. It also indicates the scoring parameters for the identified criteria for assessing framework of BIM for project delivery.

Chapter Five: Summary of Findings, Conclusion and Recommendation

This chapter contained the discussion of findings, conclusion, recommendations arising from the study and suggested areas for further research.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

The purpose of literature review is largely to explore the theoretical perceptions and facts about Building Information Modeling more specifically as it relates to public building operation delivery.This section was used to synthesize current literature that is germane to public building project delivery. This section also identified the gap in the literature and provided the methodological approaches used by earlier researchers with a view to formulating appropriate methodology for the study. It is divided into five sections based on the objectives. This section also reviewed the underlying philosophy of information management system in the construction industry within the context of educational system in Nigeria.

2.1 Theoretical and Conceptual framework

2.1.1. Theoretical Framework

The purpose of this section is to explain the theoretical perceptions and facts about Building Information Modeling (BIM).It also synthesize current literatures that are germane to the public building project delivery. It further elucidates theoretical framework that identify theories relating Building Information Modelling (BIM) and empirical studiesby earlier researchers on BIM. This section identified the gap in the literature and provided the methodological approaches used by earlier researchers with a view to formulating appropriate methodology for the study. It is divided into three sections: theoretical framework, empirical studies and conceptual framework and reports on different author’s findings on BIM and public building projects. This section also reviewed the underlying philosophy of information management system in the construction industry within the context of educational system in Nigeria.

2.1.1.1 Applicable Theories

The basic theory behind Building information modeling is well described by Thompson and Miner (2007) that if all relevant data connected to a project were stored in a single online system, the project could be executed in a virtual environment first. The dimensions of time (scheduling) and costs are added to the model this enables easy cost-time-benefit analysis of different options almost instantaneously.

Several existing theories informed the initial analysis of BIM concepts and their relationships. These theories offered clear insights into how to understand complex knowledge structures and their component parts. However, when attempting to apply these established theories to clarify the knowledge structures underlying the BIM domain and to develop practicable tools based on these constructs, the limitations of each theory became evident.

Five theories will be considered and discussed as applicable guide to this study in order to facilitate Building Information Modeling understanding as (i) System theory, (ii) System thinking, (iii) Diffusion of innovation, (iv) Technology acceptance model and (v) Complexity theory.

(i) Systems Theory(as applied to Organizations and Management):

Systems theory provides a framework by which groups of elements and theirproperties may be studied jointly to understand outcomes (Chun,Sohn, Arling, and Granados, 2008). Using

Systems Theory, BIM can beanalyzed as either an abstract system or as a system of systems. While BIM can be considered in many aspects as a System of Systems (Cerovsek, 2012), such an approach does not allow the analysis of BIM concepts andrelationships from a non-systems' perspective. Also, systems theory is applicablein understanding machine to machine and human to machine interactions, but the theoryisnot applicable in understanding human to human interactions.

(ii) Systems thinking**(**as applied to Knowledge Management)

Systems thinking focus on causes rather than events, but do not isolate thesmaller parts of the system being studied. Rather, it considers the numerous interactions of the system in question (Chun *et al*., 2008). BIM can be analysed as a knowledge systemleveraged to achieve organizational and industrial goals. Systems thinking can identify drivers of successful BIM implementation. However, actual implementation steps cannot be identified. Tofacilitate BIM implementation, both activities and causes/effects need to beunderstood. Also, granular parts of the knowledge system and their interactions are as important to analysis as the knowledge system itself.

(iii) Diffusion of Innovation (DOl)

DOI theory attempts to define the process by which an innovation iscommunicated through certain channels over time among the members of a social system (Rogers, 1995). DOI theory seeks to explain thedynamics of why/how a new technology spreads. Through DOI, the diffusion of BIM -as an innovative technological solutionspread across the constructionindustry - can be analysed(Mutai, 2009). However, DOIdoes not facilitate the understanding of BIM as an interacting set of technologies, processes and polices; nor does it facilitate the generation of practicableperformance improvement tools.

(iv)Technology Acceptance Model (TAM)

TAM theorizes that an individual's acceptance of a new technological solution isinfluenced by its perceived usefulness and ease of use. TAM incorporates severaltheoretical constructs including subjective norm, voluntariness, image, jobrelevance, output quality and result demonstrability (Venkateshand Davis, 2000).TAM is regarded as a technology driven solution, and by extention.BIM adoption by individuals and by project teams - can be analysed under this model. However, this model cannot be applied to organizational systems, or to identify the relationship between project teams.

(v) Complexity Theory: Complex systems are comprised of a large number of components and causalconnections amongst them. Each component is self-contained yet shows a high degree of synergy with other components - where the whole is more than the sum of its parts (Froese, 2010). Understanding BIM as a complex systemallows the identification of its components and their interconnectedness. However, like many other established theories, Complexity Theory does not facilitate the development of practicable performance improvement tools.

In summary, the theories described above can be applied in analyzing and developing BIM concepts and its relationships with each other.

2.1.2. Conceptual Framework

Creswell (2009) described framework as an image or symbolic representation of an abstract idea. In this context, it is the researcher's position on the research problem and show relationship that exists between different constructs that the study intends to explore. Based on the literature review the use of BIM tools for construction managers include visualization, 3D coordination, prefabrication, construction planning and monitoring, quantity take offs, and record model while Project savings will be considerably high if Building Information Modeling is used during the early design phase of the project.

However BIM has been promoted as an enabler of innovation in construction because of its data management capabilities and the opportunities for interdisciplinary work based on it.

A conceptual continuum is proposed based on functionality/technology centered and non functionality/ human centered perspectives on BIM to consider divergent arguments about its innovative capability; this continuum is used to analyze empirical findings from BIM enabled design practices.

The important variables in the contemporary issues and challenges of BIM will be elucidated in literature review and theoretical basis. This section is therefore hinged on certain construct and concepts that will form basis for developing the research BIM framework.

2.1.2.1 Existing Framework

Jallow*et al.*,(2013) observed that changes occur in all phases of construction project, and it is essential to implement an appropriate change management (CM) regime to reduce change-associated to cost and time delays. Sun *et al.*, (2004) corroborated that if changes are not properly managed, it can cause direct and indirect consequences and this will form major concern on direct effects of cost of rework and time overrun, which is generated from uncertainties and poor information communication.

Liu *et al.,* (2013) noted that previous research has emphasized the importance of work in BIM Data Hub which includes the retrieval of domain specific information (i.e., the exchange requirements specified in (MVD) from Industry Foundation Class (IFC) models for energy analysis. Thus retrieved information can be used, for example an engineer (e.g. lighting engineer, mechanical engineer, etc.) to carry out simulations. In this process, changes may be recommended for better energy performance, and such changes should be collated adequately and updated on BIM models.

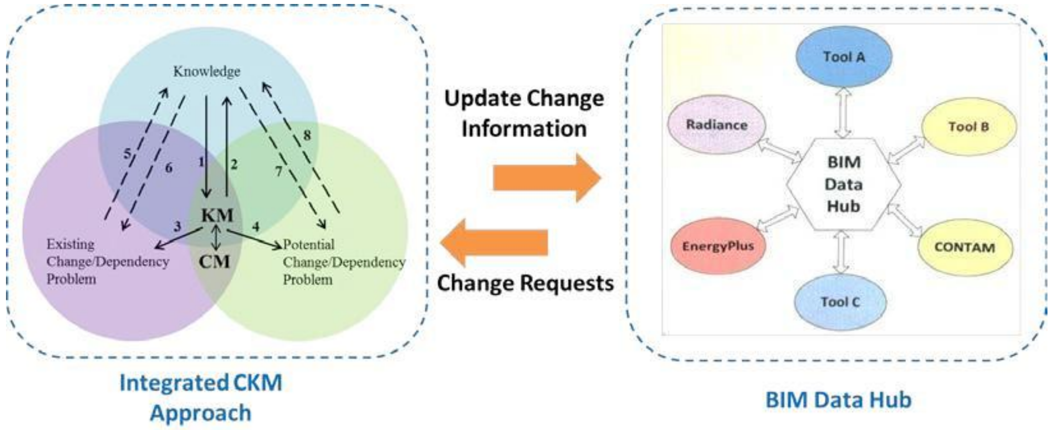
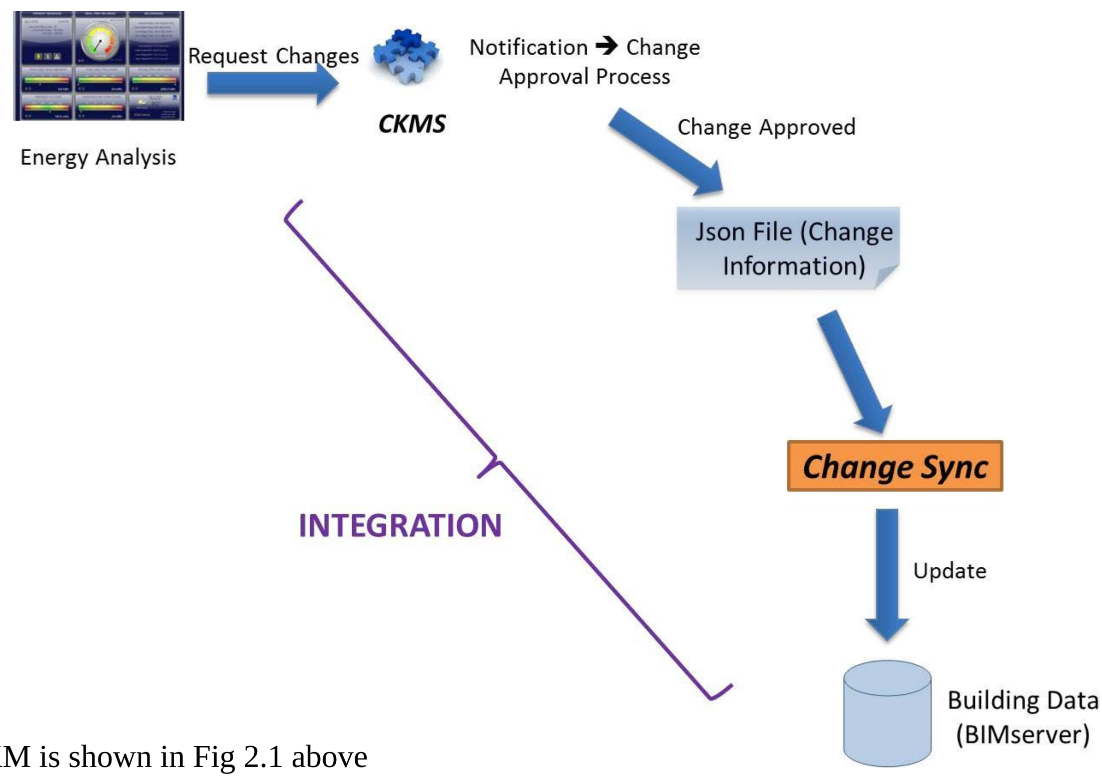


Figure 2.1: Adoption of the integrated CKM approach



CM-CKM is shown in Fig 2.1 above

Figure 2.2: Framework to integrate CM with BIM

Source: Liu *et al.*, (2013).

However, The CKM approach was developed to enhance the performance of project management work and facilitate energy efficient building retrofits. The integration of Change Management (CM) and BIM was achieved by adopting the change management aspect of the CKM approach to enable information update of an IFC model.

Also, the framework below categorizes and specifies features and technical requirements for a BIM-server to serve as a collaboration platform. As with earlier studies on requirements for collaboration platforms (Duke, 2000, and Maher, 2005)the study found that BIM server should provide technicalfeatures to support information sharing, communication media, process management, exploration space, privacy and flexible system configuration. In addition, the development of BIM-server technologies should not be limited to functional and operational requirements only because AEC projects are mostly multi-organizational and multi-disciplinary. This implied that among other factors, lack of history and experience, conflicting goals, and varied roles and responsibilities inhibit adoption of groupware technologies. These findings conform to the prior research on group support systems for multi-organizational collaboration (Gallupe, 2000). Therefore, apart from the technological capability to support the collaboration requirements of diverse user groups, BIM-servers provide adequate supporting features to assist the users in assessing, designing and implementing the BIM approach, contingent on the project requirements. As a result, the developed features and technical requirements have been broadly grouped as operational technical requirements and support technical requirements.

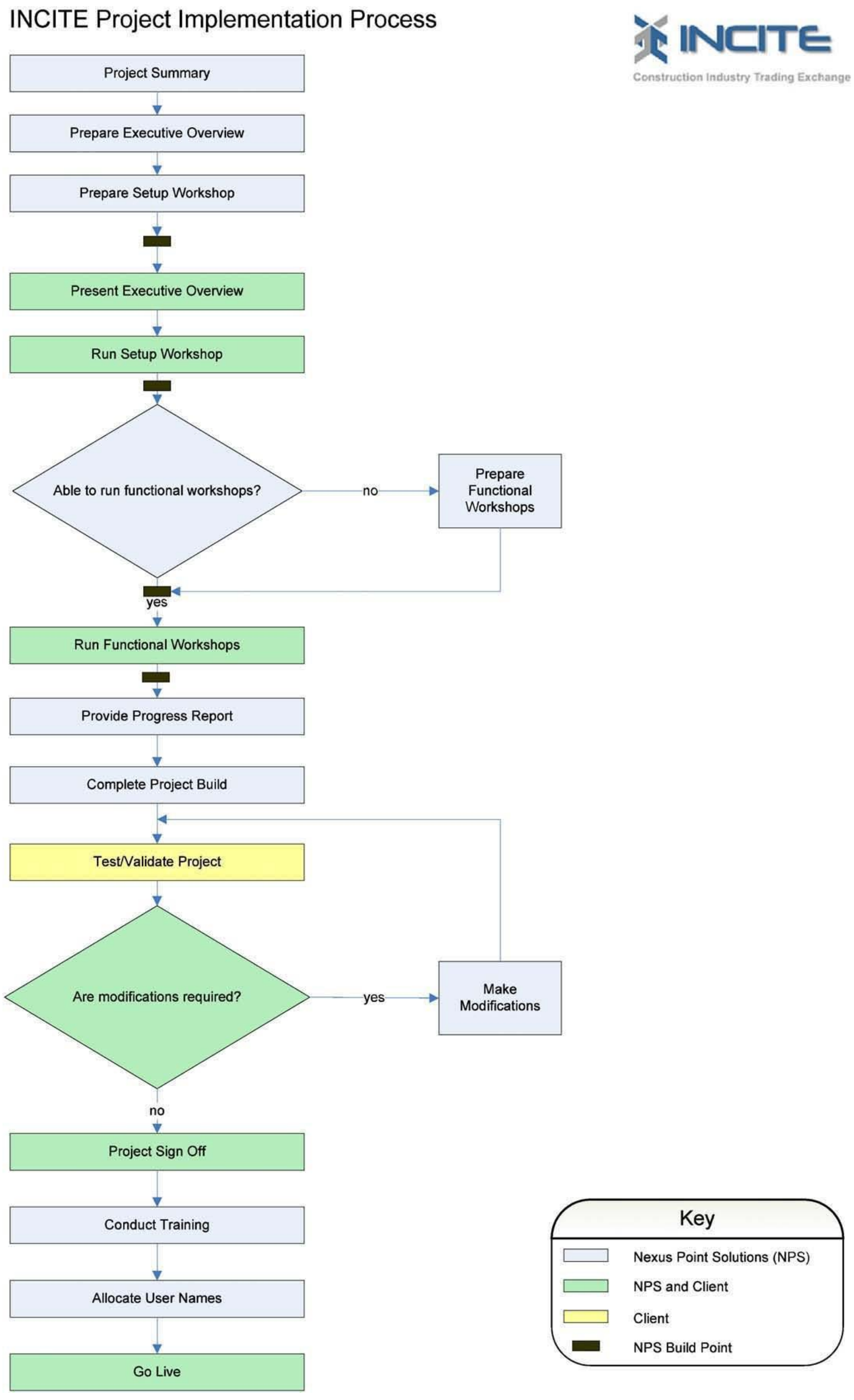


Figure 2.3: Framework for Project implementation process

Source: Jallow*et al.*, (2013).

Jallow*et al.*,(2013) observed that changes occur in all phases of construction project, and it is essential to implement an appropriate change management (CM) regime to reduce change-associated to cost and time delays. Sun *et al*., (2004) corroborated that if changes are not properly managed, it can cause direct and indirect consequences and this will form major concern on direct effects of cost of rework and time overrun, which is generated from uncertainties and poor information communication.

Succar, (2015) in his framework explained BIM concepts with focus on its applicability and update within historic preservation in the AEC sector. The framework of Historic Building Information Modeling (HBIM) bridges the knowledge gap by articulating issues regarding the technology of surveying methodologies with other informational, technical, and organizational issues of BIM. However, the framework provides an initial background for developing more comprehensive study related to HBIM implementation in historic preservation and management where HBIM database is used to gather information and make it available to researchers, professionals, and other parties involved in historic building preservation.

The framework demonstrates the vision that focus holistically on people, technology, processes, and policy to increase the impact of BIM on society and support management of historic buildings where a collaborative decision making is essential to a successful HBIM implementation. Thus, moving to HBIM is a much larger change, and thus requires both top-down and bottom-up approaches and the four pillars to be integrated simultaneously.

The developed framework was chosen from an existing framework and it will form the spring board for this study as shown in Fig 4.

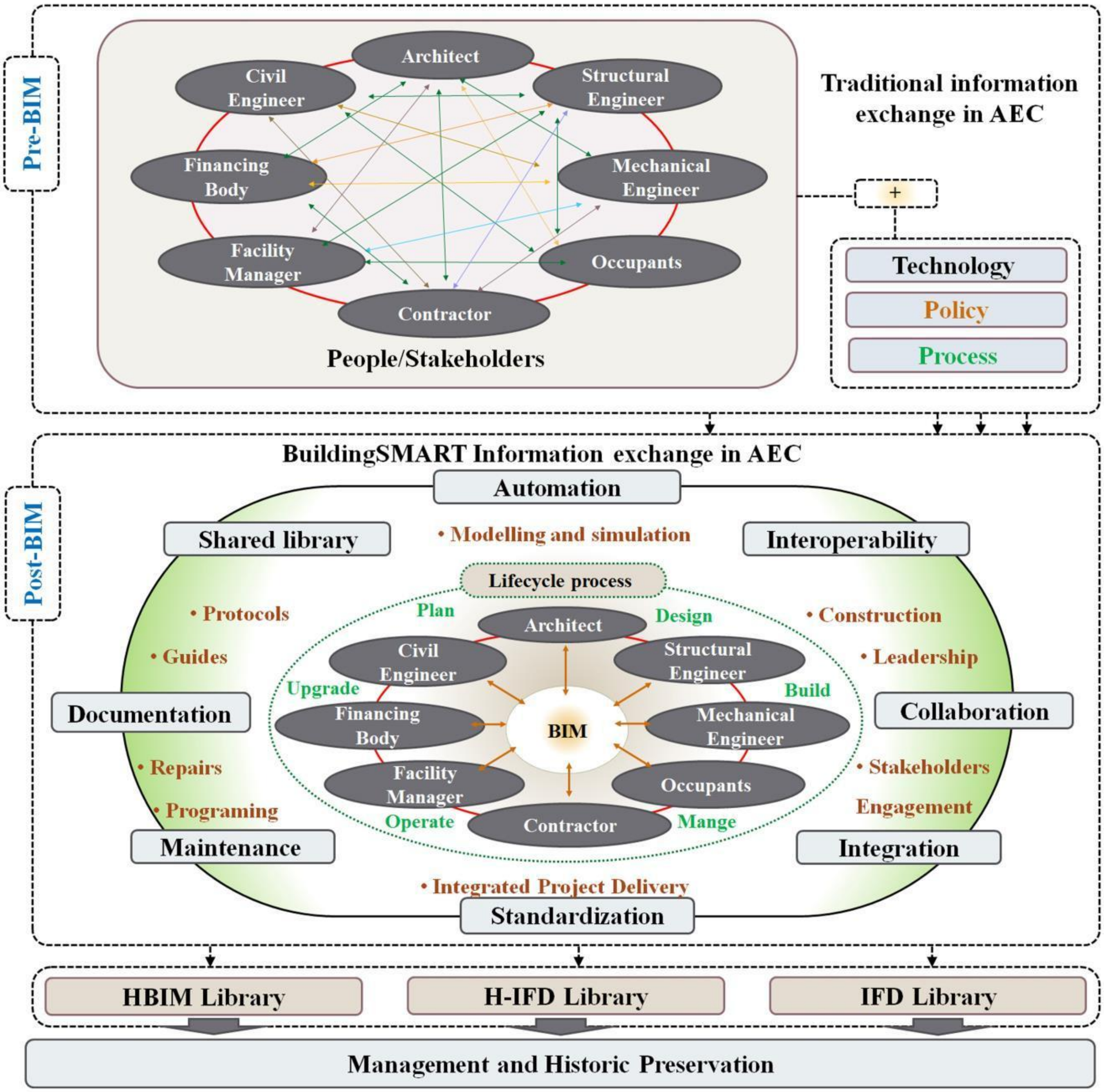


Figure 2.4**:** framework of Historic Building Information Modeling

Source: Succar, (2015)

2.1.2.2 Research Framework

Taylor and Levitt(2005)noted thatBIM is a catalyst for change poised to reduce industry's fragmentation, improve its efficiency/effectiveness and lower the high costs of inadequate interoperability. These assertions was corroborated by (Bernstein, 2005) which carried out several mental constructs derived from organizational studies, information systems and regulatory fields such divergence and coverage, hence highlights the lack of and the necessity for a research framework to organise domain knowledge which, in turn, requires a systematic investigation of the BIM domain.

However,Kimmance (2007)opined that BIM is an integration of product and process modelingand not just a disparate set of technologies and processes he explained further that lack of and a necessity for a framework that attempts to bridge the chasm separating academic from industrialunderstandings of BIM by providing a research and delivery structure adaptable to their complementary unique requirements.

Arayici *et al.*,(2009) noted the implementation of BIM in the construction industry and the use of ICT technologies is to streamline the lifecycle processes of a building and its surroundings to provide a safer and a more productive environment for its occupants. In this regard the implementation BIM has become a challenge to the AEC industry.

In this study the framework will focus on three fundamental phases: (i) Policy, (ii) Process and (iii) Technology (PPT) as a road map to understand the knowledge structures of BIM implementation.

(i) The BIM Policy Field

Policies arewritten principles or rules to guide decision-making. The Policy Field clusters a group of players focused on preparing practitioners, delivering research, distributing benefits, allocating risks and minimising conflicts within the AEC industry. These players do not generate any construction products but are specialized organisations like insurance companies, research centres, educational institutions and regulatory bodies which play pivotal preparatory, regulatory and contractual roles in the design, construction and operations process.

(ii) The BIM Process Field

Process is "a specific ordering of work activities across time and place, with a beginning, an end, and clearly identified inputs and outputs: a structure for action. The Process Field clusters a group of players who procure, design, construct, manufacture, use, manage and maintain structures. These include facility owners, architects, engineers, contractors, facility managers and all other AEC industry players involved in the ownership, delivery and operations of buildings or structures.

(iii) The BIM Technology Field

Technology is the application of scientific knowledge for practical purposes. The Technology field focuses on a group of players who specialises in developing software, hardware, equipment and networking systems necessary to increase efficiency, productivity and profitability of AEC sectors. These include organisations which generate software solutions and equipment of direct and indirect applicability to the design, construction and operation of facilities.

Therefore the research framework for this study is to focus on the core BIM modeling workflows and its deliverable standard which specify the asset models and its downstream use in other lifecycle of project phases. Using a system theory approach of input – process (techniques/tools) -output (IPO) model, the BIM phases are (i) Policy, (ii) Process and (iii) Technology (PPT) would be regarded as affective factors that influence collaboration among various project stakeholders.

The system theory will be further linked to set theory generated by Venn diagram to explain union and intersection between policy, process and technology members.

a----Policy/Process Overlap (AUB): The industry body (BIM Player) and continuous Professional Development training (BIM deliverable)

b------Policy/Technology overlap (AUC): Interoperability standard (BIM deliverable)

c------Process/Technology overlap (BUC): Communities of practice (BIM Player)

d-------Policy/Process/Technology overlap: BIM implementation (BIM deliverable),BIM specialists and individual and groups(BIM Player).

AUBUC-----------Collaboration and data management

The union is a collaboration and data management framework to control the sharing of relevant and accurate information to all the project stakeholders while the interaction is to integrate the shared information.

AnBnC-------------Integrate analysis

During each lifecycle phase people need to analyse integrated asset models. And this analysis start at 2D, then proceeds to 3D, 4D (time), 5D (cost) and to greater complexity.

2.2 Review of Empirical Studies

Previous research had provided a general path towards potential improvements of project delivery through the use of BIM. There have been a number of research studies in the area of operation research and decision sciences that illuminates some fundamental problems. Examples of such studies indicated areas where BIM are applicable. These include Rischmoller *et al.*, (2006) that worked on how BIM reinforces the core construction processes by using a set of learn principles approach as a theoretical framework in other to evaluate the impact of Computer Advanced Visualization tools. The value was generated during the design stage of the project was the main focus. This study was carried out over a four year period by making use of (CAVTs) application which improved flow and better customer value. However, this application programme did not incorporate activity on waste reduction on project. Enhassil and Abuhamra (2017) carried out another research on challenges to the utilization of BIM in Palestinian construction industry (Gaza Strip).The study made use of quantitative survey approach involving professionals. The study revealed 18 main challenges to the utilization of BIM. Notably this approach did not conduct awareness program for stockholders regarding BIM benefits utilization either BIM can minimizes project time or cost or quality on construction projects independently and not simultaneously.

Rezgui *et al.*, (2013) criticized government approach from BIM management across life cycle and supply chains using mixed models of information delivery, based on this assumption that cannot understand the essence of BIM lenses and filters applied these to modal views. Therefore, an exploratory effort did not apply the three capability stages as basis for its governance model, yet need modifiers for its connotations in a useful manner.

Kim *et al.,* (2013) developed a framework for automated space use in construction industry, however the formulation of these framework did not view the knowledge domain in an organized manner, hence the implementation on the use of the modal method was not carried out.

Hossain (2013) studied selected firms that have successfully carried out BIM implementation; he noted that this involves fundamental change in the working procedure in project delivery process. The study noted the key challenge to the adoption of this BIM is a cultural shift.

Other researchers (Tom and Cerovsek, 2011, Succar 2009) have acknowledge the support of communication activities between different participants that are involved in design and construction projects as the benefits that BIM systems has offered but has neglected the support of seamless information exchange interface of BIM systems between the applications.

Hardin (2009) stated that information produced in a BIM project is intended to be routinely shared (when, what, who, how). He stated that version control and updates needs to be maintained on the model. Also when BIM software is used in detailed modeling it creates large file sizes, making it difficult to use it in project sequencing (Ford, 2009).The BIM adoption rate is slower within the AEC industry than anticipated (Arayili *et al.*, 2011). Eastman *et al*, (2008) identify challenges in implementing BIM. Succar (2009) explores BIM framework where conceptual parts were identified and its application are provided. The framework explained the deliverables. However, the study showed that BIM maturity stages were identified by implementation maturity levels are delineated and allows unforeseen future advancement in technology. Penttila (2006) in his study noted that BIM is more than a 3D CAD system that creates a building's geometrical data, but a methodology essential to manage. The project data in a digital format throughout the building's lifecycle may be through interacting policies, processes and technologies. The study finds out that BIM aid encourages waste reduction was not the main focus.

Hatmann *et al.,* (2012) advocated that one of the main advantages of the implementation of BIM based tools is the global improvement of all project processes for all organizations that work together on one construction project. It focuses on a number of business processes on one single organization within a project. The study provided full leverage of all the benefits on such global project level. BIM thinks pace and compassions with other BIM maturity framework were carried out by (Dib *et al.* 2012). Succar (2013) offered a comprehensive framework based on a comparatively exhaustive review of precious research effort but the area of information management was very weak. Inibjorg, (2011) studied selected firms and organizations within the Icelandic AEC sector, the study is pursued by reviewing implementation processes within public organizations in five countries. The results were compared and the gap identified that the implementation process where regulations on BIM use on public projects are lacking. Trevor (2012) investigated the industry uptake of 4D and BIM the factors affecting its usage. Empirical industry survey of consultants and contractors involved in the UK civil and building industry were used in other to depict a holistic view of the issues hindering the industry uptake of 4D and BIM, existing knowledge and the depth for usage, levels of understanding benefits. The research work needed to be directed to non-technical identified issues because the technology, end-users and processes were not bridged. The work is not directed to non-technical issues due to the fact that technology, processes and end users were not bridged.

Aouad *et al.,* (2005) noted that BIM is capable of negotiating and collaborating to bring about new designs but the study did not work on the true way of analysis of design decisions. Kahnzode (2007) in his study identifies benefits of 4D modeling in a case study by applying a 4D modeling co-ordination within sub-contractors schedules. The model allows visualization of tasks and relationship between work of different sub-trades and equipment placement. The study was unable to visualize critical path method schedule of interdependencies between activities.

Jallow*et al.,* (2013) observed that changes occur in all phases of construction project, and it is essential to implement an appropriate change management (CM) regime to reduce change-associated to cost and time delays. Sun *et al.*, (2004) corroborated that if changes are not properly managed, it can cause direct and indirect consequences and this will form major concern on direct effects of cost of rework and time overrun, which is generated from uncertainties and poor information communication. Liu *et al.,* (2013) noted that previous research has emphasized the importance of work in BIM Data Hub which includes the retrieval of domain specific information (i.e., the exchange requirements specified in (MVD) from Industry

Succar (2015) in his study provides an initial background for developing more comprehensive study related to HBIM implementation in historic preservation and management it shows HBIM database and how it be used to gather information and make it available to researchers, professionals, and other parties involved in historic preservation. Thus, this model can represent a challenge with a high scope for further investigation into technical requirements and legal risks the study is useful for architects and researchers in the field of heritage conservation and, therefore, contributes to a major shift in architectural thinking, while shedding light on the future of architecture and its relation to other scientific disciplines.

However, BIM has become a proven technology, and is no longer in its infancy. There are still a number of are achieving efficiencies by introducing an order of precision. The construction industry in Nigeria has been accessed of being stalled and there is a great need for improvement. Failures and errors are arising due to multifarious causes and occur in all steps of the construction process. Hence, there is a great need for enhancing the whole construction process to obtain buildings of better quality, reduce cost, minimize project time and improve productivity. Therefore, there is need to develop a robust framework that can help construction stakeholders (professionals) in generating and evaluating all the feasible trade-off between project time and cost in order to select an optimal schedules that satisfies the project requirement with respect to time, cost and quality.

Therefore, the aim of this study is to develop a framework for BIM in Federal Universities in South-West, Nigeria. The outcome of the study will produce a framework to help decision makers in tertiary institutions with a software development that is capable of generating information, collaboration and resource utilization plans to time, cost and quality delivery of projects.

2.3 Concept of Information Management

Dave and Koskela (2009) opined that the construction industry is unique in its work environment and the distributed nature of stakeholders. Although it shares many similarities with the manufacturing industry with regards to production processes and systems, its output is usually one of its kinds, prototype like products. Also, the construction industry is centered on project based operations that are carried out by many different parties which may be geographically dispersed. Eastman *et al*., (2014) stated that as diverse organisation entities are involved in the construction process, each of the project participants and organisation has different goals to accomplish in the project. Construction process requires collaboration between and among the project participants while the contractor should be able to communicate in a clear and concise channel.

Information plays a vital role in all stages of construction such as design, production, organisation, process and management. Foley (2005) opined that over fifty percent of projects are unsuccessful due to poor information. Information must be properly managed, transferred and understood in order to achieve various objectives of the project. Ahuja (2009) opined that as the project unfolds and the design is conceptualised, information in the form of drawings, specifications and construction methods must be communicated. Corroborating this view

Dainty *et al.,* (2006)noted that the success of information management in manufacturing enterprises resulted in its adoption by some large construction companies. Yet, because of the differences in manufacturing and construction processes, information management adoption in construction companies was restricted to the integration of financial management processes only; while the amount of information and its time-sensitiveness in the construction industry present many management challenges.

Zeng *et al*., (2000) observed that there are numbers of definitions on information. For example, the study suggested that information could be defined as data collected for a specific purpose. Information about a construction project is communicated to whoever needs it, whenever they need it, in whatever form they need it, so that it can meet their objective for project management and improvement. Studies has shown that information management is concern with communication and it covers acquisition, generation, preparation, processing, dissemination, evaluation and management of information resources (Gu *et al*., 2001, Checkland and Howlell, 1998). Information management is typically characterized by evaluating the number of messages and information processing activities that occurs in an organization.

Therefore, Fischer & Kunz (2004) opined that 'management' and 'information' are two commonly used words with many shades of understanding. The shades become shadows when the words are brought together as 'information management', where interpretation is subject to a range of interests and contexts. Everyone manages information to some extent personally. When information is to be managed corporately, the perspective from which it is approached varies considerably according to the background of different corporation or organisaion whose orientation may be behavioral, technological, managerial, or educational. Hence, the study concluded that the way information is managed personally is quite different from the way it is manage corporately.

However, the difference in the management of information between corporate and personal is the way information is organised, processed and ultimately used such as in learning or decision making. Such separation may be given substance as requirement for intermediation between information processing systems and end-users. This may be in the form of direct interaction by assistance to information users who are unfamiliar with the information repositories from which they seek information. On the other hand, it may be by shaping of processing systems to facilitate its use through information procedures such as requirements analysis, interface design, classification and application of meta-information. Each of these information procedures are directed at anticipating end-user needs.

2.3.1 Management Information System (MIS) in Construction Industry

Gabbar *et al.*, (2004) opined that construction activities involved erection, installation of a portion or an entire project. These activities are usually provided on the job site by the contractor, subcontractors, material suppliers and equipment suppliers. This is different from production or manufacture of structures and equipment off-site, which is also an integral part of the production process. Earlier studies have noted that the construction industry is highly fragmented compared to other manufacturing industry. The extent of this fragmentation is unparalleled in any other sector with considerable impact on project delivery (Abolore *et al*., 2000; Dawood*et al*., 2002).

The construction industry is also heterogeneous in the nature of its organisations. It operates around projects in which different organisations come to work together within the duration of a project (Amor *et al*., 2007). However, the complexity of the construction processes due to industry fragmentation and heterogenousity is such that achieving project objective is difficult under the existing delivery system.

Management Information System or Service (MIS) was defined by Woo (2007) as an organised approach to the study of information that an organization needed at every level of decision making such as operational, tactical and strategic management level. The main purpose of MIS is to apply Information Technology (IT) to provide efficiency and effectiveness to strategy in all decision making process of the organisation for better returns on investments. Azhar (2010) opined that the specific focus in MIS always depends on the services or construction activities being provided by the organisation concerned. Tam *et al.,* (2007) explained further that in the construction sector, MIS encompasses the activities of a construction company, or consultancy firm right from the project conceptualisation phase to construction phases.

Hardin (2009) explained that information technology management is concerned with the operation and sustenance of the company's information technology resources, which include the company's operating system hard and softwares, information gathering mechanisms, including the human resources (training and retraining of the information technology experts). ITM is independent of their purpose.

Hendrickson (2008) in his findings explained that Information Technology Management System components comprises of:

i. **Management Information System-** This is responsible for the production of fixed, regularly scheduled reports based on data extracted and summarised the company's ongoing transactions processing systems to the various management level-middle, operational to executive (corporate), for the purpose of identifying, and informing for decision making.

ii. **Decision Support System** (DSS**)-** This is made up of computer programmed application used by middle and higher management to compile information from a wide range of sources (construction sites, sub-contractors/suppliers, etc.), to support problem solving, such as in materials management (ordering, supplying, inventory management). A DSS is usually used for semi-structured and unstructured decision problems;

iii. **Executive Information System** (EIS)–This comprises of a reporting tool that provides quick access to summarized reports coming from all company levels and department/sections (construction sites, quarries and depots), which are vital in the running of the company.

Others include Marketing Information System, Accounting Information System, Human Resources System, and others. These are MIS that are designed specifically for managing the various aspects of the operations of the organisation.

Furthermore, Fooley (2005) itemized the advantages of Management Information System in any organisations as:

i. Companies being able to identify their strengths and weaknesses due to the availability of relevant reports. Identifying these aspects can help the company fix any identified problems fast;

ii. Giving an overall picture of the performance of the company based on appropriate performance criteria;

iii. Acting as a veritable tool for communication and planning;

iv. Availability of clients data and feedback can assist the company to improve on its public image and good customer relationship;

v. MIS can assist a company gain competitive advantage. After all, information is power; competitive advantage is the firm's ability to have information earlier than its competitors, and hence be in a position to do something better, faster cheaper, or uniquely on the strength of information at its disposal, in comparison with its rivals in the industry;

vi. MIS reports help to take decision and action on certain issues quite on time.

Summarily, communication has developed to such an extent that project managers, contractors, design team all can keep in touch during project life cycle. People at site can receive instruction, layout, working drawings, structural details etc. and go about their work. People at the office can keep track of development at the site too. Project communication is the exchange of project specific information with the emphasis on creating understanding between project stakeholders. Communication is essential for the purpose of information distribution and human understanding of the project. Project communication in general is the responsibility of everyone on the project team. However in particular, projectmanager is responsible for the development of project communication management plan. In conclusion, Gu *et al.*, (2009) noted that 85% communication and 70% project documentation is paper based which delays the project activities and create hurdles to project delivery.

(a) Information Management and Enterprise Resource Planning (ERP) in Construction

Jung and Joo (2011) opined that the terms management information system (MIS), information technology (IT) and enterprise resource planning (ERP) are usually misconstrued. However, Tam (2007) opined that IT and MIS are broader categories that include Enterprise Resource Planning (ERP).

An ERP system is a vast information system that manages information about a company's products, customers, suppliers, employees, production facilities, financial balances, etc. It is used by everydepartment in an organization and by most employees. The sales department can check prices of products and their inventory levels, enter sales orders from customers, make deliveries, issue invoices to customers and receive payments. The production department uses it to check inventory balances of products, create production orders, manage production schedules, record the receipt of finished or in-progress orders. The marketing department can plan demand and make sales forecasts for the next sales period. The finance department uses it to manage accounts payables, accounts receivables, enter payments made by customers and payments made to suppliers, generate the balance sheet and profit and loss statements at the end of an accounting period. The human relations department tracks all employees in a company, their title, date of joining, department, and salary. Every new employee is added to the system as soon as they join the company. If they quit or are fired, this is also reflected in the system, but their information is still retained for historical records. Summarily, an ERP system in effect manages all the resources of an organisation or enterprise.

Tsokar (2015) opined that the software applications for ERP was developed to help construction managers in diverse construction activities such as project planning and management, subcontracting, material tracking, service delivery, finance and human resources management. The study described the scope of Construction Enterprise Resources Planning (C-ERP) systems and the implications on project life cycle as depicted in Figure 3.1 and itemized below:

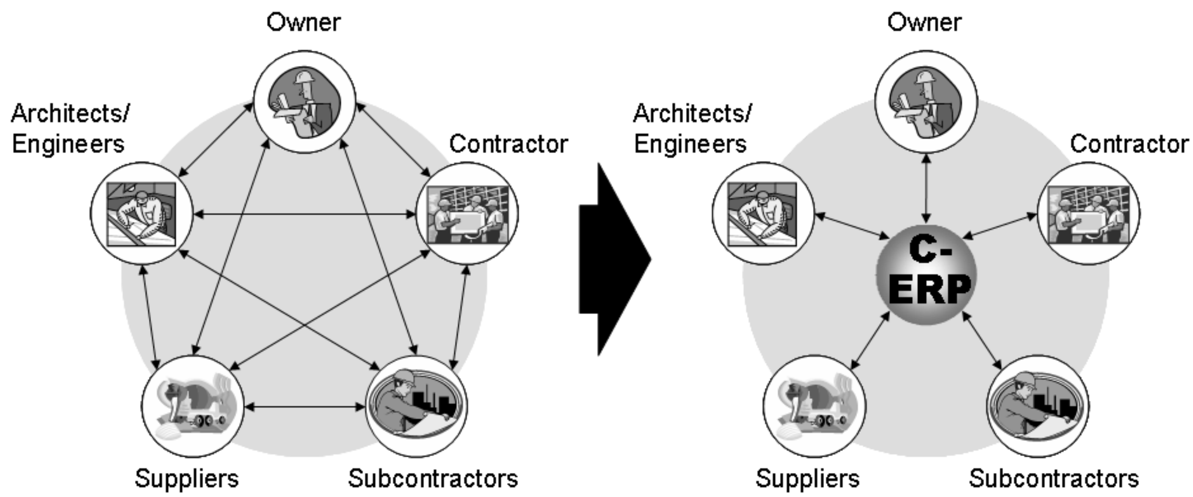


Figure 2.5Streamlining Corporate and Project Communications with C-ERP

Source: Tatari (2009)

(i) Project Bidding and Marketing: C-ERP automates the procedure of proposal preparation, bidding and reviewing bids, marketing campaign management, customer databases and competitor analysis.

(ii) Project Planning: C-ERP automates activities related to cost estimation, project budgeting, activity and resource planning, and detailed scheduling. All of these are realized in single software, which eliminates duplicate data entrance, especially between preliminary estimation and detailed planning.

(iii) Design and Engineering: With C-ERP, preparation of detailed specifications and requirements are automated. C-ERP maintains all specifications and drawings with the aid of its document management system. CAD integration is realised to avoid duplicate generation of drawings and specifications during the project life cycle; and collaboration tools are used to facilitate their communication needs of project participants.

(iv)` Procurement: C-ERP streamlines procurement of required materials, equipment and services. It automates the processes of identifying potential suppliers, supplier evaluation, price negotiation, contract management, awarding purchase orders to the supplier, and supplier billing. Supply chain management of materials is managed through this function. It also automates maintenance scheduling and service operations data for more efficient equipment management.

(v) Construction Project Control: Through integrated information visibility from other functions, many challenges of project execution are eliminated for the project manager. Also, project billing and project costing is integrated in real-time, which allow the main office to keep track of projects. C-ERP also automates the change order. Management which is a seriously time consuming activity during project execution.

(v) Workforce Management: C-ERP handles employee and payroll related activities of the construction firm. Complete employee database is maintained including contact information, salary details, attendance, performance evaluation and promotion of all employees. Also, this function is integrated with the knowledge management system to optimally utilise the expertise of all employees within the firm.

(i) Finance and Accounting: As one of its core functions, C-ERP streamlines financial operations of the enterprise as well as the projects, collects financial data from all departments, and generates all financial reports, such as balance sheets, general ledger, accounts payable, accounts receivable, and quarterly financial statements.

With C-ERP, it is possible to share and exchange information in digital format throughout the project life cycle. Thus, information is stored only once and all project participants are able to access this information in real-time. Data integration can be realized through a centralized database system in the core of C-ERP. All data is entered only once, and is visible throughout the entire project lifecycle. Process integration is realized by utilizing a single integrated information system for the whole project life cycle, instead of using several stand-alone applications. By streamlining and connecting all business functions, business processes can be executed without interruption. Lastly, linking project participants is made possible by online access to project information by all participants. Participants can view project information with varying levels of access authorization, and enter or revise information related to the functions they are responsible from.

(b) Data Warehousing

Different departments or units exist in a construction company and each of these has its own activities and work procedures (Martinez, 2002). These departments or units may have its own Information Systems (IS). On the other hand, a construction company may have several projects that require its own Information System (IS) as well. The various information systems required from different projects are considered as data marts upon which the main office data warehouse is developed. Construction companies as an enterprise are increasingly turning to software systems to seek support for enterprise performance (Rivard, 2001).

Companies need to have proper information systems and data base management systems to capture and keep different information. These are the most valuable resources. Any successful managerial decision is critically dependent upon the availability of integrated, quality information, organised and presented in a timely and easily understanding manner

(Rezoei*et al.*,2011). Despite the growing need for more information, every day organisations create billions of bytes of data about all aspects of business. However, it is noted that only a small fraction of the data that are captured, processed and stored within the enterprise are made available to executives and decision makers (Tau and Foo, 1999). This view was corroborated by McCabe *et al.*,(2007) that the concept of Data Warehouse (DW) is part of the response by IT to meet this need.

Landrum *et al.,* (2001) defined Data Warehousing as a structured software designed for the analysis of data, logically and physically transformed from multiple sources to align with business structure for quick analysis. An important concept of Data Warehousing is that its data comes from one or more operational applications manipulated into a common format and inserted into the data warehouse with necessary calculations or editing of the data. The data are thereafter loaded into appropriate reference tables for efficient performance on analysis, reporting or data mining by the user through different tools, such as web applications or crystal reporting.

Rivard (2000) opined that a functional Data Warehousing organises and stores all available data needed for informational and analytical processing over historical time perspective. .However, it does not create value. The value comes from the use of its data in other applications so as to provide decision makerswith consistent, timely, reliable and accessible data without negating on the operational systems from which the data is extracted (Tam, 1999).Data warehousing software is not a ready package to be bought and used by a company; instead, it is specifically designed to meet company requirements and needs. This enable organisation to develop its own Data

Warehousing software to solve and overcome difficulties in order to maximum benefits of data warehousing capabilities.

2.3.2 Communication in the Construction Industry

The construction industry plays a significant role in the national economy of Nigeria. This view was corroborated by Balogun (2007) that the construction industry is responsible for 61% of the Gross Domestic Product (GDP) and employs up to 20% of the labour force while

Kolawole (2002) noted that the industry is unique in its provision of infrastructure under which other industries operates. However, the industry is highly fragmented with construction firms ranging from a few multinationals firms that employ hundreds of labour force to majority of sole proprietorship firms that employ less than ten employees. This view was corroborated by Obiegbu (2002) that the construction projects represent some of the largest and most complex undertakings while Kymmell (2008) noted the rate at which the industry utilize different technological methods to consume scarce resources such as time, money and people's talent.

Hence, Song *et al.* (2005) observed that the construction industry experiences many problems. These problems include the use of inappropriate technology and systems to plan, implement, control and communicate. Foley (2005) noted that over fifty percent of projects are unsuccessful due to poor or ineffective communication. Ilozor and Kelly (2011) supported this assertion by concluding that the construction industry is often characterized as inefficient, wasteful, litigious, and unproductive and require effective communication for better improvement. Communication plays a vital role in all stages of construction such as design, organisation, process, production and management. Information must be properly managed, transferred and understood in order to achieve various objectives of the project. Dainty *et al.,* (2006) opined that as the project unfolds and the design is conceptualized, information in the form of drawings, specifications and construction methods must be properly communicated. This view was corroborated by Phoya and Kikwasi (2008) that there is need for professionals within the construction industry to effectively communicate with each other in order to accomplish project objectives and attain its social functions.

Nielson (2008) defined communication as the activity of conveying information through the exchange of thoughts, messages or information either by speech, visuals, signals, writing or behavior. It is the meaningful exchange of information between two or more individuals or organizations. Also, Balogun (2007) defined communication as the process required to ensure timely and appropriate generation, collection, dissemination, storage and ultimately disposal of project information. Communication provides the critical links between people, ideas and information that are necessary for project success. Ahuja*et al.,* (2012) concluded that the essence of project team is to communicate and provide feedback throughout the project life cycle.

Lari (2002) also defined Communication as an activity of conveyance, exchange and transmission of information (ideas, facts, from simple social or emotional concepts of high complex instructions). In general, the concept of communication is based on a two way exchange of information. Sending an information is basically not communicating except in some uncommon situations where the receiver has nothing to do with the service being delivered; in most cases, a receiver has to respond with the information in other to establish communication. Hence, communication takes place when information is provided and it is received; However confirmation has to be established that information was transmitted and received (Kymell, 2008). In order to achieve an effective communication, information should exist only once, rather than be duplicated unnecessarily.

2.3.3 Types of Communication System

Albino, (2002)) observed that for construction to function effectively, a construction company must have different types of communication systems, such as: interpersonal, interdepartmental and Intra-organizational. This view is supported by Lari (2002) that different communication tools are required for communicating within the internal environment and the external environment. Also communication within the stakeholders could reduce project failure if the information is disseminating to the appropriate channel.

Nielsen (2008) opined that construction projects can be delivered on time and within budget without any failure due to ability of the project manager who communicate project success to the stakeholders effectively. Hence, Fischer and Kunz (2004) identified two forms of communication usually required on construction site as formal and informal.

(a) Formal Communication – This form of communication is usually in printing or written form. It may come in the form of letters, reports, bulletins and newsletters etc. depending on its target of primary audience and the message it intends to convey. Letters may be meant for internal audience as memorandum (memo), or for external audience as business or corporate letters from one organisation to others. Memoranda (memos) are usually contained in the company's official memo sheets, and are usually intended to convey message or notes among officials within the same organisation. Memos could be between one to one officials, or for the entire officials in a department (section/unit), or the entire organisation for information and or necessary action. The later type of memos is usually pasted on the notice boards, while the former have some form of confidentiality.

External letters are usually written by the company's secretary on behalf of the organization to other organizations / individuals outside the management of the corresponding organisation. It is usually inappropriate for any other person within an organisation to write on any matter unless with the express mandate of the company's secretary or his representative. Such letters may be in the form of business, informative/explanatory and others to enhance the operations of the organisation. For construction firms, external letters are usually written to show interest on potential jobs, inform the public and potential clients on the activities of the firm and so on. It may also be written in response to queries by clients in relation to ongoing contracts. Such letters are usually contained in the company's letter headed sheets.

Reports can be both internal and external depending on the intended audience as had earlier been pointed out. Internal reports are for internal consumption, usually at the request of a superior from a subordinate. For example, initial or periodic project reports. Such reports provide clarifications on the state of on-going projects, highlighting problems and constraints on the projects. Reports normally end with requests on the needs to ensure the realisation of the projects according to work schedules, with such needs as attachments to the reports.

Reports may be technical, or general in nature. Technical reports are specific to particular audience, with the wordings and terminologies used peculiar to the specific profession. It could be reports from laboratory experiments, or market survey and analysis. Each report has its manner and style of presentation that is peculiar to its profession.

(b) Informal Communication –This type of communication is usually conversations between superiors and subordinates and takes place in informal forums or settings. In gatherings such as meetings and social events, a superior may engage in conversations with his or her subordinates or colleagues during which vital management information are passed from one to another. Grung (2000) defined informal communication as oral which can be expressed at a glance through sign or silence. Informal communication is implicit, spontaneous, multidimensional and diverse, it is usually works within a group of people that is when one person has some information of interest, he/she passes it on to his or her informal group. Despite its many advantages, informal communication has certain disadvantage. It contains combination of facts, deceptions, rumours and unclear data. Another danger inherent in this type of communication is that it may be misquoted out of context when the receiver tries to pass the same information to another person who was not present during the conversation. In its second hand form, such communication is likely to be distorted. More so, it is unlikely to be verified, since there may not be any concrete evidence about its authenticity and reliability. Information obtained from informal sources may not be used in the law court in case of disputes, as it is regarded as mere hearsay. Informal communication unlike formal cannot be used for technical reporting for obvious reasons. It is however a vital aspect of communication in management, as it could be used by managers to boost the personality of the subordinates, giving it in the process some air of importance and sense of belonging.

2.3.4 Communication Channel

Communication can occur in various directions depending on who is communicating. There is

Management of performance from ones whom the communication takes place with customers and within project teams. Kim *et al.*, (2003) stated that machinery needs to be put in place for further communication to take place, either downward communication (from superior to Sub-ordinate), horizontal communication (between colleagues) or upward communication (from sub-ordinates to superior).Mehra, (2009) collaborated this that communication will always involve more than one person.

The basic communication flows on construction site can be described in four directions as: downwards, upwards, horizontally and laterally. Downward communication: It is a communication that flows from the superior to the subordinate, in such an organizational structure, superiors exhibit abilities to attain the desired target, that is superior can issue commands, instructions and policy directives to the persons working under him (at the low levels). In downward communication, a superior anticipate the instant performance of a job and is thus highly directive. Downward communication includes statements of philosophy, politics, project objectives, schedules, budgets and constraints, position descriptions and other written information related to the importance, rationale and interrelationship and interactions of various department projects and jobs in an organization.

Tam (1999) noted that upward communication is beneficial for companies because it increases the participation of employees and reveal prominent issues and problems. In this type of communication, information is provided to the upper management in order to evaluate the overall performance of the project for which he is responsible to or to refine the organizational strategy.

Horizontal communication occurs at the same level and facilitates the linking of different areas of expertise, encouraging innovation in an organization.

Lateral communication works in a contrary way to the top-down, bottom-up communication methods. Individuals participating in these form of communication often become aware of new events before the people in the higher up of the communication ladder. Information that spreads through lateral communication usually moves at a faster pace than the other form and enables individuals with a diverse action.

2.3.5 Communication Instrument

Communication can be defined as internal and external communication between members of an organization at all levels for the achievement of a mutual goal or goals (Rivard, 2000)

In other to achieve this goal, communicating or interacting at various levels of organization is necessary. Internal communication is referred to as whereby members have to communicate with individuals and where groups who are not members of the project team are referred to as external communication.

Project communication instrument is defined as how and what the project will communicate to its stakeholders. This type of communication occurs within the team and between the team and external entities. The project communication instrument identifies the processes, methods and tools required to ensure timely and appropriate collection, distribution and management of project information to all project stakeholders. It also describes the team strategy for communicating internally among team members and company personnel, as well as externally with vendors and contractors. In the construction industry, some communication instruments are used among the stakeholders. These types of communication includes estimation, cost plan, payment advice, cost report, escalation cost preparation, final account standard document, contract document and drawings, standardization of this documents through a rigid system used by the construction company enables professionals to work properly and deliver messages at the right time (Hammer 2002).

2.3.6 Communication Structure

Structure defines the lines of authority and communication and specifies the mechanism by which tasks and programs are accomplished (Balogun, 2007). The performance depends on the coordination between the parties involved, the system of communicating, the culture of the project, the staff members and the communication structure. In many ways, intercultural communication is far more complicated because participants need to be aware of an increased possibility of misunderstanding. Project team members are part of different sub-cultures. In a project team there may be communication problems because of the differences and expressions in different professions.

People, systems, culture and structures may be used as communication strategies to ensure the performance of the project. Every sub-project has a set of people, systems and culture different to that of those of the main project. These different strains the project, increase communication problems and make it less likely to complete a project without incidents. People in the organization use the proper system implemented by the organization to communicate effectively, whether internally or externally. This proper system also helps in improving communication within the organization. It plays a vital role among the stake holders because it results in good understanding within the organization and among the different parties. Organization structure influences the coordination and flow of the organization system. A proper organization structure should be formed to encourage good flow of information and enhance effective communication in the organization and in the industry. Better organization structure leads to the practice of time, quality and cost management as well as to the increase in organization performance (Dainty *et al.,* 2006).

2.3.7 Project Communication Management

Project Communication Management is the knowledge area that employs the processes required to ensure timely and appropriate generation, collection, distribution, storage, retrieval and ultimate disposition of project information. Communication Management is a fundamental part of any organization and needs to be treated with care. It is investigated that Communication Management Process is a set of steps that needs to be adopted for every project in an organization. Using this Communication Process, we can communicate effectively at all times.

The communication processes are, Identify Stakeholders, Plan Communications, Distribute Information, Manage Stakeholder, Expectations and Report Performance. Theseprocesses interact with each other and with processes in the other knowledge areas such as Project Integration Management, Project Scope Management, Project Time Management, Project Cost Management, Project Quality Management, Project Risk Management, Project Human Resource Management and Project Procurement Management.

2.3.8 Communication Management Process

Communication management process is made up of four steps: Communication planning, Information distribution, Performance reporting and Administrative closure.

Communication process helps to undertake communication management for the team through step by step process. To keep the right people informed with the right information, at the right time, and then this process come in to help in the implementation and communication process.

Table 2.1 Communication Management Process.

S/N	COMMUNICATION MANAGEMENT PROCESS
1.	Communication planning
2.	Information distribution
3.	Performance reporting
4.	Administrative closure

Source: Tatari (2009)

(a) Communication Planning:

Communication Plan is the process of determining the project stakeholder, information needs and defining a communication approach. The Plan Communication process responds to the information and communications needs of the stakeholders; for example, who needs, what information, when will he need it, how it will be given to him, and by whom. While all projects share the need to communicate project information, the informational needs and methods of distribution vary widely. The important factors for project success is identifying the information needs of the stakeholders and determining a suitable means of meeting those needs.

Effective communication means that the information is provided in the right format, at the right time, and with the right impact. Efficient communication means providing only the information that is needed. On most projects, the communication planning is done very early, such as during project management plan development.

(b) Information Distribution

Information distribution involves making needed information available to project stakeholders in timely manner. It includes implementing the communication management plan as well as responding to unexpected requests for information. It shows which deliverable have been completed and which have not, the extent at which quality standards are met, what costs have been incurred or committed. It is collected as part of project plan execution and it is also useful in report performance.The project plan is a formal, approved document used to manage and control project plan execution.Communication management plan may be formal or informal, highly detailed or broadly framed based on needs of the project. It is distributed structure which details to whom information will flow, and what methods will be used to distribute various types of information. These must be compatible with the reporting relationship described by the project organization chart.

2.3.9 Patterns of Communication among Members of the Design and Construction Team

Jung and Joo (2011) noted that there is no clear division of communication system within the industry, therefore the general method of communications among the stakeholders is classified as follows: communication between client and consultants; communication between consultants; communication between the consultant and contractor; communication on site.

(a) Client-Consultant Communication

Communication between the two parties is a continuous process from the inception of the project to the final completion. The client is the initiator and financier and more so, it must be executed to suit his taste. To these effect professional advisers i.e. architect, quantity surveyors, and engineers are to obtain first-hand information on daily development of the project (Tam, 2007). Under this heading occurs the very step towards communication in the construction industry which is the client statement of requirement. The information will include the size of the building, nature of building, fund available, functions of the building and time limitation of the project.

The architect or quantity surveyor after carrying out feasibility studies with other consultant who have been appointed to establish that the project is feasible, functionally, technically and financially prepares a general outline of client requirement and communicate it with other members of the design team for collective action. The development of the client brief is a collective effort of all consultants who in the course of granting approval of such work communicate any alterations and modifications in the project. This procedure continues until the design of the project is completed and consultants jointly present their design report to the client to confirm that it is clear transaction of his brief.

The design report must be detailed to include all relevant information required and presented in a manner to be understood by the client (Polgar and Thomes, 2013). As soon as the client approval is obtained on the report, the architect and engineers start preparing the working drawings, schedule and specification and at the same time seeing the opinion of the quantity surveyor who gives the cost implication of the project to see if the project design is still within the approval.

(b) Communication among Consultants

This involves effective exchange of ideas and information among the professionals; the design team is to advice the client on smooth running of the project. The architect, quantity surveyor, or engineers by the nature of their position in any construction project are expected to establish links between consultants and coordinate the activities for successful execution of the project. Regular meetings to review the project forms a means of effective communication which in turns aid building project delivery of that team. In various processes involved in the administration of the project, telephone is used to communicate urgent matters which could be followed up by letters to consultants involved. Basically, consultants transfer information through drawings, schedules and specification notes to ensure project are completed on time, with god quality. (Azhar, 2010).

(c) Communication between the Consultants and the Contractor

According to Hardin (2009), the efficiency and effectiveness of the construction process strongly depend on the quality if communication under this heading the communication network has been extended to a very important member of the building industry, the contractor who translates all the efforts of other consultants into practical reality which will be seen to correspond with the client's requirement.

The idea of a tender for a project is first communicated to contractors through public advert of invitation letters depending on the tender procedures adopted as stated by (Woo, 2007). Contractors are requested through this medium to collect tender documents consisting of drawings, specification, bill of quantities and condition of contract. The quantity surveyor examines the bill of quantities and communicates his findings and recommended action to the client through a tender report for the purpose of selecting specialists and subcontractors. Supervision is also used by these consultants as a means of follow up to their communicated information to ensure that the contract provision is applied. Interim valuation is an exchange of information between the contractor, quantity surveyor and the architect, claiming the payment of work properly done during the specified period. There is a great reason for the quantity surveyor valuation to contain the total breakdown of the work and the amount involved instead of using a "lump sum" to help the settlement of the final account and enable the client to understand each valuation. Variation orders is also form of communication between the architect or engineer and the contractor giving notice on intended alteration to the original design.

The architect prepares the interim certificate and certificate of practical completion so as to communicate to the contractor the amount due for him to confirm that the contractor has completed his project.

(d) Communication on Site

Dawood and Akinsola (2002) defined construction site as the place where the effort made by the design team is visualizing as the client's requirement and dream will be put into practical and reality and communication between the consultant in form of drawing, specification and schedule and bill of quantities shows the extent of work to be done, the contractor is also in close contact with consultant during site meetings. Generally, site meeting and regular meeting held on site are to discuss the progress of the project to date, difficulties and delays arising from the project at hand.

This offers the contractor and the sub-contractors good opportunities to sort out project's problems with the design team. The first site meeting is expected to formally establish a good link between all the parties involved as well give a clear indication of the way the project is to be administered (Nawari, 2012). While most building projects transfer data/information in hard copy (i.e. most projects are paper based communications) and form essential part of most organizations, this often got in the way of real productive work. Jung and Joo, (2011) observed that the current way of communicating there have been errors in contract documents, specification and drawings which forms the majority of communication problems that occurs and have negative effects on execution of the project i.e. (effect on cost, schedule and overall quality). Where this traditional mode could not satisfy the project objective, ICT offers a great solution to these problems.

2.3.10 Information and Communication Technology (ICT)

ICT is a varied set of technology tools and resources used to communicate, and to generate, spread, keep and manage information (Landrum, *et al*, 2009). The word information communication technology can be understood from different perspectives, as well as ICT view, as a whole new meaning of its own from the functionalist.

(a) Uses of ICT in the Building Industry

Jung and Joo (2010) opined that depending on the type of project, the chain may involve large numbers of skilled professional and companies with quite often, much repetition of activities and accumulation of paper work. Building project requires effective collaboration and coordination between all the members for successful project delivery (Nawari, 2011). ICT can provide effective communication especially when the project team organises are geographically separated and project team structures are becoming increasingly complex. Hendrickson (2008)agreed that some of the identify benefit of communication are richer information which aid decision making, project information obtained quicker, improve communication, close relationship, improved communication flow and greater management flow.

Currently the building industry is experiencing a paradigm shift from traditional based to digitally based information exchange, which other industries such as aircraft and banking have adopted and benefited from long ago (Harsdin, 2009). This shift has been aided to a large extent by the drastic reduction in computer hardware and software prices and increased power, usefulness and popularity of computer over the last few years (Rivard, 2000). The use of ICT has impact on the traditional processes of organization in construction has resulted in change in organizational process, working methods and culture.

(b) Benefits of ICT

Bernstein and Pittman (2005) identified the benefits of ICT critical to the performance of the building industry as:

(i) To reduce the time for data processing and communicating information (speed & visual proximity)

(ii) To improve communications for effective decision-making and coordination among construction productivity.

(iii) It saves employee time.

(iv) It avoids circuitous means of transferring data e.g. printing a document, faxing it and then retyping the data at the receiving end in order to save it as an electronic file.

(v) It allows the company and individuals to publish and distribute their work efficiently, while attaining a high and consistent quality in textual or graphical appearances.

(vi) It provides access to information; allow communication and distribution of documents in a single uniform fashion.

All these are possible because the internet-based tool of ICT allows communication between remote users and enables them to share files, comment on changes and post request for information.

(c) Problems of ICT in the Construction Industry

Amor, (2012) itemized the following as the problems to the adoption of ICT in the building industry as:

(i) Lack of ICT professional on site or within ready access

(ii) Inability to quantify process improvements and uncertainty of benefits of ICT

(iii) Initial cost and cost of keeping up to date with the technological developments in training and hardware/software

(iv) Inadequate/erratic power supply

(v) High cost of hardware and software: This actually differs from the opinion of (Rivard*et al.*, 2004)

(vi) Inadequate ICT content of construction education

(vii) High cost of employing computer professional

(viii) Lack of appreciation of ICT by firm's management

(ix) Fear of mass job losses in the industry

(x) Fear of ICT making professionals redundant

(xi) Fear of personnel abuse

(xii) Fear of virus attacks

(xiii) Lack of sufficient jobs

2.3.11 Effects of ICT on Project Success

Tam, (1999) opined that the use of ICT has impact on the traditional processes of organization in construction and result in change in organizational processes, working methods and culture, in this regard, some benefits of ICT is essential to operation delivery in the construction industry so as to reduce the time for data processing and communicating information, and to improve communications for effective decision-making, coordination among construction participants in other to enhance construction productivity. This is possible because the internet-based tools in ICT allow communication between remote users and enables stakeholders to share files, comment on changes and post request for information.

(a) Effect ICT on Cost:-The cost of any given construction project can be reduced significantly as a direct result of effective communication. With the omission of human error due to digital based machinery and also proper project supervision the estimated cost for a project can be achieved within the frame without any cost overrun. (Dainty *et al*., 2003).

(b) Effect of ICT on time:-Completing project in a predictable manner on time (within schedule) is an important indicator of project success. (Cohen *et al*, 2011, Fok, *et al*, 2001). With the elimination or reduction of the barrier called distance the time project execution can be reduced especially during the pre-construction phase. Since there is no distinct barrier between the parties involved with the use of E-communication. Preparation and meeting and decision making can proceed without having to travel down to a particular place.Also with accurate understanding where omission and errors are reduced there will be little or no time wastage as schedules are prepared accurately and minimization of work been done.

(c) Effect of ICT on project quality:-The concept of quality closely related to customer satisfaction, which has gradually been elevated as important in the construction industry. (Lee *et al*, 2002). Quality in construction refers to the standard of work that is expected to base on the requirements of clients as stated in the contract documents which include drawings, specification, and other additional conditions supplementary to the contract. Contract documents are a method of communicating scope of work, project details and all pertaining information to builders, contractors, sub-contractors and other parties involved in project construction. Therefore, a well communicated contract documents are the key to ensuring that the required project's quality is met.

2.4 Origin of Building Information Modeling (BIM)

In the late 1970s, according to Aryani, Brahim, and Fathi, (2014) noted that Professor Charles Eastman of Georgia University of Technology, School of Architecture initiated the Building Information Modeling (BIM) concept. The idea of BIM concept development is to enable stakeholders in the built environment to use it in various stages on project executions whether it be pre-construction stage, construction stage and post construction. At that time, Professor Eastman argument was that, drawings made for construction has limitation due to visualization of the buildings and also difficulty in updating drawings which goes a long way to affect efficiency in drawings production and quality. In light of this for mentioned observation by Eastman, ICT researcher and corporate organization from Finland and USA team-up to design and developed a comprehensive Computer software's capable to address the problems indicated in regards to project drawings and its management.

BDS, 1975 - stands for Building Description System. It function as database tool use in describingbuildings during design and construction development. It has the capability to modify and operated numbers of element such as clashes detection design, analysis of cost from the individual database library.

GLIDE, 1977 - Graphical Language for Interactive Design. It function as a tool that providesaccuracy in evaluation of structural design and cost estimation. It mostly used in design stage only and it incorporated well with BDS parts.

BPM, 1989 - Building Product Model. It provides the platform for construction stakeholdersopportunities for to works on estimation, design application and construction process. Thus, this innovation was made in Finland, is called "RATA" meaning Computer Aided Building Design. It functions as CAD (Computer Aided Design) interpretable communication tool. Again, it serve as project library which is enrich with projects information from planning stage to completion of construction.

GBM, 1995 - Generic Building Model. The idea of Generic Building Model is to compensate theweakness that has been identified in the operation of GPM functions. It has the ability to improve and integrate project information from new design and future construction activities throughout the construction process life cycle. (Aryani, Brahim, and Fathi 2014)

2.4.1 BIM numeric labels Dimensions

The following numeric labels defined the meaning in BIM technology and the functions it represent in the construction environment. (Krygiel *et al.*, 2008):

(i) 2D stands for two-dimensional drawings such as elevations, plans, sections

(ii) 3D stands for 3D digital model, in addition of height measurement

(iii) 4D stands for the integration of time with 3D, such as project schedule, construction sequencing and phasing

(iv) 5D stands for addition of cost to the BIM model, meaning cost estimation during conceptual design phase or quantity take-offs for bidding

(v) 6D stands for life cycle, energy management components, and facilities

(vi) 7D stands for life safety issues within the building e.g. building code analysis.

2.4.2 An Overview of BIM for Project Delivery

Arayici*et al.*,(2009)noted the construction industry has been facing a paradigm shift so as to increase: productivity, efficiency, infrastructure value, quality and sustainability, reduce lifecycle costs, lead times and duplications. It is advocated that most of these can be obtained through Building Information Modeling (BIM). BIM can be defined as the use of the ICT technologies to streamline the building lifecycle processes of a building and its surroundings, so as to provide a safer and more productive environment for its occupants; and to assert the least possible environmental impact from its existence; and be more operationally efficient for its owners throughout the building lifecycle.Today in many organisations multi-disciplinary teams are clashing with traditional methodologies (e.g. business models, processes, legal and compensationschemes, etc.) that impede knowledge sharing which cause reinventing the matters and processes on a daily basis. Fragmentation and calcified processes inhibit widespread change in the building industry, which is also traditionally disconnected from lifecycle evaluation methods. However, modeling techniques replaces this fragmented process with an interdisciplinary approach that consolidates the team effort, (Bernstein and Pittman, 2005). It seems that the building industry is under pressure to provide value for money,sustainable infrastructure, etc. and hence adaptation of Building Information Modelling (BIM) technology has been inevitable (Mihindu and Arayici, 2008).

BIM as a lifecycle evaluation concept seeks to integrate processes throughout the entire lifecycle of a construction project. The focus is to create and reuse consistent digital information by the stakeholders throughout the lifecycle (Figure 3.2). BIM incorporate a methodology based around the notion of collaboration between stakeholders using ICT to exchange valuable information throughout the lifecycle. Such collaboration is seen as the answer to the fragmentation that exists within the building industry and that has caused various inefficiencies (Bernstean and Pitman, 2004).

To date, there are many projects that have utilised BIM systems within; environmental planning, design and development, optimisation, safety and code checking construction, and have realised its benefits. Such projects have recommended BIM systems as a remedy to address low productivity issues and proper delivery of project (Mihindu, and Arayici, 2008).

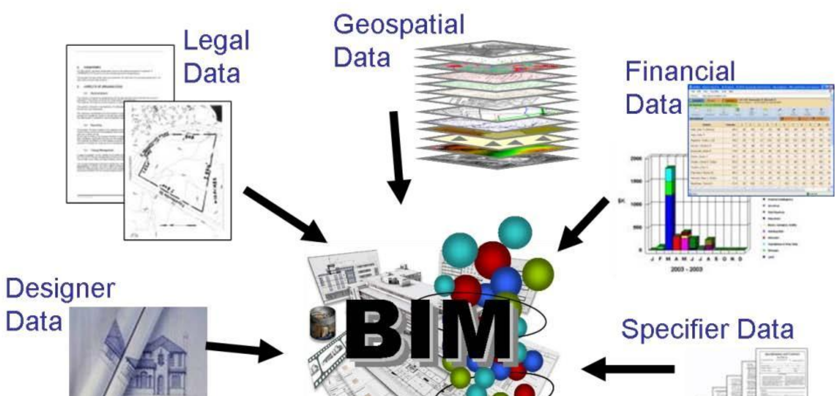


Figure 2.6: Communication, Collaboration and Visualisation with BIM model

Source: (NIBS, 2008),

Demchak*et al.*, (2008) defined Building Information Modeling (BIM) as process and practice of virtual design and construction throughout its lifecycle. It is a platform to share knowledge and communicate between project participants. In other words, Building Information Modeling is the process of developing the Building Information Model.

Lowe (2009) corroborated that the High quality 3D renderings of a building can be generated from Building Information Models. However if the contractor only uses the model to better communicate the BIM concept in 3D and does not further use the built-up information in the Building information Model, then this is referred to as “Hollywood” BIM. Contractors may use the “Hollywood” BIM to win jobs but they do not seize the full potential value of Building Information Modeling.

Vardaro, 2009) explained that when Building Information Modeling is practiced internally within only a single organization of the project and not shared with the rest of the organizations this is referred to as “lonely” BIM. For example, an architectural firm may decide to design a Building Information Model, and use it for visualization and energy analysis. Architect’s firm may even have an internal collaboration. However, the architect may decide to provide the drawings in two dimensions and restrict the Building Information Model access. This would hinder the participation of the construction manager (CM) unless the CM creates a new model. (Rizal, 2011)

Rizal, (2011) opined that a more collaborative approach would be the “social” BIM which enables the sharing of the model between the engineer, architect, construction manager, and subcontractors. At the BIM meetings, the construction manager and subcontractor can provide their expert construction knowledge to the design team. Moreover, the construction manager can use the building information models to generate constructability reports, coordinate, plan, schedule and cost estimate. After collaboration efforts such as MEP coordination among the contractors, engineers and architects are completed, specialty contractor can then use the information from Building Information Model to prefabricate products.

2.4.3 BIM Implementations in Other Countries

The examples, best practices and the maturity of the process of BIM utilisation in construction projects have been discussed by many researchers (Eastman *et al.*, 2008, Mihindu and Arayici, 2008). Some of the developments over recent years are HUT-600 (Helsinki University of Technology) auditorium extension project in Finland and the construction of Eureka Tower project (2002-2006) in Melbourne with the total of 92 stories (Mihindu, and Arayici, 2008).

Other projects benefited by utilising BIM technology are through technological enhancements;

new tools, techniques and applications are being researched and best practices are created in many countries. For example, the Building Construction Authority in Singapore developed e-PlanCheck system for automating the building code checking for the building assessment and regulatory approval, through an independent platform called FORNAX, which uses the basic BIMinformation from IFC files to incorporate relevant code checking requirements. This system promotes the designs to be submitted to local authorities in IFC file format. This has become a reference point on how local governments and authorities can utilise BIM within its strategy for the development of built environment (Holzer, 2008).

Over the years many projects were piloted and live projects have been completed and documented in Finland, Sweden, Norway, Germany, France, Singapore, UK and Australia, which demonstrated the capability of using BIM within the construction process facilitating construction lifecycle. Many ongoing projects have been proven to develop more environmentally sustainable products, compared to non-BIM based projects. For example, Tocoman Professional Services of Finland claims that they have facilitated over 200 projects each with reasonable savings due to the utilisation of BIM within building construction lifecycle activities, producing significantly better infrastructures with improved stakeholder satisfaction. The software such as Vicosoft aimed to provide services based on the full lifecycle of the building development much more successfully than other competitive products. However, it will take few more years to learn the importance of such tools by the construction stakeholders due to the risen skill gap (Mihindu, and Arayici, 2008).

2.4.3.1 BIM ADOPTION AND IMPLEMENTATION IN MAJOR COUNTRIES OF THE WORLD

BIM (Building Information Modeling) has changed the way architects share information for construction projects. Now, you can have more information about products that will be used as well as the design, logistics or maintenance of the project. Many countries are still at the very beginning of developing and deploying their own BIM strategies. Let's have a look at how BIM adoption is progressing in some of the major countries of the world.

Moreover, Building Information Modeling (BIM) provides an unparalleled opportunity for improvements in productivity and cost-savings through all phases of the AEC industry has been long espoused. BIM adoption is progressing in major countries of the world.

BIM IN UNITED STATE OF AMERICA

The US General Services Administration (GSA) formulated the National 3D-4D-BIM program way back in 2003.This program established policy mandating BIM adoption for all Public Buildings Service projects. GSA also actively partners with BIM vendors, federal agencies, professional associations, open standard organizations, and academic/research institutions to develop a community of BIM leaders within GSA. Today, 72% construction firms in the US are believed to be using BIM technologies for significant cost savings on projects. And it's not just the government that has been pushing for the power visualization, coordination, simulation, and optimization in the construction, several US stats, universities and private organizations are supporting the adoption of higher BIM standards.

In 2009, the Architect's Office at the Indiana University issued IU BIM Standards and Project Delivery Requirements. In the same year, the Penn State University also acquired a leadership role in articulating the use of BIM by facility owners.

In 2010, Wisconsin became the first US state to require all public projects with a budget of $5 million or more and all new construction with a budget of $2.5 million or more to incorporate BIM. Meanwhile, through the NBIMS-US Project, the National Institute of Building Sciences buildingSMART alliance has curated consensus-based open BIM standards to foster innovation in processes and infrastructure.

Today, 72% construction firms in the USA are believed to be using BIM for important cost savings on projects. Several US states, universities and private organization are adopting BIM standards.

BIM IN UNITED KINGDOM

The UK has swiftly risen become the undisputed BIM champion of the world riding on the wings of clear national strategy and government support. The British Standards Institute (BSI) have formal liaison with standards committees like the AGI and the others. Since April 2016, as art of the Government's Construction Strategy which aims to achieve 20% savings in procurement costs, all centrally-procured construction projects in the UK are require to achieve BIM level 2. This mandate not only made the whole industry sit up and take notice, it also accelerated the process of BIM adoption in the country, because if you are not BIM level 2 complaint, you just cannot get your hands on any government project in the UK

The NBS' sixth National BIM Report 2016 released around the same time and reported that BIM adoption in the UK had reached 54%, up from 48% in 2015. Today, above 80% of those surveyed by the NBS are expected to have adopted BIM. The report also noted that in 2014-15, the UK government saved £855 million on existing schemes, which basically facilitated investment in new ones.

UK has become a world leader in the implementation of BIM thanks to the government for their support. Since April 2016, all centrally-procured construction projects in the UK are required to achieve BIM level 2. Nowadays, BIM has been deployed on pilot projects such as the UK Ministry of Justice extension of Cookham Wood prison in Kent where they got a measurable reduction in capital costs, project delivery time and carbon usage.

BIM IN SCANDINAVIA

The Scandinavian countries of Norway, Denmark, Finland, and Sweden count amongst the earliest adopters of BIM technologies, with public standards and requirements already in place. Finland started working on implementing BIM technologies as early as 2002, and by 2007, the Confederation of Finnish Construction Industries had mandated that all design software packages need to pass Industry Foundation Class (IFC) Certification. It should be noted that IFC is a vendor-neutral file format which allows models to be shared and worked on independently of any specific piece of software

In Norway, the civil state client Statsbygg, as well as the Norwegian Homebuilders Association, has been actively promoting the use of BIM. Since 2010, all Statsbygg projects have been using IFC file formats and BIM for the whole lifecycle of their buildings. A leading organization called SINTEF is also conducting research on BIM as part of national R&D program focusing on sustainable tools to improve construction and operation of buildings.

Denmark has mandated its state clients, including Palaces and Properties Agency, the Danish University Property agency and the Defense Construction Service, to adopt BIM practices.

Several private organizations and universities are also conducting R&D work in BIM in Denmark.

In Sweden, the adoption of BIM is so high that best practices have emerged even in the absence of clear-cut government-led guidelines. The country is only behind the US in the publication of academic papers focusing on BIM. And now, the government is also taking initiatives to facilitate nation-wide implementation, and public organizations like the Swedish Transport Administration have mandated the use of BIM from 2015. To be fair, since all these countries are relatively smaller, convincing fewer market players and people to adopt BIM has been a clear advantage for the Scandinavian region

BIM IN GERMANY

According to a McGraw Hill Construction report on BIM, 90% of project owners in Germany either often or always demand BIM. The survey also found out that rather than the government, the emphasis is more on commercial and residential buildings. However, the traditionally conservative German AEC industry hadn't shown much inclination toward BIM adoption, and major public sector projects – Berlin's Brandenburg Airport, Stuttgart 21 railway stations, Elbphiharmonie concert hall in Hamburg – often went over-budget or would be late in delivery

So, in 2015 the government announced the formation of the Digital Building Platform – a BIM task group created by several industry-led organizations to develop a national BIM strategy. However, experts still fear that Germany's federal system – with nearly 16 autonomous or semi-autonomous states and local authorities – might take the implementation a national BIM mandate very hard.

In Germany, the government is playing a big role in promoting the BIM technology. The emphasis is more on commercial and residential buildings in order to implement BIM on all infrastructure projects by 2020.

BIM SINGAPORE

Just like the Nordics, Singapore also benefits from being a small market. The government has created a central repository for building codes, regulations and circulars published by various building and construction regulatory agencies in Singapore. Through this Construction and Real Estate Network, or CORENET, the Building & Construction Authority set out to implement the world's first BIM electronic submission. Since 2015, BIM e-submissions have been mandated for all projects greater than 5,000 sq. meters.Not just that, since 2010, the Building & Construction Authority has been dispensing grants through the BIM funds well, which covers the cost of training, consultancy, and hardware and collaboration software. Moreover, to facilitate information sharing, Building and Support Authority (BCA) and buildingSMART. Singapore have developed a library of building and design objects, as well as project collaboration guidelines.

And now, to standardize BIM modeling conventions and to facilitate data exchange between various project stakeholders, BCA will be implementing phased voluntary and mandatory submission and processing of building documentation in the Native BIM format for regulatory compliance, based on the code of practice for BIM e-submission. Building & Construction Authority BCA will also lead the development of automated model checking for BIM e-submission.

BIM IN FRANCE

France decided in 2014 that it would develop 500,000 Bulding Project using BIM by 2017. A budget of €20 million was also allocated to digitize the building industry. As the benefits from this project will be evaluated, there is a good possibility that BIM will be made mandatory in public procurement this year. The initiative was a part of the French government's Digital Transition Plan for the construction industry, which aimed to achieve sustainability and reduce costs. Also in 2104, the government launched a research and development project in the construction area called MINnD to develop BIM standards for infrastructure projects.

Meanwhile, the French region of Burgundy had deployed BIM models for managing building operations across 135 sites consisting majorly of high schools way back in 2004. Today, the regional council works exclusively within a BIM-based process for construction, maintenance and building operations.

The French Government has deployed BIM within the housing sector on 500,000 houses by 2017. Le Plan Transition Numérique dans le Bâtiment task group is responsible for the French BIM strategy which aims to achieve sustainability and reduce costs.

SPAIN: PUBLIC INFRASTRUCTURE GET BIM IN 2018

Spain has introduced a BIM mandate on public sector projects for 2018 and further mandatory use in infrastructure projects by July 2019. The Spanish Commission for the implementation of BIM methodology has been set up to promote the implementation of BIM in the Spanish construction sector.Nordic countries were the earliest BIM adopters. For example, Finland began using the Building Information Modeling in 2002. BIM has been used for complex infrastructures such as Helsinki metro line

In summary, BIM is a relatively new technology and the industry has only begun to realize the potential benefits of Building Information Models. Nowadays, most countries have made the BIM the global building industry standard. So the rest of the world will need to take on this technology in the next few years.

USE OF BIM IN CHINA

2012 Study by China Construction Industry Association found that less than 15% of a total of 388 surveyed companies were using BIM. According to industry players, this slow rate of adoption can typically be associated with resistance toward new management processes.

The popular sentiment regarding BIM in China is that the government provides encouragement to use the technology, but leadership is missing. Even though the Ministry of Housing and Urban-Rural Development chalked out a role for BIM processes in industrialization, urbanization and agricultural modernization in its 12th Five Year plan, it is not mandatory to use BIM. The Ministry of Science and Technology has also approved the China BIM Union to develop the national standard of practices.

Meanwhile, the Hong Kong Institute of Building Information Modeling (HKIBIM) was established in 2009, and the roadmap for BIM implementation was formulated by the Housing authority in 2014. The contractors are leading the BIM agenda in Taiwan, where hiring a third party to model the design is the norm.

BIM IN SOUTH KOREA

South Korean is one of the early adopters of BIM processes, the South Korean government has been working systematically to increase the scope of BIM-mandated projects in the country since 2010. The South Korean Ministry of Land Infrastructure and Transport even provided $5.8 million over a period of three years to build open BIM-based building design standards and information technology. And since 2016, the Public Procurement Service has made BIM compulsory for all public sector projects over US$50 million.

The McGraw Hill Construction report on BIM finds that 78% of the contractors who are using BIM in South Korea are doing so at low or medium levels of engagement. This low level of engagement can be attributed to the absence of formal measurement of Return of Investment (ROI) – 39% respondents said there was no measurement being done at all.

2.4.3 Current Implementation of BIM in the Construction Industry

In some states such as Finland, Denmark, Norway and USA, the use of BIM has been endorsed, while some other states have progressed toward it. Rapid advancement of some of these activities is discussed briefly. The U.S. General Services Administration (US-GSA, 2008) notified the requirement of utilising Industry Foundation Class (IFC) model server standards by October 2006. Through conducting 10 pilot projects many BIM authoring tools have been certified as to fitness for use. Authoring tools; Autodesk's ADT, Autodesk's Revit, Graphisoft ArchiCAD, Bentley's Architecture, and Onuma Architecture and Master Planning were the initial tools that passed this certification (US-GSA, 2008) and the continual development of modeling requirements progress further.

Details on IFC version specification which support each of these tools were published by Chan and Dainty (2007). During 2007 National Building Information Model Standard (NBIMS) has initiated another US project, which aimed to raise awareness of using BIM systems and consequently NBIMS has released National BIM Standard Version 1 (NBIMS, 2007). Nevertheless National CAD Standard (NCS) Version 4.0 was released in January 2008 to further streamline design, construction, and facility operations communication among construction stakeholders over the lifecycle. Through improved communication these standards hope to reduce errors and lower costs for all disciplines. It coordinates the efforts of the entire industry by classifying electronic building design data consistently allowing streamlined communication among owners, and design and construction project teams (NIBS, 2008).

BuildingSMARTwas initiated as a Norwegian activity, which followed the IFC compatibility that has been introduced by IAI. Many of the buildingSMART are actively promoting and sharing the latest findings related to BIM implementation within the building product development lifecycle. Today BuildingSMART is an alliance of international organisations within the construction and facilities management industries dedicated to improving processes through active collaboration.

HITOS project of University of Tromso has been one of the well -known international activities that used IFC model server technology (www.epmtechnology.com) in a comprehensive manner. Theresearchers involved publishing current business processes required to change to gain advantage from BIM (Koo *et al.*, 2007). The Norwegian Directorate of Public Construction and

Property also produced brief documentation of the project. Further works on BIM and associated IFC files were carried out in the technology programme launched (Value Networks in Construction, 2003-2007) by TEKES focusing on developing eco-efficient solutions for multi-storey and low-rise buildings and provides tools to facilitate the adoption of BIM in construction. During the programme, BIM tools and processes have been developed in order to considerably improve productivity in the industry and make it possible to manage the information generated and maintained throughout the lifecycle of buildings more efficiently (TEKES, 2008). Finland as the world leader in BIM implementation has 108 projects (TEKES, 2008).

On the other hand, slow progressive changes are taking place within the UK industry whilst many UK companies are happy to continue using traditional CAD. However, it is noticeable that US organisations working in the UK markets are effectively converting their processes to utilize BIM technologies (Holzer, 2008). This conversion requires; training, resources, content creation, team working and new workflows which needs to be managed simultaneously. It is clear within the UK industry that change will not happen overnight; however having a clear strategy along with the correct guidance will enable this process (Austin & Delany, 1998). Lack of cohesive directions from the UK authorities comparable to the discussed international initiatives have created this drag and further research is needed to direct them through meaningful engagement with the industrial bodies to bring the intelligence forward for making the valuable decision to aggressively engage with BIM within the construction projects in a timely manner.

2.4.4 Requirements for the Implementation of BIM

BIM implementation requires proper planning, patience and full commitment from all levels of the organization. When introducing BIM to an organization, proceeding with only a minimum amount of knowledge is a common mistake and can be costly.

BIM requires the implementation of BIM execution plan which identifies the BIM needs of 10 for the project (Lowe 2009).

It consists of checklist of issues including but not limited to

(i) the type of Models to be created,

(ii) required level of detail,

(iii) purpose of each model,

(iv) responsible party for creation of each model,

(v) schedule for delivery of Model,

(vi) file formatting,

(vii) file naming,

(viii) object naming,

(ix) interoperability of BIM tools, coordination and clash detection, and

(x) BIM website utilization.

2.4.5 Development of BIM Plan

Amor (2012) opined that developing a solid BIM action plan should be the first step toward getting organization up and running in a BIM environment. When this plan is not in place it is easy to lose track of what information is required to be successful.

The plan should consist of two major sections: analysis and implementation.

(i) Analysis:

Amor (2012) opined thatmajority of the plan should be focused on information gathering about current methods, procedures and business strategy. The transition to a BIM workflow is a major shift for any organization on all levels; as such, it is an excellent time to look deep into your workflow to find any inefficiency that can be fixed.

Alshami and Ingirige (2003) were of the opinion that the analysis portion of a BIM action plan should include:

(a) **Existing Processes Identification and Analysis:**

It is important to conduct a detailed analysis of existing internal and external business processes to help establish a base line for where to start to achieve the goals established later in the plan. This analysis should include a detailed review of how projects are currently being processed through the organization from initial marketing through completion.

(b) Technology Analysis

A detailed technology analysis identifies existing hardware and software technologies and associated costs utilized by the organization. A review of current document and data management should also be included in the analysis.

(c) Personnel Analysis

A detailed review of personnel should be conducted to help establish a few key pieces of information by providing answers to the following:

What are the current roles of your project teams? Who will need to be trained with the new software? What levels of training will each type of employee require?

How will the new requirements of a BIM-based project modify the current make-up of your teams? Do you still require pure drafters?

Can your current drafters become junior-level designers?

(d) Cost Analysis

The transition from a CAD-based organization to a BIM-based organization carries a significant cost impact on three major fronts:

(i) Hardware: Current BIM software requires a higher-performance workstation when compared to CAD software on a comparable-sized project. This BIM implementation may require a significant upgrade of current systems to ensure efficient workflow.

(ii) Software: BIM software will need to be purchased. The best resource for information regarding the best version of software and support to purchase are the many resellers out there. With resellers you can discuss the details of your needs and business plan to help identify the correct route to take whether it is a single license or a full blown subscription with technical support.

(iii) Personnel: Educating and training employees to use BIM software and the new associated delivery processes costs money. This cost will most directly be related to training but there will also be a temporary loss of productivity while existing processes are transitioned to a new methodology.

Once the aforementioned analyses have taken place, the next step is to develop an overall phased strategy for implementation.

(e) Timeline

A detailed timeline is required to ensure that the overall strategy is being implemented in a timely and organized process.

(f) Personnel Changes

A change to a BIM delivery process represents a big change to an existing CAD workflow and thus a change to individual employee roles. The biggest change is a move away from pure drafters. With the BIM process focused around building a project in the virtual environment, those who are interacting with the model require more trade knowledge to be efficient.

Generally speaking, two new roles will be defined within the organization: a company BIM manager and project BIM managers. A company BIM manager will lead the charge for the company and be the guiding force behind implementation, standards development and software decisions. On each project, a project BIM manager should be assigned who is responsible for project related BIM decisions, interacting with other project team members, BIM managers and maintenance of the model.

(g) Training Plan

Training on a BIM platform is best completed using a “Just in Time” method. A lot of the concepts involved with BIM are very different when compared with a traditional CAD workflow and are best learned working on an actual project. A proven method of success is to have multiple training days consisting of half a day for classroom instruction followed by half a day of actual project work with the instructor available for hands-on teaching. Training should start with only a small group of employees on a single project so that they can help streamline the BIM workflow prior to getting the entire organization up to speed.

It is also advantageous for at least a single employee to receive in depth training and then act as the BIM manager for the company. This person can then be the go to person for help and can lead the establishment of standards.

(iii) Implementation

Azhar (2011) observed the following as the basic requirements for effective BIM implementation as:

(a) Clarity as to the extent of integration required – that is use BIM protocol to put foundations in place from the start particularly if BIM data is going to be used directly to support facility Management etc.

(b) Clear BIM protocol describing deliverables, deliverables programme, purpose of deliverables and formats.

(c) Consistent use of compatible BIM packages or effective translation/integration software.

(d) Recognition of cultural and business changes required and how these might be supported by the client.

2.4.6 Keys to Success for BIM Implementation

Successful BIM implementation within a company starts with the shared vision of change and buys in from all members of the organization. Senior leadership needs to support the change and be willing to sacrifice a little in the beginning to reap the future rewards (Tam *et al.,* 2007).

Other organizations are at all stages of the BIM implementation process from thinking about how it's implementation and its operation in a BIM workflow. Additionally, there are many local and regional BIM and IPD groups that meet on a regular basis to discuss BIM related topics. It is important to network with industry peers to share successes and failures to help better the industry as a whole.

Arayici *et al*., (2009) noted that the key to success in any BIM project is collaborative effort among all team members, which includes but is not limited to the project owner, the design team, general contractor, subcontractors and vendors/suppliers.Information data must flow freely between all of the BIM project team members to obtain maximum advantages in the BIM project. The project owner plays a central role in leading the discussion and decision-making process when it comes to applying BIM to the project.

Use available BIM resources to further understand of more advanced BIM concepts and practice. Set aside enough resources to ensure that the organization is not just buying software but is engaging in a business process that will meet the current and future business needs and opportunities.With an intelligent implementation of BIM technology, the team should start to develop skills and techniques, build confidence in the software and pace the future work for potential benefits.

2.4.7 Levels of BIM

Currently there is a lack of a clear definition in regard to what BIM actually is (Howard and Björk 2008). There are many different levels to what professionals define as BIM and this makes discussions regarding BIM somewhat unclear. Many different organisations have tried to define BIM butthere is a lack of consensus, many aspects are similar in regards to the model but the level of how BIM affects the work processes differs (Isikdag, *et al.*, 2007).

BIM used by the NBIMS (National Building Information Modeling Standard) is used as a reference point, because it covers more than just the model.

Building information modeling is a new way of creating, sharing, exchanging and managing the information in the project throughout the buildings entire lifecycle. Isikdag, *et al*., (2007) categorized BIM into different parts such as:

i. Product –An intelligent representation of the building. It is intended as repository for information to be used by the owner or operators and maintained throughout the buildings entire life-cycle.

ii. Collaborative process –Covering business standards, automate the process capabilities and ;

iii. Interoperability for sustainable information usage.

The development of BIM tools have progressed in the pursuit of solutions for different professions. This process resulted in different programs that do not interface well with each other or with advanced project management tools. The two largest challenges for technology developers in regards to BIM have ended up being interoperability in existing BIM systems and creation of multi accurate models to fulfill different purposes (Thompson and Miner 2007).The Industry Foundation Classes (IFC) defined by the "buildingSMART alliance", is the accepted standard for BIM models. IFC is an ambitious attempt to achieve model-based interoperability. It covers a wide range of modeling information, not limited by the geometry of the objects, but also Metadata related to other aspects of the building. (Song*et al.,* 2005).

When analysing the level of interoperability in IFC, Song*et al.,* (2005) consider it in four different levels.

(i) File level interoperability - This covers the ability for different tools to successfully exchange files.

(ii) Syntax level interoperability - This covers the ability for different tools tosuccessfully purse files without errors. This also covers the ability for different tools to interoperate without errors.

(iii) Visualization level interoperability - This covers the ability for different tools to correctly visualise the exchanged model.

(iv) Sematic level interoperability - This covers the ability for different tools tocome to the same understanding of the meaning of a model being exchanged.

The analysis by Steel *et al.,* (2012) came to the conclusion that IFC has so far achieved relative success in providing interoperability in the file and visualisation levels within a subset of domains. This is most notable within architectural design. In situations demanding sematic interoperability it still faces challenges however. That is always the case when its use is broadened to become more sub-domains (Zhang *et al.,* 2000).

The problem with interoperability within the construction industry is the width of the domain itself, different projects can range from a simple one family house to large airports. This breadth has been problematic to IFC and its interoperability because no one tool implements all of its language (Austin & Delaney, 1998). Because of the fragmented and collaborative nature of the AEC-industry interoperability is an important issue. BIM has many viable advantages over CAD, but the ability to share intelligent building information is critically important (Howard and Bjork, 2005). In order to maximise many of the benefits BIM enables in regards to productivity and design quality the challenges with interoperability must be addressed. Many definitions of BIM address it as a single model as the repository for the information (Isikdag, *et al*,. 2007). This single model is however seen as cumbersome by many professionals and it will need to be used together with other type of data storage (Li et al., 2008). It might be more practical to coordinate through a single database linked to the model and keep the geometrical model simple (Bew and Underwood, 2010). The single building information model has been a holy grail but it is doubtful if it will be achieved or not (Keegan & Christopher, 2010).

There are varieties of different types of companies in the AEC-industry, with different size, type of profession, experience with BIM, and so on. To make a business case reliable it should be developed to accomplish specific objectives taking the particular requirements and characteristics of the company in consideration. It is not possible to make a typical business process for the implementation of BIM. It is also possible that a single company should develop more than one business case, each based on different scenarios. For example, there might be different level of model sharing between the consultants in different projects. Depending on the level of implementation of the possibilities with BIM, the initial cost will vary, with highest costs following high level of implementation. It is however suggested that organisations will recover quickly with a positive return on investment as their performance will improve dramatically (Aranda-Mena *et al*., 2009).

2.4.8 BIM Implementation Potentials

Due to the nature of BIM software, there are several wide ranging benefits to be gained by Implementing BIM. Despite this, the adoption ofBIM in the UK has been slow compared to the US. However, it is generally accepted that BIM is finally gaining acceptance and momentum within the industry (Hobbs, 2008).

Some of the main benefits of BIM that are driving the implementations are listed below:

(a) Accuracy and consistency of data– All the information produced by BIM software is deriveddirectly from the building model, ensuring that all data is consistent and accurate. 2D drawings are a prime example of this, as any drawing that is extracted from the building model will be consistent with other views, eliminating errors between various drawings. These drawings are not stored but are generated ‘on the fly’. This means that any design modification made in one view will be fully propagated throughout all views.

(b) Design Visualisation– 3D representations can be generated from the building model at anystage in the design. These can range from simple wireframe models or complex photorealistic renders. Like the production of 2D drawings, the 3D views are produced from the building model meaning the views are consistent with each other and with other 2D drawings.

(c) Ease of quantity takeoff– At any stage of the design BIM software can quickly extract datasuch as floor areas, material volumes and bills of quantities from the building model. Not only is this useful for quickly producing schedules, but by importing or directly linking this data into cost estimating software, cost estimates can be produced quickly at any point in the design process.

(d) Multi-user collaboration– The idea of multi-user collaboration on a project is nothing new.Nonetheless, BIM makes it significantly easier to achieve by using a single building model or several coordinated models. The ease in which information can be exchanged between team members helps the project team to fully understand the project from the outset.

(e) Energy efficiency and sustainability– With the introduction of (Building Research Establishment Environment Assessment Method(BREEAM) environmental ratingsfor buildings in the UK, designers need to produce designs that are both energy efficient and sustainable. There are several software packages that allow a designer to perform the relevant building analyses to ensure projects meet these standards; however, without the use of BIM this would require the onerous task of re-entering the information into each piece of analysis software (Autodesk, 2007). Therefore, BIM allows energy analyses to be produced more efficiently and hence is driving greener designs.

The advantage of BIM technology is greater than the sum of its parts. By looking at each individual benefit of BIM it can be seen that each element is a means to reduce cost, either Directly through better designs and reduced material usage, or indirectly through efficiency gains. Consequently, BIM technology has the potential to go a long way in addressing the inefficiency issues that exist within the construction industry.

2.4.9 BIM Implementation Issues

Despite the many benefits BIM offers, the implementation of BIM within the construction industry poses many significant problems. BIM is a disruptive technology, unlike the adoption of

2D CAD which simply automated a traditional process; BIM requires a whole paradigm shift and a new way of working. Some of the more significant issues are listed below:

(a) Workflow Disruption– The implementation of BIM requires the traditional design processes to bechanged to suit the workflows associated with BIM. This disruption of workflows is an inevitable aspect of BIM implementation; however, the benefits of BIM will soon outweigh the initial drop in productivity that this will produce.

(b)Staff and Training– There are great demands on staff when adopting BIM software. Rundell(2005) likens training for a new technology to a balancing act, stating that it’s about teaching the right skills to the right set of people with minimal disruption. This issue is compounded further by the fact that there is some debate whether BIM should primarily be used by engineers or technicians (Woo, 2007). With BIM software, the design evolves with the building model. This means it is advantageous to have an engineering background when producing a model as a user who knows how a building fits together will be more adapted at using BIM technology.

(c) Legal and Contractual Issues– Due to the large number of companies and stakeholdersinvolved in a construction project, BIM introduces unique issues of responsibility and ownership of building models and intellectual property rights. As the building model is transferred between each stakeholder, it needs to be clear who is responsible for ensuring the model is accurate and up to date. Due to the possible threat of legal action, this increases the risk that a business takes on when accepting responsibility for a building model (Thomson & Miner, 2007).

(d) Interoperability– Succar (2009) defines interoperability as the ability of two or moresystems or components to exchange information and to use the information that has been exchanged. As there is no single piece of software that can carry out all tasks throughout the construction process, the need for good interoperability is essential due to the large number of data exchanges required. Interoperability is a major issue and there are international efforts to establish exchange formats to address this issue.

However construction projects required good collaboration and information exchange between all involved actors due to the collaborative nature of the industry (Gu *et al*., 2008). Traditionally this exchange was made in the form of drawings anddocuments, when moving to adopt BIM new requirements are introduced to ensure effective information exchange. BIM is not only a tool in the design phase of the project, but rather an interface for information exchange between different actors and phases in the project. Currently the different actors are often using different tools, either from different vendors or specialized for their business. Such difference in BIM tools presents challenges for information exchange between the different actors because of inadequate or lacking interoperability (Grillo and Jardin., 2012).

2.5 BIM as a Management Tool for Public Building Project delivery

2.5.1 BIM Tools

Grillo (2010) observed that there are various open and proprietary BIM tools that are available in the market. Most of them are intended to be capable of handle industry Foundation Class (IFC) files. IFC is supported by about 150 software applications worldwide to enable better work flows for the AEC industry (buildingSMART International Ltd., 2013). BIM tools have the ability to extract required information from BIM platform like Revit, and manipulate it with inits API or derive information from BIM platform to it.

The following tables depict the BIM authoring tools and their primary functions. The list includes MEP, structural, architectural, and site work 3D modeling software. Some of this software are also capable of scheduling and cost estimation.

Following are the notable BIM tools:

Table 2.2: BIM Authoring Tools

S / N	Product Name	Manufacturer	Primary Function
1.	Cadpipe HV AC	AEC design group	3D HV AC Modeling
2.	Revit Architecture	Autodesk	3D Architectural modeling and parametric design
3.	Auto-CAD Architecture	Auto-desk	3D Architectural modeling and parametric design
4.	Revit Structure	Auto-desk	3D Structural modeling and parametric design
5.	Revit MEP	Auto-desk	3D Detailed MEP modeling
6.	Auto-CAD MEP	Auto-desk	3D MEP modeling
7.	Auto-CAD Civil 3D	Auto-desk	Site Development
8.	Cadpipe Commercial pipe	AEC design group	3D Pipe modeling
9.	DProfiler	Beck Technology	3D conceptual modeling with Real-Time, Cost, Estimating
10.	Bentley BIM Suite		3D Architectural,

S / N	Product Name	Manufacturer	Primary Function
			Structural
11.	Micro-station Bentley		
12.	Architecture, Structural, Mechanical, Electrical, Generative Design	Bentley System	Mechanical, Electrical, Generative Design
13.	Fastrak	CSC (UK)	3D Structural modeling
14.	SDS/2	Design Data	3D Detailed Structural modeling
15.	Fabrication for Auto-CAD	East-Cost	3D Detailed MAP modeling
16.	MEP	CAD/CAM	3D Detailed MAP modeling
17.	Digital Project	Gehry Technologies	CATIA based BIM System for Architectural, Design, Engineering and Construction Modeling
18.	Digital Project MEP System Routing	Gehry Technologies	MEP Design
19.	Archi-CAD	Graphi-soft	3D Architectural modeling
20.	MEP modeler	Graphi-soft	3D MEP modeling
21.	Hydra-CAD	Hydra-Tech	3D fire sprinkler Design and Modeling
22.	AutoSRINK VR	MEP CAD	3D fire sprinkler Design and Modeling
23.	FireCad	MC4Software	Fire Piping Network Design Modeling
24.	CAD-Duct	Micro Application	3D Detailed MEP Modeling
25.	Vectorworks Designer	Nemetschek	3D Architectural

S / N	Product Name	Manufacturer	Primary Function
			Modeling
26.	Duct Designer 3D,Pipe Designer 3D	QuickPen International	3D Detailed MEP Modeling
27.	RISA	RISA Technologies	Full suite of 2D and 3D Structural Design Applications
28.	Tekla Structures	Tekla	3D Detailed Structural Modeling
29.	Affinity	Trelligence	3DModeling which can be used to generate cost and Schedule data
30.	Power Civil	Bentley Systems	Site Development
31.	Site Design, Site Planning	Eagle Point	Site Development

Source: (Reinhardt, 2009)

A variety of shop BIM tools for drawing and fabrication are available for structural and M&E contractors as depicted in Table 2.3

Table 2.3: BIM Tools for Shop drawing and Fabrication

Product Name	Manufacturer	Primary Function
Cadpipe Commercial Pipe	AEC Design Group	3D Pipe Modeling
Revit MEP	Autodesk	3Ddetailed MEP Modeling
SDS/2	Design Data	Detailed Structural 3D Modeling
Fabrication for AutoCAD MEP	East Coast CADCAM	3D Detailed MEP Modeling
CAD-Duct	MicroApplication Packages	3D Detailed MEP Modeling

Duct Designer 3D Pipe Designer	3D Quick Pen International	3D Detailed MEP Modeling
Tekla Structures	Tekla	Detailed Structural 3D Modeling

Source: (Reinhardt, 2009)

Revit Architecture provided by Autodesk Inc. has built in sequencing options. Each object can be assigned a phase. Revit then uses snapshots of the model for each phase creating a simple sequencing for the viewers. Currently, there are a lot of architects that are using Revit Architecture.

Various BIM construction management and scheduling tools are available as depicted in Table 3.3

BIM Construction management tools that support coordination are: (i) Navisworks Manager, (ii) ProjectWise, (iii) Digital Project Designer, and (iv)Vico. Furthermore, Vico, NavisworksTimeliner, Innovaya and Synchro support BIM and schedule integration. Navisworks, Synchro and VicoOficesoftwares

Table 2.4: BIM Construction Management and Scheduling Tools

S/N	Product Name	Manufacturer	BIM Use
1	Navisworks Manager, Navisworks Scheduling	Autodesk	Clash Detection Scheduling
2	Project Wise	Bentley	Clash Detection Scheduling
3	Digital Project Designer	Gehry Technologies	Model Coordination
4	Visual Simulation	Innoyaya	Scheduling
5	Solibri Model Checker	Solibri	Spatial Coordination
6	Synchro	Synchro Ltd	Planning & Scheduling
7	Tekla Structures	Tekla	Structure Centric Model, Schedule driven Link
8	Vico Office	Vico Software	Coordinating, Scheduling Estimating

Source: (Reinhardt, 2009)

Autodesk Navisworks Manager is wellknown for its clash detection feature.However, it comes with a feature called Timeliner to simulate construction schedules. Timeliner can link Microsoft Project, and Primavera project planner with various BIM (i.e. Revit), CAD and Laser Scan formats. Unfortunately, Timeliner is only a unilateral information exchange platform. Similar to Autodesk Navisworks Manager, TeklaBIMsight runs clash detections. The user can combine models and add comments. This brand new product developed by Tekla is likely to be quickly adopted throughout the world since it is a free product to use and share. These are several very powerful middleware softwares. The two most common are Innovaya and Synchro. Both are capable of providing integration services between the common scheduling softwares (Primavera or Ms Project) with various types of BIM softwares.

Vico Software Inc. provides BIM software packages geared more towards the construction management industry. Its construction software package includes Constructor, Estimator, Control and 5D presenter. Building Information Model is developed in Constructor, Quantities and costs are estimated in Estimator. The data is imported from Constructor 3D model to Estimator. Vico's Estimator software features include processing of quantities, tracking of model revisions, addition of margins, and creation of bid packages.

Location based scheduling is used via Vico's Control software. This is an approach that optimizes the productivity of works by using line of balance method. Simulations are available through the Presenter. Vico's Control software can also integrate with other scheduling softwares. Control has a bidirectional link to Primavera or Microsoft Project. Project schedule in Controller can be exported to Primavera or Microsoft Project and vice versa.

2.5.2 The BIM cost

Building information model costs and savings depends on many factors. Costs are based upon the level of detail of the model, complexity of the project and the expertise of modeling team in the technology. The level of detail (LOD) can be categorized through system published by AIA. LOD 100 is conceptual stage. LOD 200 is approximate geometry stage. LOD 300 is precise geometry stage. LOD 400 is fabrication stage. LOD 500 is as-built stage. (Bedrick, 2008).The main uses of BIM tools for construction managers include visualization, 3D coordination, prefabrication, construction planning and monitoring, quantity take offs, and record model.

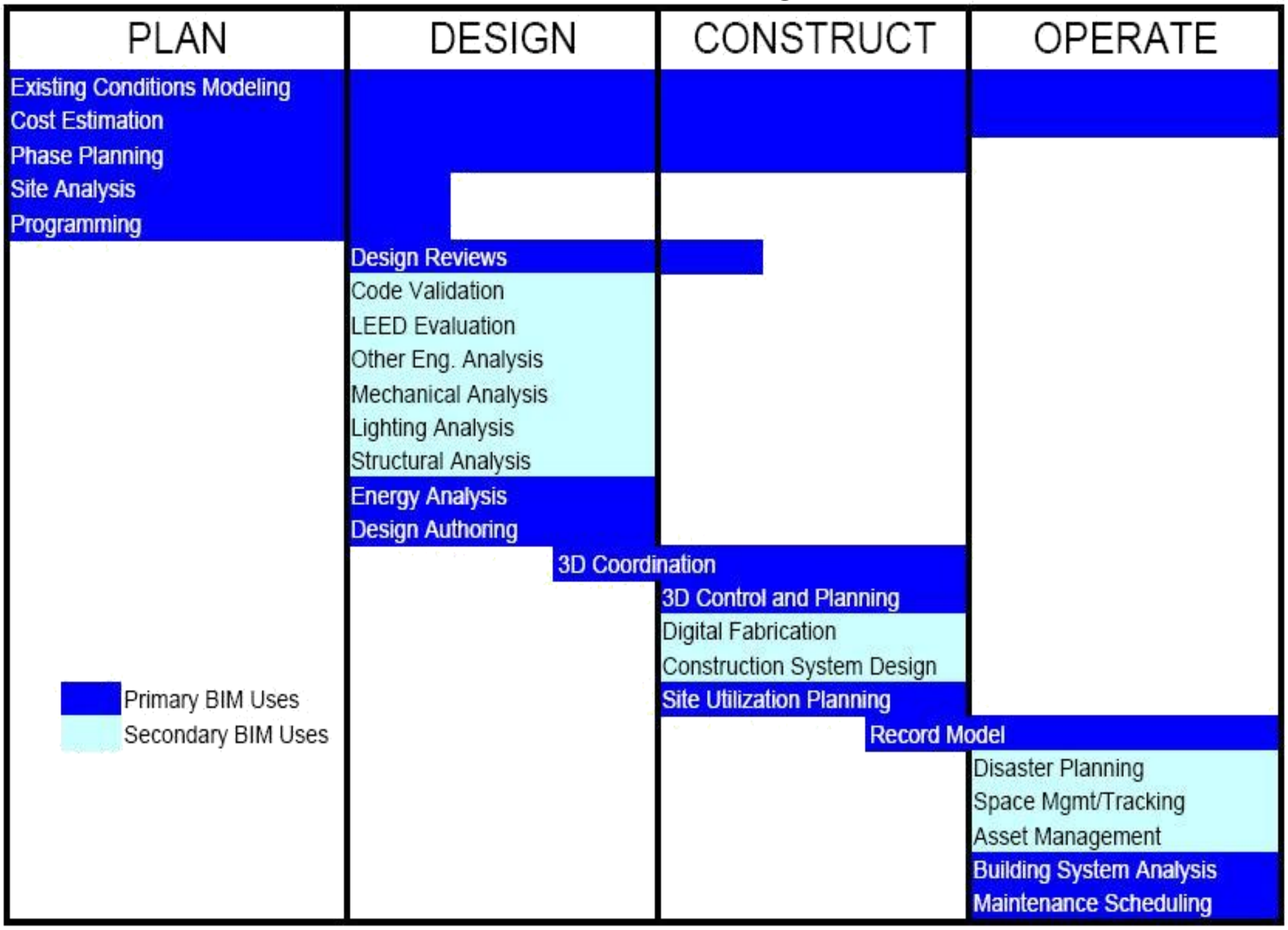
Project savings are considerably high if the Building Information Modeling is used during the early design phase. This is mainly due to coordination efforts that yield to minimization of trade conflicts in the field.

The owner, architect, and engineer can eliminate some of the coordination issues in LOD3 via BIM. Later, the subcontractor can provide more detailed shop and fabrication drawing as LOD 4. At this stage, construction manager can coordinate the approval process of the shop drawings. Furthermore, construction manager can provide more detailed and accurate schedule and cost estimation as the LOD increases from 100 to 400. Lastly, record Building Information Model can be achieved in L500. Overall, the different uses of BIM for construction managers as indicated above can be realized at various stages of LOD that would yield to cost savings.

2.5.3 Use of BIM Tools for Construction Management

There are many uses of Building Information Modeling for each project participant. Table 3.5 depicts these uses for the planning, design (pre-construction), construction and operation (post construction) phases:

Table 3.5: Uses of BIM Tools for Construction Management



Source:Messner, 2009

During the design phase, the use of BIM can maximize its impact on a project since the ability to influence cost is the highest (Succar, 2009). The team can creatively come up with ideas and provide solutions to issues before problems become high cost impacts to the project. This can be realized through the cooperation and coordination of the entire project staff. Therefore, it is extremely important to have a good collaboration. The use of BIM enhances the collaborative efforts of the team. The architect and engineer can test their design ideas including energy analysis. The construction manager can provide constructability, sequencing, value and engineering reports. They can also start 3D coordination between subcontractors and vendors during early stages of design. The owner can visually notice if the design is what he is looking for. In overall, BIM promotes collaboration of all of the projection participants.

There are beneficial uses of BIM during the construction phase. However, the ability to impact the cost in a project reduces as depicted in table 2.5 as the construction progresses. Several uses include sequencing, cost estimation, fabrication and onsite BIM.

These uses are discussed in detail.

During the post construction phase, maintenance scheduling, building system analysis, asset management, and space management and tracking, disaster planning, and record modeling can a record model can help to maintain the building throughout its lifecycle. Ideally, the building automation systems (BAS) which controls and monitors the use of mechanical and electrical equipment can be linked to the record model to provide a successful location based maintenance program. Furthermore, building system analysis including energy, lighting, and mechanical can be used to measure building’s performance. Moreover, upgrades may be initiated to various equipment and components of the building.

(a)Visualization

Building Information Modeling (BIM) is a great visualization tool. It provides a three dimensional virtual representation of the building. During the bidding phase of the project, the construction manager can provide renderings, walkthroughs, and sequencing of the model to better communicate the BIM concept in 3D.

Visualization provides a better understanding of what the final product may look like. It takes away thought process of bringing the different traditional 2D views together to come up with the 3D view of a detail. Furthermore, virtual mock-ups such as laboratories or building envelope can be provided to the designer and the owner. This would help to visualize, better understand, and make decisions on the aesthetics and the functionality of the space. As depicted in figure 5 and presented in the BIMForum Conference in San Diego, virtual mock ups can be used to review 3D shop drawing of the building envelope (Khemlani, 2011). The virtual mock ups help to communicate and collaborate among the project participants. It promotes planning, and sequencing the curtain wall construction. Even though a virtual mock up is cost efficient in comparison to a physical mock-up, a physical mock-up may still be required if a member such ascasework drawer or an assembly of the building such as a curtain wall need to go through a series of physical tests.

(**b) 3D Coordination**

Collaboration of the construction team with the architect, engineer and the owner is preferred to be started on early stages of design phase. At that time, the Building Information Modeling shall be implemented immediately. If the architect is only providing 2D drawings, then the construction manager should convert the 2D drawings to 3D intelligent models. When the specialty contractors, especially the MEP contractors and the steel fabricators are involved, they need to spatially coordinate their work. The 3D coordination can be started right after the model is created to ensure that any same space interference (hard clash) or clearance clash (soft clash) conflicts are resolved. Overall, the coordination efforts of construction manager and specialty contractors with respect to construction help to reduce design errors tremendously and give better understanding ahead of time the work is to be done.

(c) Construction Planning and Monitoring

The construction planning involves the scheduling and sequencing of the model to coordinate virtual construction in time and space. The schedule of the anticipated construction progress can be integrated to a virtual construction. The utilization of scheduling introduces time as the 4^{th} dimension (4D).

There are two common scheduling methods that can be used to create 4D Building Information Model. These are critical path method (CPM) and line of balance. In the Critical Path Method, each activity is listed, linked to another activity, and assigned durations. Interdependency of an activity is added as either predecessors or successors to another activity. Moreover, the duration of the activities are entered. Based on the dependency and duration of the activities, the longest path is defined as the most critical path. The activities defined in the longest path are defined as the critical activities. These activities do not have any float. In other words, if these activities are not completed within anticipated duration, the total duration of the project will be further pushed out. Overall CPM is a commonly used technique that helps projects stay within schedule.

Line of Balance technique uses location as the basis for scheduling. This method is an alternate to the CPM. It is advantageous for repetitive tasks to increase labor productivity. In this method, activity durations are based on the available crew size and the sequence of the location. Productivity of the labor force can be altered as needed to accurately depict the construction schedule. The approach focuses on the locations being completed by a trade before the other trade moves in. This reduces the number ofmobilizations and resources. Overall, line of balance is a good scheduling method to plan and monitor repetitive tasks during construction progress. (Keegan and Christopher, 2010)

The planning through using BIM enhances site utilization, space coordination, and product information. A 4D model can either include a site logistics plan or tools such as SMARTBOARD on top of a virtual construction can be utilized to visually depict the space utilization of the job site. The model must include temporary components such as cranes, trucks, fencing etc. Traffic access routes for trucks, cranes, lifts, excavators, etc. need to be incorporated into the BIM as part of the logistics plan. For example, the site logistics planning for the Hennessy Centre steel erection (Azhar, 2011). Moreover, the site utilization consists of lay down areas, site work progress, and location of trailers and equipment and hoist assembly. Similarly, when the building is being closed in, the space coordination must be managed for the roughing and eventually finishing activities.

(d) Cost Estimation

The two main elements of a cost estimate are quantity take-off and pricing. Quantities from a Building Information Model can be extracted to a cost database or an excel file. However, pricing cannot be attained from the model. Cost estimating requires the expertise of the cost estimator to analyze the components of a material and how they get installed. If the pricing for a certain activity is not available in the database, cost estimator may need a further breakdown of the element for more accurate pricing. For instance, if a concrete pour activity is taking place, the model may account for the level of detail for the rebar, wire mesh, pour stop, formwork, concrete etc., but not include it as part of the quantity take-off extraction. Cost estimator may need this level of detail from the model to figure out the unit price which consists of the unit material cost, unit labor cost, overhead and profit. The unit labor cost is driven by the mobilization and installation durations, and the labor wage while the unit material cost is the sum of the material costs used for the activity per unit. Once the unit price is attained, the cost of the entire activity can be attained by multiplication of the total quantity extracted from BIM and unit price.

In Building Information Model, the data output is as good as the data input. It is significantly important to have the constructor and the designer to agree on component definitions. For instance, if an architect is using concrete slab to show the roof for modeling purposes, the roof quantity information will not be accurately accounted for quantity extraction purposes in the model. Overall, the BIM technology is a great tool to optimize the productivity of the estimators through quantity extraction from the model especially if the construction and design team work collaboratively.

(e) Record Model

Construction Managers can provide a record Building Information Model to the owner at the end of a project. The model includes the integration of the as-built from the subcontractors. Furthermore, each object property in the model can also include links to submittals, operations and maintenance, and warranty information. Centralized database can help the facilities department to find information easier. Record model can be used to manage security and safety information such as emergency lighting, emergency power,egress, fire extinguishers, fire alarm, smoke detector and sprinkler systems (Lowe, 2009). Furthermore, the facility team can analyze energy efficiency of a virtually built model. In addition to that, facilities team can plan with record model to maintain and renovate

buildings by tracking spatial information such as furniture, equipment, and MEP (mechanical, electrical, and plumbing) connections. Finally, the facilities department can use the model to generate cost and schedule impacts for maintenance and renovation projects. Overall, a record model can be utilized to optimize facility management and maintenance.

Generation of Building Information Model as a record model is an area in the process of development. The interoperability of the record model with various applications could potentially be a challenge. Furthermore, the owner needs to be willing to allocate funding to train employees, update and maintain the record Building Information Model (Keegan, 2010). As the benefits of the record model are realized, the owners will be more demanding of the record Building Information Model. An accurate record model that contains the scope of the project and the needs of the facilities department can help the owner manage and maintain the building tremendously. This can leave a long lasting positive impression of the construction manager to the owner of the project.

Summarily the main uses of BIM for construction managers include visualization, 3D coordination, prefabrication, construction planning and monitoring, quantity take offs, and record model. Project savings are considerably high if the Building Information Modeling is used during the early design phase. This is mainly due to coordination efforts that yield to minimization of trade conflicts in the field. The owner, architect, and engineer can eliminate some of the coordination issues in LOD3 via BIM. Later, the subcontractor can provide more detailed shop and fabrication drawing as LOD 4. At this stage, construction manager can coordinate the approval process of the shop drawings. Furthermore, construction manager can provide more detailed and accurate schedule and cost estimation as the LOD increases from 100 to 400. Lastly, record Building Information Model can be achieved in L500. Overall, the different uses of BIM for construction managers as indicated above can be realized at various stages of LOD that would yield to cost savings.

2.6 The Role of BIM in Construction Management

Construction management involves the optimum use of available funds, the control of the scope of the work, effective project scheduling, the avoidance of delays, changes and disputes, enhancing project design and construction quality and optimum flexibility in contracting and procurement (Arditi and Ongkasuwan, 2009). Information is of great value for the construction manager (CM). Traditionally, CMs access the necessary information via periodic meetings, blueprints, reports, and work schedules; they coordinate the construction processes with this information. However, preparing and presenting the information is time consuming and includes human factors. It can be stated that traditional methods fall short in monitoring complex construction projects. On the other hand, developments in IT allow the CM to access more accurate and current as well as visual information, which in turn allows the CM to monitor construction processes more effectively. Developments in IT have affected the CM duties and responsibilities and therefore, are expected to change the practice of construction management too.

Information Technology systems used today in construction encompasses all disciplines and is used to describe and document the contributions of each member of a project team (Alshawi *et*

al., 2007). The most current IT product is Building Information Modeling (BIM) which is a process by which a digital representation of the physical and functional characteristics of a facility are built, analyzed, documented, and assessed virtually, then revised iteratively until the optimal model is documented (NIBS, 2007). BIM is not only a 3D virtual representation of building, but also a giant database which includes significant information packages for the basic construction management practices such as estimating, scheduling, change orders, etc. So, the designer can use BIM as a real simulation of the actual project before real construction starts.
However, there is ambiguity about the compatibility of the construction management body of knowledge and BIM.Computerization has improved speed and accuracy in most construction management services. Web-based systems have allowed access to information, communication between parties and overall efficiency. The basic practices of construction management involve the use of sophisticated computer tools. Budget, schedule, risks, constructability, etc. are modeled and analyzed before the execution of the actual project and tracked during the construction process on the computer system. These computer tools allow Construction Managers (CMs) to perform their duties with great speed and accuracy. Most CMs are familiar with traditional practices that involve basic computer tools, but should they also need to get acquainted with BIM and should they explore ways to integrate BIM applications into their duties.

(i) Budget Management

Budget management encompasses all project-related cost aspects of CM practice (Haltenhoff, 1998). The CMs has the responsibility to confirm, generate, track, report, and substantiate all budgeted costs from the first estimate to the final accounting. The conceptual budget for the project, prepared by the CMs before design begins, becomes the team's line-item financial guide as the design process moves toward the bidding phase. After bids are received, the amounts of accepted contractor proposals replace estimated line-item amounts and become the construction phase budget. As construction proceed,payments to contractors, contract changes, and budgeted expenses are accounted for in detail. Every aspect of project cost is estimated as early as possible and substantiated as it occurs.

One of the important parts of budget management is cost estimating which includes the development of an estimate of the materials and other resources needed to complete the project activities. BIM models can be used for cost estimating to generate a bill of quantities. It is also possible to establish a direct link between the BIM model and the estimating software. Once a cost estimator establishes this link, changes in the BIM model are automatically propagated through the whole estimating cycle (Staub-Frenc, Fischer, Kunz, Paulson, 2003). Since there are links between the BIM model and the cost estimate, the CM can get cost-related or expenditure-related evaluation for any activity. Cost budgeting includes allocating the overall cost estimate to individual work activities and controlling the cost of the changes to the project budget. BIM interconnects structural design, time, and cost effectively (Gabbar, Aoyama and Naka, 2004).

Alternative computer-aided methods have been developed for effective budget management. For example, Zhang *et al.*, (2009) developed a building information system that includes among other things a budget information and monitoring dimension. Hardin (2009) described the use of BIM for effective budget management. Popov *et al.,* (2010) stated that cash flow can be predicted in 5D models, where the 5^{th} dimension represents cost-related data.

(ii)Contract Management

According to Haltenhoff (1998), contract management encompasses the involvement of the CM in the operational and administrative provisions of the contracts used in the project. Construction management expertise includes the recommendation of standard contract forms and the performance responsibilities to be included in contracts, but does not extend to the writing of contracts or in any way infringe upon the legal profession. This area is important because the construction management system is a unique contracting system, the success of which depends on a workable alignment of traditional contracting roles and participant responsibilities. It is the CM's responsibility to establish a contracting format for the project and see that each contractor's operational and administrative requirements are included.

AGC is the first organization that marketed contract documentation focusing on the use of BIM in a project in September 2007. The Building Information Modeling (BIM) Addendum of Consensus DOCS 300 Tri-Party Collaborative Agreement promotes an integrated process and focuses on BIM as a tool that can enable the project team. These contracts aim focus on responsible data sharing through BIM technology. AIA has also released contract language that addresses the use of BIM. American Institute of Architects documents A295-2008, B195-2008 and A195 2008 require protocols for sharing, owning, and transferring data throughout a project (AIA 2010). Since BIM brings a new dimension to project delivery methods, the CM should be familiar with these new types of contract.

(iii) Decision Management

Decision management encompasses the development and handling of the interrelationships between the project and the construction team, and the relationshipbetween the members of the construction team. It is the CM's responsibility to consistently extract decisions from the team without alienating any team members in the process. Team members must make decisions cooperatively, respecting each other's project function, expertise, and operational capacities. Decisions that become contentious must have a prescribed path for resolution.

Since BIM includes all of the design and management source data of the building, the CM can support the construction team by using BIM applications in the decision making process. Each phase of a project requires a unique decision-making process. The CM can use BIM to generate drawings, reports, design analysis, cost estimates, schedule simulation, facilities management, and ultimately enabling the building team to make informed decisions.

(v) Information Management

Information management encompasses the collection, documentation, dissemination, safe keeping, and disposal of verbal and graphic project-related information. The team structure and the use of multiple contracts significantly increase the information available to the owner. The volume of information generated for project accountability purposes requires a multilevel, need-to-know reporting structure and an efficient information storage and retrieval system (Gabbar, Aoyama and Naka 2004). Information management can be established by setting up a communication platform such as BIM. Since BIM is a database of information, the CM can reach the digitized documents whenever needed and set up a computer-based communication system. Underwood and Isikdag (2010) stated that BIM acts like a shared information backbone through the lifecycle of the project. The BIM approach is essentially a conceptual way of managing project information even though the majority of construction business processes are heavily based upon traditional means of communication such as face-to-face meetings and the exchange of paper documents in the form of technical drawings, specifications and site instructions. It should be noted that the historical, industrial and market forces that perpetuate the industry's culture affect negatively the extent of adoption of IT tools like BIM (Badwin*et al.*, 1999). Nevertheless, BIM can be used to communicate with project team members.

(v) Material and Equipment Management

Material/equipment management encompasses all activities relating to the acquisition of materials and equipment from specification to installation and warranty. Material handling includes procurement, inventory, shop fabrication, and field servicing. The construction management delivery system facilitates direct owner purchase of materials for the project. The planning, specifying, bidding, acquisition, expediting, receiving, handling and storing of direct purchases must accurately reflect the requirements of the project schedule. Proper control and management of materials can increase productivity significantly (Navon and Bercovich, 2005).

On the other hand, the use of modern equipment impacts construction technologies and enhances the competitiveness of construction companies. Materials and equipment constitute a large portion of a projects total cost and must therefore be subject to strict control. Organizations thatdo not recognize the impact of various innovations in materials and equipment get forced out of the mainstream of construction activities (Hendrickson,2008).

4D and 5D BIM models can be used to analyze the time and cost impacts of the selected materials (Amor, 2012). Also, Mahalingam *et al.,* (2010) stated that construction planners can use 4D simulations to select the appropriate construction equipment for the project and to check the safety conditions for the movements of equipment. Currently, 4D BIM models are used to optimize site layouts (Zhang*et al.*,2000), and improve site logistics and space work execution (Akinci*et al.,* 2000).

(vi) Project Management

Project management encompasses all of the operational aspects of project delivery, including determining, formulating, developing, installing, coordinating and administering the necessary elements from the beginning of design to the termination of the warranty period. The CM has the responsibility to coordinate the efforts of the team in achieving a common goal. There is a growing use of BIM models to minimize the potential for design and construction errors, to identify critical space and time during construction (Dawood*et al.,* 2005) in his findings determined the most suitable construction methods and sequence, and to monitor construction progress (Sriprasert and Dawood 2003). Russell *et al*., (2009) discussed how visual representations and interaction technologies support a range of project management functions and enhance the understanding of project status. Dawod *et al.*,(2002) proposed a 3D model-based project management control system that enables the CM to display a holistic picture of a project by applying the multiple project data sets to the 3D building model components (Russel*et al.*, 2009). Zhang*et al*., (2005) used an integrated building information system and digital images captured on-site to semi-automate the calculation of progress measurements and project status.

(vii) Quality Management

Quality management ensures that the project will satisfy the needs for which it was undertaken. It includes all activities that determine the quality policy, objectives and responsibilities and implements them by means such as quality planning, quality assurance, quality control, and quality improvement (Nielson, 2008). Since the fundamental element of BIM is a 3D virtual model, the owner and the design team have a first impression of the overall project from the 3D model.

In the traditional approach, it is difficult to reconcile the different designs such as architectural vs. MEP or structural vs. MEP unless the design team is very experienced. However, BIM models allow the design team and the CM to virtually review the conflicts and resolve them during coordination meetings (Hartman *et al.*, 2008). Therefore, the quality of the project is substantially enhanced before actual construction begins. During the construction process, quality can be controlled with traditional methods such as benchmarking the process against quality standards, but the construction process can be captured and integrated to the BIM environment too. For example, Brilakis*et al.*, (2006) experimented with automated construction site image retrieval technologies; Kim *et al.*, (2003) explored how 3D models of existing construction sites can be rapidly generated using data from laser scanners; and Akinci*etal.*, (2006).

Yalcinkayaand Arditi (2009) investigated how as-built laser scan data can be used for ongoing site inspection. The captured construction processes can be used to ensure that the quality requirements of the contract are satisfied.

(viii) Resource Management

Resource management includes the selection, organization, direction and use of all project resources, both human and physical. The construction management delivery system places all consulting, design, management, contracting, and construction services in a team environment coordinated by the CM.

BIM technology is used for visualization purposes by most construction professionals. But this technology has moved far beyond its original visualization stage. Some researchers have investigated the integration of construction resource management to BIM. For example, Babic*et al.,* (2010) used BIM to link information from the enterprise resource planning (ERP) information system with the building design data, thus tracking the status of the different components of the project; and Wang *et al.,* (2004) developed a BIM-based system that integrates dynamic resource management and the decision support system.

(ix) Risk Management

Risk management encompasses the dynamic risks that are directly tied to team decisions and static risks that are simply inherent to construction. Risk management has traditionally been applied in the area of safety, cost, time, and contract management in construction projects. It can also be used in bidding policies, feasibility studies, marketability studies, performance evaluations, and contingency management (Han *et al*.,2008).

The CM can use BIM to reduce safety risks and as a starting point for safety planning and communication. The utilization of BIM can result in improved occupational safety by connecting safety issues more closely to construction planning, providing more illustrative site layout and safety plans, managing and visualizing up-to date plans and site status information, as well as by supporting safety communication in various situations (Sulavinki*et al*., 2010).

The CM can use BIM to reduce not only safety risks, but also the risks associated with cost and time management. For example, Zhang *et al*.,(2009) developed a building information system to address the impact of project management risks on time and cost during the construction of the superstructure of buildings.

(x) Safety Management

Construction is one of the most hazardous industries in the world due to its unique nature including frequent work team rotations, exposure to weather conditions, and high proportions of unskilled and temporary workers (Jannadi and Bu-Khamsi, 2002). Safety management includes the processes required to assure that the construction project is executed with appropriate care to prevent accidents that cause personal injury, death, or property damage. Accidents and their consequences are a major concern in the construction industry both in terms of human suffering and the direct and indirect costs to the industry.

Many researchers have addressed the lack of integration between construction and safety. Traditionally, safety is achieved through periodic meetings and training. Virtualization of the projects before the actual construction phase allows safety managers and CMs to simulate their safety precautions and identify potential safety problems. For example, Popov *et al.*, (2010) used 3D simulation to locate cranes such that their booms do not hit structures; Alshawi*et al*., (2007]) gave BIMÕs visualization technologies a central role in safety training; Vacharapoom and Sdhabbon (2009) defined a rule-based hazard identification model using BIM to analyze and anticipate unsafe conditions; Sulavinki*et al*., (2010) proposed BIM models to incorporate safety related activities into construction schedules; and Hu *et al.,*(2008)defined the analytical procedures based on 4D simulations to reveal potential safety threats.

(xi) Schedule Management

Construction planners typically use CPM-based networks and bar charts to describe the proposed schedule of a project. The CPM schedule does not provide any spatial information and any information about the complexities of the project components. Therefore to identify the spatial aspects of a project, planners must look at 2D drawings and conceptually associate the components with the related activities. Because CPM networks are an abstract representation of the project schedule, users need to interpret the activities to comprehend the sequence they convey (Hobbs, 2008). The outcome could be arbitrary since different planners could have different perspectives of developing a project schedule. In addition, the current CPM methods do not allow planners to explicitly describe the constraints of a construction project, such as availability of resources, the site conditions, and the availability of capital, which are very important factors for making decisions (Feng*et al*., 2010).

Therefore, planners can only determine the impact factors of project scheduling in their mind, which is time consuming and frequently prone to error (Koo *et al*., 2007). Besides, it is very difficult to integrate the time and cost information in the current CPM scheduling framework, one of the reasons being that schedules generated by the CPM method are activity-based, whereas in the construction process, the project is executed according to work items. The work items contain the cost and resource data of the project but are not well connected to the activities of the project schedule.

4D models integrate 3D geometry with time as the fourth dimension. Any building component in a 4D model contains geometric attributes that describe its 3D shape, as well as a time attribute that indicates the start and finish times of the construction of this element. A 4D model of a structure can therefore be used to graphically simulate the sequence of construction operations, thereby providing the operator with a virtual, visual understanding of the construction process (Navon and Berkovich, 2005) 4D visualizations can be used by a wider variety of project participants at varying levels of skills and experience (Mahalingham*et al*.,2010).

Hardin (2009) developed integrated systems to schedule projects with basic BIM applications. Dawood and Akinsola (2002) proposed a virtual construction site model to develop a decision support system for construction planning; Chau *et al*., (2005) developed and implemented a 4D site management model for construction management; Migilinskas and Ustinovichius (2006) proposed a 4D model for project life cycle management.

(xii) Value Management

Hu *et al.*, (2008) stated that Value management addresses a project's cost versus its value, and this has three value components: designability, contractibility and constructability.

(a) Designability relates value to overall project design. BIM models allow designers to design a building with respect to the required specifications. Having an effective knowledge about the material libraries makes the virtual model more acceptable.

(b) Constructability relates value to construction materials, details, means, methods, and techniques. BIM models allow the design team and the CM to virtually review the conflicts and resolve them during coordination meetings (Keegan and Christopher, 2010). Current BIM software applications detect clashes and enhance constructability.

(c) The Contractibility relates value to contracting options, contractual assignments, and contracting procedures. The Construction Management is expected to extract maximum value for the owner with respect to designability, constructability and contractibility.

2.7 Traditional Method of Construction

2.7.1 An Overview of Traditional/Conventional Method

Traditional Design-Bid-Build, Construction Management at Risk, Design/Build and Integrated Project Delivery (IPD) methods are the most common project delivery approaches that the industry currently practices (Hartman *et al*, 2018).

The construction manager job is officially started in a project as soon as it is awarded. The project award timeline to the construction manager and the organizational structure of the project are dependent upon the construction delivery approach (Gallaher *et al*, 2004)

In the traditional approach, the design, bid, and build phases follow each other. The architect, the lead designer in building projects and construction manager works directly for the owner.

The engineering consultants are part of the designer's team. The engineer and the architect first design the building. Upon, the completion of the design phase, the construction manager's also known as general contractors in the traditional approach bid for the job. Once the bid is awarded, then the construction starts. It is not a fast track project delivery method. In other words, the approach does not involve early participation of the construction team during design. If the designers generated a 3D parametric model for the project, the BIM will lack the knowledge of the contractors during the design phase. Overall, Design-Bid-Build eliminates thebenefits of having the construction input during design phase when the ability to influence the cost is the highest as depicted in figure 2.4. The architects and the engineers may not want to share their models due to risks, liability concerns,unauthorized reuse of intellectual properties and misinterpretation of the information included in the model.

In Construction Management at Risk delivery method, (Traditional method) both the designer and the construction manager work directly for the owner. They can collaborate and complement each other's work and report to the owner. When BIM is used, this approach carries the risk like the traditional method that the architects and the engineers may not want to share their models due to risks such as liability concerns, and unauthorized reuse of intellectual properties. Also, Traditional method usually entails the pre-construction services. This enables the input of the construction team to the Building Information Model early on during the design phase. It can be used for private and public fast track projects.

Design/Build delivery approach requires a single entity to take over the responsibilities of the designer and the builder for the owner. Selection of Design/Build professionals is usually based on a combination of cost and professional qualifications. Since the designer and the general contractor work together, quality control assurance is limited. In other words, cost could become a priority over quality.

(a) Advantages of Traditional Method

Traditional method usually comes out with high quality works since the client has the closer control to the works. For example, the consultant team must provide a design which meets the requirements of the client. Besides, due to the advice and construction expertise provided by the consultant and contractor, client may compare and consider which design and budget is more suitable for the project. In traditional method, all tenderers are requiredto produce a tender based on the same information. Therefore, client may obtain the best or lowest price through competitive tendering. Besides, the construction cost will be more accurate since the tender is bases on the complete design and specifications. It is because this method had been commonly used for a long time, so, both contractor and consultant team are familiar to solve or face the risks during the procurement stage of construction project.

(b) Disadvantages of Traditional Method

(i) For traditional method, it is very hard for client to manage the project since he needs to communicate with many parties at the same time. For example, the consultant and contractor do not have contractual relationship, hence, if they need to communicate with each other, they must communicate with the client first, which is very inconvenience.

i. There may be miscommunication since the client need to communicate with so many organization too.
ii. Traditional method requires longer period to complete the project. It is because the tender will be provided after the design is fully completed.
iii. If problems occur, consultant and contractor may shirk in their responsibility to each other. The argument and problems may need a long time to be settled. For example the purpose of
iv. the project is to build a 20 storey condominium, assume that there is a problem from the drawing of the design and the contractor wants to communicate and get information from consultant team. For traditional method, the contractor will only be appointed after the design is done, therefore, contractor is unable to plan for the project and input his design. So, the contractor need to communicate with the client first, then only the client will communicate

with the consultant, since, there is no contractual relationship between the consultant team and contractor team. Besides, the changes of the design need to be approved by the client first.

Table 2.6 Difference between Traditional method and BIM

S/N	PROJECT FACTOR	TRADITIONAL DELIVERY	BIM DELIVERY
1.	Team	Fragmented, assembled on 'as needed' or 'minimum necessary' basis, very hierarchical, controlled.	Integrated team entity of key stakeholders, assembled early in the process, open, collaborative.
2.	Process	Linear, distinct, segregated, knowledge gathered 'as needed' hoarded, silo of knowledge and expertise.	Concurrent and mid-level, early contributions of knowledge and expertise, information shared, trust and respect.
3.	Risk	Individually managed, transferred to the greatest extent possible.	Collectively managed, appropriately shared.
4.	Reward /Compensation	Individually pursed, minimum efforts for maximum return, often cost based.	Team success tied to project success, value-based.
5.	Communication / Technology	Paper-based, two dimensional, analog.	Digital, virtual, Building Information Modelling, 5D+

6.	Agreements	Encourage unilateral efforts, allocate and transfer risk, no sharing.	Encourage, foster, promote and support multilateral open sharing and collaboration, risk sharing.

Source: Sacks (2012)

2.7.2 Performance in Traditional Method of Construction

Ujene *et al.,* (2009) observed that the level and adequacy of the construction planning has influence on the general performance of the project. Wang *et al.,* (2004) identified cost, time, quality, client satisfaction, safety profitability and productivity as the major indicators of the performance of construction projects while Jannadi *et al* (2002) defined contractor performance to embrace construction cost, construction time.

Construction quality and sustainability development, while, Arditi and Ongka Suwan (2009) also noted that it is commonly agreed among researchers that client needs are generally in terms of time, cost and quality and usually, project success is measured on those terms. Nielson (2008) noted that that the aim of any project manager is at achieving project within predefined time, cost and quality constraints. These three factors play significant roles in achieving project objectives; hence Vacharapoom and Sahabbon (2009) observed that if limited capital budget is the prime consideration of the client, quality is likely to be restricted in the form of a reduced specification and project duration will be the optimum in terms of construction and cost rather than client choice. Dainty *et al* (2006) related project performance to prescribed goals or objectives which form project parameters. The study from project management perspective sees project performance as being all about meeting or exceeding stakeholders' needs and expectations from a project which variably involves placing consideration on major project elements of time, cost, quality, health and safety profitability, productivity and others.

2.7.3 Builders Execution and Control Tools

Builders' Execution and Control tools are production management documents prepared as part of construction planning so that a building project is executed successfully (Brilakis *et al.*, 2006). Burke *et al.*, (2007) observed that the documents are required to be prepared, examined, reviewed and monitored by member of the client team who should be a builder, he may also vet those prepared by the contractors or sub-contractors.

These documents are discussed as follows:

(a) Construction Programme: This is a workable schedule in diagrammatic format of what is to be done and when it is to be carried out. The major purpose is to map out the program expected on a construction cost in a timeline that is the most efficient and cost effective. Dawood *et al.*, (2002) noted that its purpose include to record agreed intention with the client or his representative, to show the sequence of operation and the total output rates of labor and planrequired in other to provide a good yardstick for monitoring progress and project control and to discourage changes in the design by indicating the natural consequences. According to Than (2009) the preparation of a workable schedule using Gantt chart, critical path method and other elements in the development projects have been predicted to reduce the problem of late possession of site and ensure optimum cost, time and quality throughout the project.

2.7.4 Factors Affecting the Operation and Use of Construction Programme

The listed factors affect operation and use of construction programme in the industry:

(i) Competence and abilities of personnel

(ii) Competition date of a project

(iii) Monitoring/Control system

(iv) Project budget

(v) Effective time management

(vi) Resources requirement

(vii) Skills of the available people on the project

(viii) Changes and disturbances in workflow

(ix) Clients project experience and culture

(x) Leader communication and organizational skill

(xi) Precise and measurable milestone

(xii) Task duration

(xiii) Task relationships

(xiv) Critical path

(xv) Team member relationship

(xvi) Tendering procedure

(xvii) Simplicity of programme

(xviii) Size of a project team

(xix) Task priorities

(xx) Type of schedule

(xxi) Client schedule requirement

(xxii) Tasks and sub-tasks

(xxiii) Task risks

(xxiv) Weather

(xxv) Procurement system

(xxvi) Political changes

(b) Construction Methodology: Chau *et al* (2005) defined construction methodology as a management tool which arranges the builders idea of how the production process of a building project would be best executed. Construction methodology is also what Haltenhoff (1998) identified as construction work statement, a component of a method statement prepared for the following purposes: to explain the contractors proposed methods and sequence of working for checking by the representative; to calculate activity durations for the programme; to decide on gang composition and resource requirements for individual activities; to plan activities in detail so that a logical construction sequence is adopted; to provide an easily understood document that can be communicated to those who will carry out the work on site. Dawood *et al*., (2012) observed that construction methodology develops a number of alternative preliminary concepts for the construction work, which outlines the key features of operations in each section of the operation thereby provides frameworks and strategic plan within which diligence obligation could be met without damage to the environment.

2.7.5 Factors Affecting the Preparation and Use of Construction Methodology

(i) Complexity of a project

(ii) Size of project

(iii) Project specification

(iv) Competence and abilities of personnel

(v) Availability of equipment and operators

(vi) Skills of the available people on the project

(vii) Duration of project

(viii) Nature and number of tasks to be performed

(ix) Technical difficulties

(x) Easiness of techniques used

(xi) Monitoring / Control system

(xii) Team member relationship

(xiii) Weather

(xiv) Size of a project team

(xv) Expected profits from the project

(xvi) Nature of site

(xvii) Material/labor requirement and availability

(xviii) Procurement system

(xix) Tendering procedures

(xx) Number of sub-contractors

(c) Project Quality Management Plan: Koo *et al*., (2000) observed that many institutions and organizations are concerned about the quality and safety of buildings, as a result of incessant collapse of buildings in Nigeria. Staub- Frenc *et al* (2010) defined quality management as sum of all management activities: planning, organization, implementation, inspection, monitoring, auditing etc, so that the quality of product can satisfy the updating quality requirements. Quality has remained in the forefront amongst other factors used to determine the degree of success or failure of a project and its performances on construction project is results oriented, and seeks evidence of quality awareness within the operations and output of a building team. Hence, the preparation of quality management plan was made compulsory by the National Building Code (2006) in Nigeria.

(d) Project Health and Safety Management Plan: According to PMI (2000), building construction activities are inherently risk and construction workers were subjected to fatalities and ill health problems such as working at higher height, underground, in confined spaces and close proximity to falling materials, handling loads manually, handling hazardous substances, noises, dusts, using plant and equipment, fire and exposure to live cables. Hence, Occupational Health and Safety (OHS) concern the physical and mental well-being of the individual at a place of work for better project performance.

Kiviniemi *et al.,* (2002) opined that the elements of the health and safety management comprises of (i) planning phase involving the assessment of risk (ii) an implementation phase involving communication of critical tasks to be carried out on site (iii) a control phase involving monitoring the activities (iv) and follow up phase which provides feedback and enables corrective measure to be taken. Balogun (2004) described project health and safety plan as a management tool that guides construction managers in other to ensure that works are carried out in a manner that secures the health, safety and welfare of worker and visitors to site. The importance of health and safety of site worker has necessitated the preparation of health and safety management plan which was made compulsory in the National Building Code (2006) in Nigeria.

2.7.6 Factors Affecting the Preparation and Use of Health and Safety Management Plan

(i) Organizations safety policy and investment

(ii) Developing in-house safety rules

(iii) Assigning safety responsibilities to site workers

(iv) Safety plan and records

(v) Safety rewards/incentives

(vi) Safety knowledge and training

(vii) Presence of safety management team/system

(viii) Monitoring/control system

(ix) Workers safety attitude

(x) Employment of safety officer and supervisor

(xi) Complexity of project

(xii) Provision of safe working environment

(xiii) Safety meetings

(xiv) Workers compensation insurance

(xv) Size of the project

(xvi) Relationship among project stakeholders

(xvii) Provision of plant and equipment maintenance

(xviii) Number of sub-contractors

(xix) Procurement system

(xx) Tendering procedure

(e) Information Requirement Schedule: Obiegbu (2002) described Information Requirement Schedule (IRS) as a prompting document, in the form of a schedule, for the constructors to advise the design team of the information requirements and release dates. It contains list of information which is required, together with the dates by which it must be received if the start date of each project operation is to be met, hence an important tool in the planning, monitoring and control of production information. Baldwin *et al.*, (1999) opined that the construction industry is an information intensive environment from design offices to project construction sites; hence the efficiency of information management is crucial to the success of construction industry. Akinci *et al.*, (2006) noted that there is need for improving the link between the construction site and designers, and to improve communication between all stakeholders on site.

(f) Early warning system: Foley and Mackmillan (2005) defined early warning as an observation, a signal, a message, or some other item that is or can be seen as an expression, an indication, a proof, or a sign of the existence of some future or incipient positive or negative issue. It is an omen, signal, or indication of future developments. Early warnings can give advance notice of arising risk. Kim *et al*., (2003) opined that an Early Warning System (EWS) provides a formal procedure for evaluating the significance of the deviation between the plan and the actual progress. It further observed that an early warning system is an essential part of project controlling progress. With a reliable EWS, a project team is able to decide the timing when additional attention is required to detect some symptoms or early indicators of future problems. Balogun (2004) described early warning system chart as one of the technical methods used by the builder to monitor off-site activities. It graphically represents all important events from period of receipt of production information by the constructors to the operation commencement date on site as it would have been shown on the construction programme.

2.7.7 Review of Related Works

Various studies exist within and outside the geographical boundaries of Nigeria. Sacks (2009) in his study of the implementation process of BIM in construction projects noted that the adoption of BIM has been slow and many barriers hindering widespread adoption of BIM technology. BIM was adopted in two different construction projects, this was to develop the under study of the barriers hindering BIM adoption in other to make it more accessible for the AEC. The study concluded that the adoption of BIM is not only a change in technology; BIM is a tool to improve processes in order to reach certain goals but not a goal in its own sight.

Nawari (2012) in his report explained the benefits of BIM for construction managers and BIM based scheduling. He stated that BIM is a collaboration process in the construction industry and many construction firms are now investing in “BIM” technologies during bidding, preconstruction, construction and post construction. The research was conducted through literature review, case studies, and interviews. The research identified the uses of Building Information Modeling for preconstruction, construction and post construction phases. Then, the project examined the uses and benefits of BIM in the construction of a research facility. Subsequently, a prototype 4D Building Information Model was created and studied. Furthermore, the BIM-based schedule was integrated to the 4D model. Finally, the study concluded with an analysis on the use, advantages and setbacks of BIM and its tools.

Arayici *et al.;*(2009) noted that the construction industry has been facing a paradigm shift in order to increase productivity, efficiency, infrastructure value, quality and sustainability, reduce lifecycle costs, lead and duplications. In his report he evaluated implementation of BIM in the construction industry and how the use of ICT technologies is to streamline the lifecycle processes of a building and its surroundings to provide a safer and more productive environment for its occupants. The study was performed by surveys carried out in the U.K, with the U.K construction stakeholders and by interviews carried out in Finland with Finish construction practitioners and academics. The study focused on determining key strengths and identifying the challenges involved in implementing BIM in the country.

Woo (2007) in the study of the deployment and impact of BIM software in the construction industry reported that BIM is a technology that is currently gaining momentum within the construction industry. It allows buildings to be modeled virtually and stores information about the building in a central coordinated model. The methodology adopted was reviewing the current literature on the subject, which was followed by conducting case study of two U.K consultancies in the form of face to face interviews in order to validate the former research and to provide a comprehensive assessment of deployment issues in practice. The study concluded that BIM has the potentials to eradicate many deficiencies within the construction industry; it is not the complete solution.

Amor *et al*., (2007) showed that there has not been much research-based critical analysis of the adoption of BIM standards and their impact on the industry. However, Amor (2012) further indicated that there is a momentum behind BIM adoption and the construction industry will have a BIM-dominated transformation going beyond anticipated progress. Despite these studies, a detailed analysis of all the identified drivers for BIM is still missing.

However, Building Information Modeling (BIM) has become an emerging tool in the design industry that is used to design and document a project, but it is also used as a vehicle to enhance communication among all the project stakeholders. This tool has already begun changing how designers work with their consultants and with builders, but it also has the ability to guide the industry in a more sustainable direction by allowing easier access to the tools necessary to quantify a greener design approach. The project owners are becoming focused on deriving more value on their investment, they are aware of the late delivery of project, low productivity, design errors, technological advancement and the demand changes.

Therefore this new method is to set out vision for cutting-edge service that is flexible, innovative, and leverage on high standards of BIM to achieve higher productivity and sustainability in the AEC industry and developing economy. Therefore, there is need to develop a robust framework that can help construction planners (principal planners) in communicating, integrating, generating and evaluating all the feasible trade-off between project to time, cost and qualityin other to select an optimal schedule that satisfies the specific project requirement to time, cost and quality. Therefore, the aim of the study is to appraise BIM with a view to developing a framework for the effective implementation of Building Information Modelingto enhance effective public building projects delivery in South-West, Nigeria. The outcome of the study will produce a framework to help the stakeholders in AEC industry with a software developed that would allow communication, collaboration, integration among the stakeholders which would enhance quality of project delivery, increase client satisfaction of job and shortened time of project. Also, it would assist service provider organization to identify pertinent quality variables from perspective of the professionals.

2.7.8 Summary

This section discussed contemporary development in BIM, theories relating to BIM and conceptual framework that are germane to the study. This section was also used to identify gap in literature and provided the methodological approaches used by earlier researchers with a view to formulating appropriate methodology for the study. The next section boarders on measurement and data collection used for this study.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Introduction

Generally, the search and gathering of facts/data and information for the advancement of knowledge is regarded as research. Okmen, (2008) defined research methodology as the principles and procedures of logical thought processes which are applied to a scientific investigation; while Doloi (2008) defined research as a 'combination of techniques used to enquire into a specific situation'. Research methodology therefore means the overall strategy designed to achieve the aim and objectives of the research. It includes the procedures and techniques of investigation for effective and reliable representation of the research.

Research methods on the other hand are merely tools used in gathering and analyzing data for the research. Put differently, it is described as a subset of the research methodology. Thus, within a research methodology, different research methods or tools may be used to achieve the aim and objectives of the research (George, 2009).The appropriateness of research methodology either validates or invalidates the research approach and consequently the results. Amaratunga *et al* (2002) were of the opinion that only the use of appropriate methodologies and methods of research applied with rigor can the body of knowledge be established and advanced with confidence. This section therefore provides assurance that appropriate procedure was followed and organized around the following major topics; research design; population of the study; sampling techniques; data collection instrument; validity and reliability of the research instrument as well as me

3.2 Research Design

Research design could be described as the planning of scientific inquiry or designing a strategy for finding out something (Dixon, 1994). Also, Kothari (2004) defined research design as a definite plan for obtaining a sample from a given population. Summarily, research design refers to the technique or procedure the researcher would adopt in selecting items from the sample. However, research design is not only concerned with what is being sought but the best way of getting it done. Therefore, the essence of this research is to appraise the prevalence of BIM for effective delivery of building project in physical planning units of federal universities in South West Nigerian.

The source of facts collected was through primary and secondary data. Primary data was obtained through the use of well-structured questionnaire administered to the professionals in the physical planning units of the universities in Nigeria. Also, interview was used to acquire in-depth information from the respondents within the target population on the research subject matters; while secondary data was collected through review of relevant literature.

3.3 The Study Population

All items in any field of inquiry according to Cohen *et al.,* (2011) constitute a universe or population. The population for this research work shall be of two different data sets. The first data set will be professionals that fall within the purview of architectural, engineering and construction industry (AEC) in the physical planning unit of selected federal universities of the study area. This will entails Architects, Engineers and Builders that are registered with their respective professional bodies and are involved in the conceptualization, designing and construction of educational facilities.

The second data set of the population for the study will include Federal Tertiary Institutional Buildings in south-west Nigeria developed under the TETFund program. The TETFund program transited from Education Trust Fund (ETF) by the TETFund Act 2011 (Tetfund, 2011). The possibility of getting the documented project information is high since the federal tertiary institutional buildings are owned by government. Also, the projects are executed under the federal government policy and public procurement, thereby providing a viable source of project information that will be required. Using tertiary institutional building, also provide the opportunity to assess the policy direction of the federal government for the development of BIM in Nigeria.

3.4 Sampling Frame

Cohen *et al.,* (2011) noted that the adequacy of sample is assessed by how well such sample represents the whole population. Sample frame is a list of representation of element of the targeted population. Kothari (2004) affirmed that such a list should be comprehensive, correct, reliable and appropriate.

The sampling frame for the first data set as stated in the research population will include the professionals (corporate members) within the within the physical planning unit of selected federal universities that are registered with their respective professional body.

Table 3.1 Professionals in the Physical planning unit of each Tertiary institution.

S/N	FUOYE	FUTA	OAU	UNILAG	UI	FUNNAB
1	1	3	5	5	3	2
2	2	3	4	4	4	3
3	1		2	2		1
4	5	5	4	10	5	2
5	2		2	3	3	1
6	4	2	4	4	4	3
7	2	2	2	3	3	1
SUB TOTAL	17	15	23	31	21	13

TOTAL	120

Source: Physical planning unit of each Tertiary institution.

For the second data, the sampling frame will include completed and on-going (TETFund) building projects in Federal Universities in the southwest Nigeria as shown in Table 3.2.

Table 3.2: TETFUND projects in Federal Universities in South-West Nigeria

S/N	States	Institutions	No of completed projects	No of on-going projects
1	Ekiti	Federal University, Oye – Ekiti	20	3
2	Ondo	Federal University of Technology, Akure	20	7
3	Osun	Obafemi Awolowo University, Ile-Ife	18	6
4	Ogun	Federal University of Agriculture, Abeokuta	12	6

5	Oyo	University of Ibadan	6	7
6	Lagos	University of Lagos	14	7
	Sub Total		90	36
		Grand Total = 126		

Source: Physical planning unit of each Tertiary institution.

The buildings to be considered will be solely academic buildings as used by Langdon (2004). Academic buildings include classroom, computer laboratory, Library and faculty office buildings in Higher education settings.

3.5 Sampling Technique

Having identified the targeted population and determined the sample size, it is imperative that a sampling technique be adopted to survey the population for the study. Yusuf (2013) noted that it is logically impossible to collect data from all the construction firms or participants within the study area. It was therefore desirable to adopt a sampling process that will be suitable for the targeted population. Also, Kothari (2004) categorized sampling technique probabilistic sampling technique and non-probabilistic sampling technique.

Due to peculiarity of research design adopted for this study being a case study and the study population that is finite and falls within manageable size and locations,therefore, census method were adopted. Census means that the entire population will be used as sample. The entire number of all the professionals working within the physical planning units were chosen for the administration of the questionnaires. In this case all the respondents will be captured for administration of questionnaires in the physical planning units. In this case, the sampling frame constitutes the sample size.

3.6 Research Instrument for Data Collection

Since, the aim of the study is to develop a framework for the implementation of BIM to enhance public building projects delivery of university educational institutions in South west Nigeria. The research instrument will be questionnaire. The questionnaire for this research will be classified into A, B, C, D, and E a multiple choice type. Section A which is the preliminary section of the questionnairewill centre on the demographic information of respondents this will be on the general characteristics of the respondent in order to ascertain the quality of data to be collected, the other sections of the questionnaire will dwell on matters regarding to the research questions. Survey method were adopted for the distribution of the questionnaire. These were administered in other to obtain information from the wealth of experiences from the selected professionals (Architect, Engineer, Builder and Quantity surveyor) that are familiar with the use of BIM for designing, engineering, quantifying and construction of educational facilities in the physical planning unit of universities in South West, Nigeria.

This section was structured to achieve each of the stated objectives of the study. A 5-point Likert scale of measurement was used to calibrate the questions with 5 being the highest of the rating.

3.6.1 Procedure for Data Collection

The questionnaire was self-administered to the respondents while others were administered through the help of trained research assistants. Prior to engaging them, they were properly briefed about the research topic and given the necessary information on how to administered the questionnaire. The interview was conducted personally.

3.6.2 Validity and Reliability of Research Instruments

Anderson (2010) noted that qualitative research is often criticized as biased, small scale, ancedotal, and/or lacking rigor; however, when it is carried out properly it is unbiased, in depth, valid, reliable, credible and rigorous. In qualitative research, there needs to be a way of assessing the ‘‘extent to which claims are supported by convincing evidence. Although the terms reliability and validity traditionally have been associated with quantitative research, increasingly they are being seen as important concepts in qualitative research as well. Examining the data for reliability and validity assesses both the objectivity and credibility of the research.

The study held the view that validity related to honesty and genuineness of the research data, while reliability related to reproducibility and stability of the data. The validity of research findings referered to the extent to which the findings was accurate representation of the phenomena it intended to represent. The reliability of the study refers to the reproducibility of the findings.

Johnson (1997) noted that discussions of the term ‘validity’ and ‘reliability’ have traditionally been attached to the quantitative research. This view was expressed by some positivists that the basic epistemological and ontological assumptions of quantitative and qualitative research are incompatible. However, the study expressed that qualitative researchers regard validity and reliability in terms of research that is plausible; credible; trustworthy and defensible.

Johnson (1997) presented some strategies usually adopted in qualitative research to address the issue of validity and reliability as shown in the Table 3.2:

Table 3.2.: Validity and Reliability Strategies

Strategy	Description
Researcher as 'Detective'	A metaphor characterizing the qualitative researcher as he or she searches for evidence about causes and effects. The researcher develops an understanding of the data through careful consideration of potential causes and effects and by systematically eliminating 'rival' explanations or hypotheses until the final 'case' is made beyond reasonable doubt.
Extended fieldwork	Qualitative researcher collects data in the field over an extended period of time.
Low interference descriptors	The use of description phrased very close the participants' accounts and researchers' field notes. For example, verbatim (direct quotations) are a commonly used type of low interference descriptors.
Triangulation	'cross-checking' information and conclusions through the use of multiple procedures of sources.
Data triangulation	The use of multiple data sources to help understand a phenomenon.
Method triangulation	The use of multiple research methods to study a

Table 3.2: Validity and Reliability Strategies Cont'd

Strategy	Description
	phenomenon.
Investigator triangulation	The use of multiple researchers in collecting and interpreting the data.
Theory triangulation	The use of multiple theories and perspectives to help interpret and explain the data.
Participant feedback	The feedback and discussion of the researcher's interpretation and conclusions with the actual participants for verification and insight.
Strategy	Description
Peer review	Discussion of the researcher's interpretation and conclusions with other people. This will be in two folds – 'disinterested peer' and 'interested peer'. The disinterested peer should be skeptical and play the devil's advocate; challenging the researcher to provide solid evidence for any interpretations or conclusions. Discussion with interested peers who are familiar with the research can also help provide useful challenges and insights.
Reflexivity	This involves self-awareness and 'critical self-reflection' by the researcher on his or her potential biases and predispositions as these may affect the research process and conclusions.
Pattern matching	Predicting a series of results that form a 'pattern' and then determining the degree to which the actual results fit the predicted pattern.

Source: Johnson (1997).

Bell (2012) opined that sound measurement must meet the tests of validity and reliability. These attributes were regarded as two major considerations in evaluating research instrument. Cane, O'Connor and Michie (2012) described validity as the extent to which an instrument measures what it actually wishes to measure while Cohen *et al* (2011) described reliability as the accuracy and precision of a measurement procedure. Thus, Cronbach alpha test was used to test the reliability of the questionnaire. The Cronbach's alpha reliability coefficient measure the reliability of the 5-point Likert type scale used for the study. This is one of the most commonly used reliability coefficient. The Alpha isbased on the "internal consistency" of research instrument. That is, it is based on the average correlation of items within the instrument. If a test were perfectly reliable, this correlation would be 1.00. If the test were totally unreliable, the correlation would be zero. The Cronbach's alpha was computed using the following formula:

$$\alpha = \frac{k\overline{cov}/\overline{var}}{1+(k-1)\overline{cov}/\overline{var}}$$

Where k is the number in the scale, $\overline{cov}$ is the average covariance between items, and $\overline{var}$ is the average variance of the items. Bell (2012) noted that if the items are standardized to have the same variance, the formula could be simplified to;

$$\alpha = \frac{k\bar{r}}{1+(k-1)\bar{r}}$$

Where $\bar{r}$ is the average correlation between items

k is the number in the scale

Statistical Package for Social Sciences (SPSS) software was used to compute the Cronbach'stest using the 5-point Likert.

3.7 Methods of Data Presentation and Analysis

The data collected from survey was analyzed through the use of descriptive and inferential statistics. The descriptive statistics entails data presentation techniques like percentiles, pie-chart, bar-chart among others while the inferential statistics employedwere mean score, weighted mean score,mean item score (MIS), relative importance index (RII), Kruskal wallis test, Duncan Post Hoc test, Mann Whitney U test, Kaiser-Meyer-Olkin measure of sampling adequacy, Friedman test and Pearson correlation. The weighted mean score was computed as follows:

$W = \Sigma X_i W_i / \Sigma X_i$

Where W_i=weight index

X_i=frequency of respondent

The mean item score was interpreted as follows :

1.00 < MIS < 1.49 Not frequently occur

1.50 < MIS < 1.99 Seldomly/rarely occur

2.00 < MIS < 2.99 frequently occur

3.00 < MIS < 3.99 Highly frequently occur

4.00< MIS < 5.00 Very High frequently occur

The Relative Importance Index (RII) wasused for two purposes; ranking and determination of significance of different factors of the data collected. The premise of decision for the ranking is that the factor with the highest relative index 'RII' is ranked first and others in such subsequent descending order.

The formula for relative index is $\frac{\varepsilon fx}{\varepsilon f}$

Where X is the rating used per column

F is the sample size for each rating.

Since A 5-point Likert scale will be used for the data collected. Relative Importance Index will be computed as follow:

RII= $5F_5 + 4F_4 + 3F_3 + 2F_2 + F_1 \backslash\ 5 \times N$

3.8 Analysis of Variance (ANOVA) and Pearson Correlation

Analysis of Variance (ANOVA) and Pearson correlation are the two highly used methods in mathematical statistics in determining if there exists any relationship among variables. Because of its importance in scientific research, much has been published in the form of historic, and theoretical explore and procedures (Kothari, 2004; Okereke, 2004; Eze*et al.*, 2005; Ebhotemhen, 2001). Apart from providing the basis for assessing the relationship among variables, it also provide the basis for taking far-reaching decision or drawing up of statistical inferences about certain phenomena.

Hypothesis Testing:

The two-way analysis of variance was employed to test hypothesis one (H_{01}) that "there is no significant relationship between BIM management tool and effective public building project delivery in Nigeria". The analysis of variance is a parametric test used in comparing means of different samples more than two i.e. K means where K>2. The analysis of variance (ANOVA) is used to test that several means are equal (Yusuf and Jimoh, 2003). It is used in hypothesis will be accepted at 95% confidence interval at a P Value less or equal to 0.05 significance level.

The two-way analysis of variance will also be used to test hypothesis two (H_2) that "there is no significant relationship between Traditional 2D and cost of implementing BIM in the selected institutional buildings"

3.9 Method of Data Analysis and Presentation

The primary objectives of this study that entails both quantitative and qualitative analytical data were analyzed using the under listed tools:

For objective 1 – 5:Relative Importance Index (RII) was used to know the level of awareness of professionals and usage in relation to BIM under the study. These ranking made it possible to cross-compare the relative importance of the factors of information and communication as understand by the professionals. Mean item Score (MIS)

The mean score formula is given by:

$$\frac{5n_1 + 4n_2 + 3n_3 + 2n_4 + n_5}{5} \qquad \text{………………………….. (i)}$$

Using 5 (five) point Likert's scale which corresponds to any mean score below 3.00 is considered a negative decision, while any mean score form 3.00 and above is considered a positive decision (Kothari, 2009).

The Pearson Correlation non-parametric test of significance will be applied to determine the different in the use of BIM as a management tool within the study area.

The Pearson Correlation non-parametric test of significance will also be employed to assess the difference in between the cost of implementing BIM and Traditional method. Pearson Correlation test according to Azadeh (2012) is used to test the difference between observed and expected frequencies of bivariate observations. At 5% significance level, if the value of x is greater than 0.05, the null hypothesis that there is no significant relationship between Traditional 2D and the cost of implementing BIM

Objective 6 (to develop a framework to promote the use/adoption of BIM in Universities building projects.

Objective 6 was achieved by the development of a framework termed Building Information Model for public use (BIMPU) using system theory approach of input –techniques/ tools-output model (ITO).The system theory will be further linked to set theory which will be generated by Venn diagram to explain union and intersection between policy, process and technology members.

The BIMPU framework was capable of actualizing the project to be delivered to quality, time and cost.

3.10 Summary

This section has articulated the philosophical issues of research; method and procedure of data collection and justified the adoption of survey in this study. The section also discussed how research bias; validity and reliability were addressed. The next section borders on data presentation and analysis for this research.

CHAPTER FOUR

4.0 DATA PRESENTATION, ANALYSIS AND DISCUSSION OF RESULTS

4.1 BRIEF

This chapter involves the computation and analysis of the primary data obtained from field survey. One hundred questionnaires (100) were distributed out of which eighty-two (82) were retrieved. This represent 82% which is above the usual rate of 20-30%for questionnaire survey in construction management studies as suggested by Kline (1994) and corroborated by Fellow and Liu (2008) that samples must not only be representative but sufficient size to produce reliable results. Therefore this section present the analyzed results based on the formulated objectives for the study. It also discusses and relates the results obtained with previous studies while the hypotheses earlier stated were tested using appropriate statistical tools an differences were drawn from the analyzed results. This section also form the basis of discussion of findings based on the aim and objectives of the research work.

4.2 DATA PRESENTATION AND ANALYSIS

4.2.1 Demographic Information

Figure 4.1 shows the pie-chart of the background of the respondents. This indicated that$79^o$of the respondents were from Obafemi Awolowo University (OAU), Ile-Ife and University of Lagos (UNILAG) respectively while 58^o of the respondents are from University of Ibadan (UI). Also, 48^o of the respondents were from Federal University Oye (FUOYE), Federal University of

Technology Akure (FUTA) and Federal University of Agriculture Abeokuta (FUNAAB) respectively.

Table 4.1 shows that all the Federal Universities surveyed in the study area has physical planning unit while Figure 4. 2 show the sections/units available in each of the schools. This Figure 4.2 indicated that all the physical planning units surveyed have sections/units of Architecture, Building, Engineering and Quantity Surveying.70.73% indicated that Estate Management are available in the physical planning unit of OAU, FUOYE, UNILAG and FUNAAB while 29.27% noted that the same is not available in UI and FUTA. Moreover 57.32% noted that GIS is available in the physical planning units of OAU, FUOYE and UNILAG while 42.68% noted that the same is not available in UI, FUTA and FUNAAB. Finally 73.17% indicated that Urban and Regional Planning is available in the physical planning unit of OAU, UI, FUTA and UNILAG while 26.83% noted that same is not available in FUOYE and FUNAAB. The survey shows that all the sections of the physical planning units has the discipline of the built environment departments and the capacity of executing any tertiary building project undertaking by the physical planning units of each institution. However, it could be inferred from the analyzed results that the first generation universities are more encompassing and developed in terms of personnel/professionals in the physical planning unit and volume of projects handled by respective institutions.

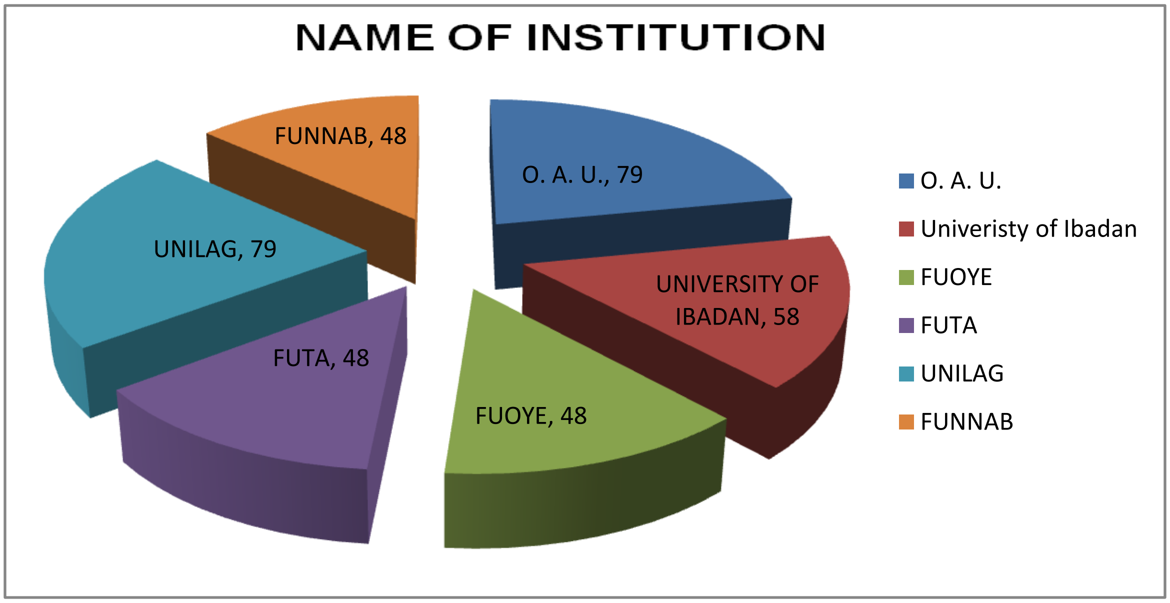


Figure 4.1: Name of Institutions

TABLE 4.1: Physical Planning Unit in your Institution

Physical Planning Units in Institution	**Frequency**	**Percentage**
Yes	82	100
No	-	-
Total	**82**	**100**

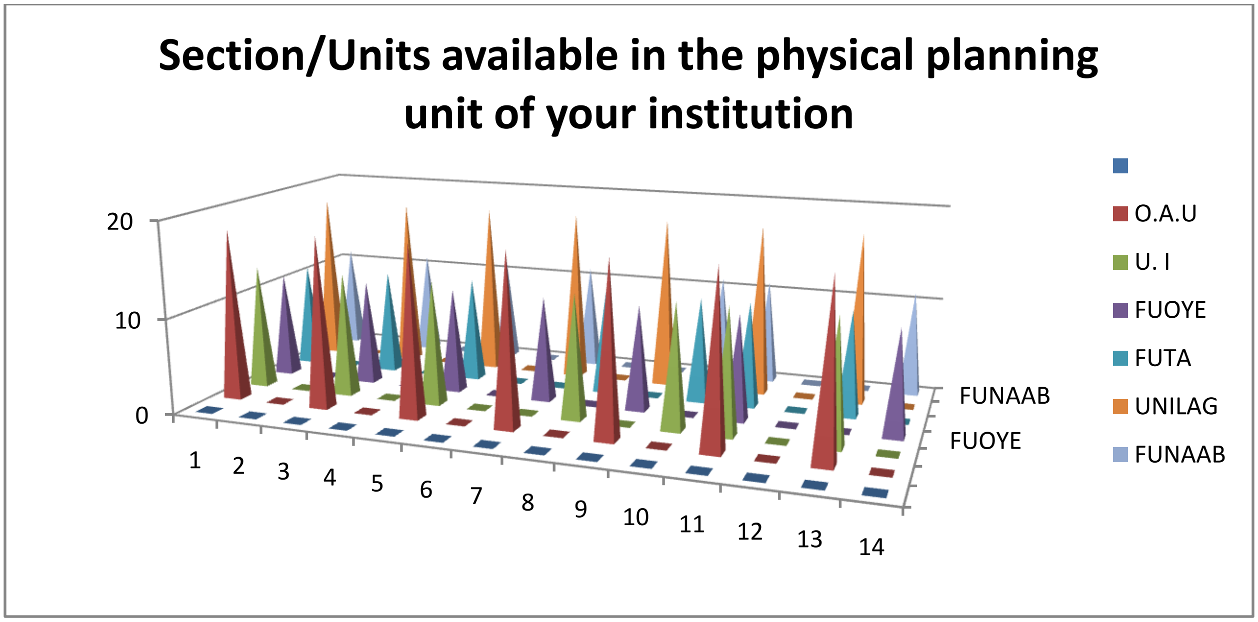


Figure 4.2 Section/Units available in the Physical Planning Units

Figure 4.3 shows the pie-chart of professional specialization of the respondents in the physical planning units of the Federal Universities in the South-West Nigeria. This indicated that 105^o in Engineering field while Architecture and Building accounted for 75^o, Quantity Surveying 65^o, Estate Management 22^o, Geo-Informatics/Land Surveying, Urban and Regional Planning 9^o respectively.

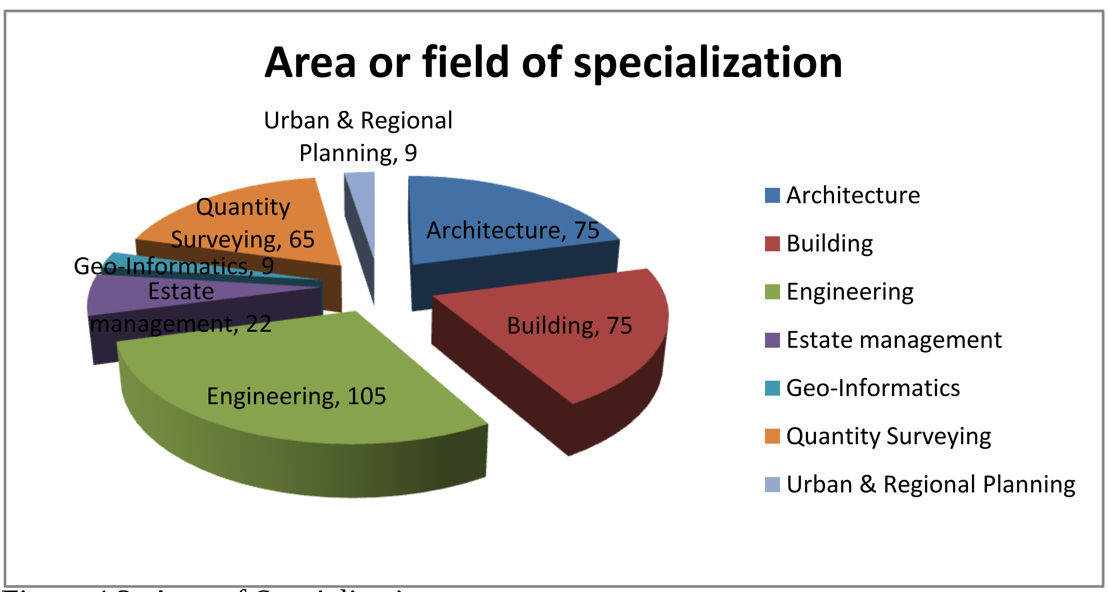


Figure 4.3: Area of Specialization

Also, Table 4.2 presents the academic qualification of the respondents. It shows that majority of the respondents had Master Degree (42.68%) while those with B.Sc degree were (31.71%), Higher National Diploma Degree (21.95%) and Post-Graduate Diploma Degree (14.63%) respectively. This Table 4.2 also indicated that the respondents have had more than 10 years of experience on the job.

Furthermore Table 4.3 reveals the professional affiliation of respondents. This indicated that 18.29% of the respondents were professional members of the Nigerian Institute of Architect while 2.44% were fellows of the Institute. 19.51% were professional members of the Nigerian Institute of Building while 1.22% is fellows of the Institute. 28.05% are professional member of the Nigerian Society of Engineers while 1.22% is fellows of the professional Institute. 6.10% are professional members of the Nigerian Institute of Estate Surveyors are Valuers, 2.44% were professional members of the Nigerian Institute of Surveyors and Nigerian Institute of Town Planners, 18.29% were professional members of the Nigerian Institute of Quantity Surveyors.

Summarily, 95.12% of the respondents were affiliated to their various professional bodies while 4.88% were fellows of the various Institutes.

Inference from the analyzed data of Figure 4.3 and Tables 4.2 to 4.3 shows the quality of professional personnel in the physical planning unit in terms of area of specialization, academic qualification, years of experience and competence. This implied that tertiary institutional building projects executed by the physical planning units in the study area have been monitored by qualified and experienced professionals from time to time.

Table 4.2: Academic Qualification of Respondents

Description/Range	Mid-Value	Frequency	Percentage
Academic Qualification (N=82)			
HND		14	17.1
PGD		7	8.5
B.Sc		26	31.7
M.Sc		35	42.6
Ph.D		2	2.4
Others		82	100.0-
Total			
Years of Experience (N=82)			
1 – 5	3.0	12	14.63
6 – 10	8.0	30	36.58
11 -15	13.0	24	29.27
16 – 20	18.0	11	13.42
Above 20	23.0	5	6.10
Mean	**10.99**		

Table 4.3: Professional Affiliation

Profession	Member	Percentage	Fellow	Percentage
Architecture	15	18.29	2	2.44
Building	16	19.51	1	1.22
Engineering	23	28.05	1	1.22
Estate Management	5	6.10	-	-
Geo-Informatics	2	2.44	-	-
Quantity Surveying	15	18.29	-	-
Urban & Regional Planning	2	2.44	-	-
Total	**78**	**95.12**	**4**	**4.88**

Figure 4.4 and figure 4.5 shows the level of knowledge of respondents about BIM and level of usage of BIM softwares. Figure 4.4 indicated that 35.59% of professionals in the physical planning units of the study area are moderately knowledgeable about the BIM while only 4.88% of the professionals are very highly knowledgeable.

Also, figure 4.5 revealed that 39.02% of the professionals make use of BIM while only 8.54% very highly use the BIM software.

This implied that a high majority of the professionals are not knowledgeable about BIM. Reasons could be adduced to BIM being a new technological innovation and collaboration/synergy among professionals. More so, the use of BIM is just gaining momentum among the academic environment and has not come to the full knowledge of professionals in the practice field in Nigeria.

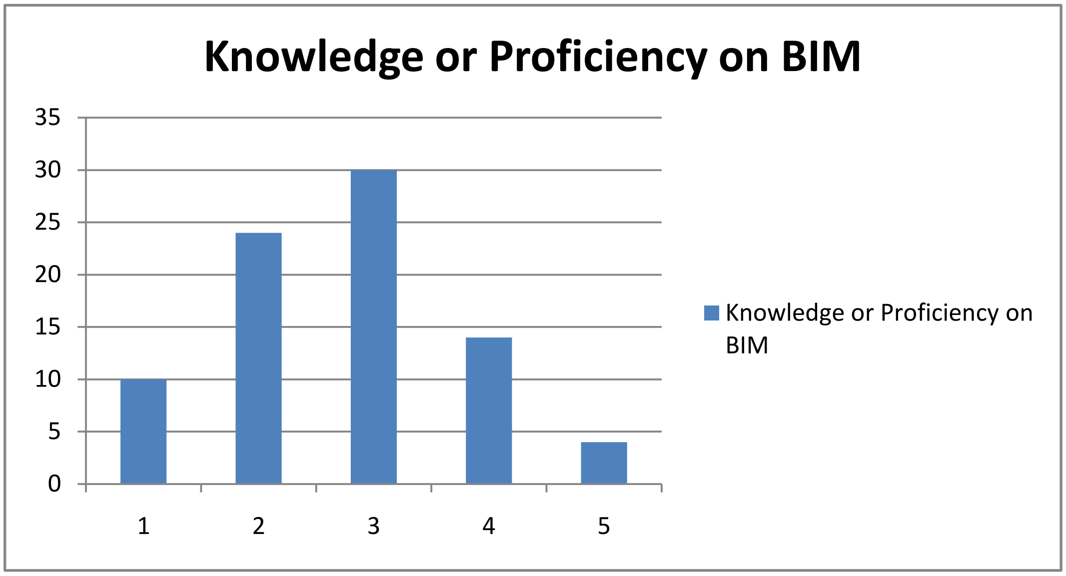


Figure 4.4: Knowledge or Proficiency on BIM

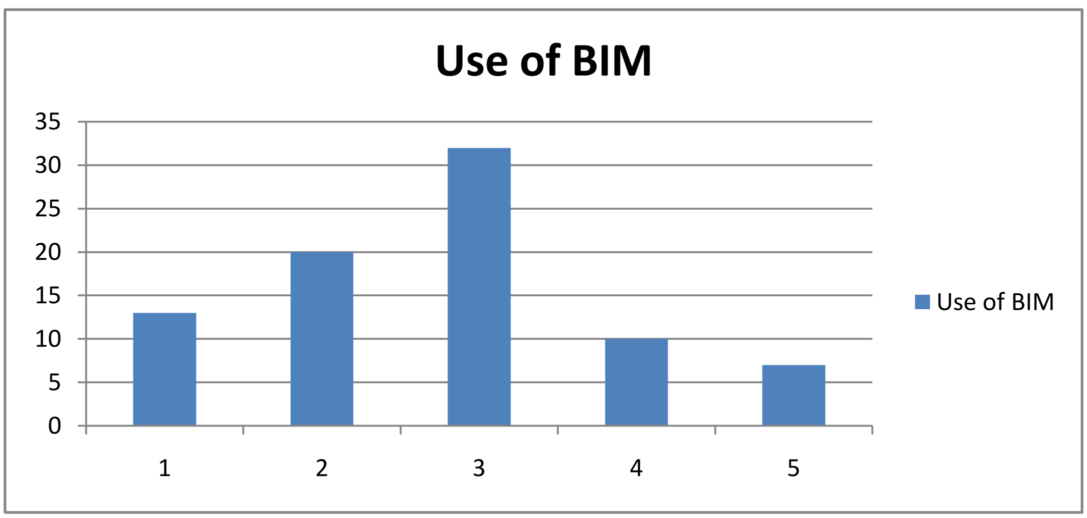


Figure 4.5: Use of BIM

Table 4.4. Shows that there is statistical reason to reject the null hypothesis since the significant probability 0.004 and chi-square value of 17.440 with 5 degree of freedom less than the alpha level 0.05. We therefore concluded that there is significant difference on the Knowledge or Proficiency on BIM Softwares/tools in the physical planning unit of Federal Institutions in south west Nigeria. The Table further revealed that University of Ibadan (UI) physical planning unit has the highest proficiency rate on BIM Softwares/tools with mean ranking of 51.90 closely followed by the Obafemi Awolowo University (OAU) with 51.5. While Federal University Oye (FUOYE) and Federal University Abeokuta (FUNAB) had the lowest proficiency with 28.05 and 27.53 respectively. However, the Post Hoc analysis in table 4.4.1 further showed the level of significance difference on the Proficiency on BIM Softwares/tools in various institutions.

Table 4.4.0: Kruskal Wallis Test on the Institutional Knowledge or Proficiency on BIM Softwares/tools in the physical planning unit

Institution (Grouping Variable)	**Mean Rank**	**Ranking**	**Chi-Square**	**df**	**Asymp. Sig.**
UI	51.90	1	17.440	5	0.004
OAU	51.50	2			
UNILAG	48.03	3			
FUTA	37.80	4			
FUOYE	28.05	5			
FUNAB	27.53	6			

Table 4.4.1 shows that there is no significant difference in the physical planning unit of (FUOYE, FUNAB AND FUTA) with mean values of 2.3636, 2.4118 and 2.9000 respectively with significant probability of 0.244 on the knowledge of BIM softwares/tools. In the same vein, (FUTA, UNILAG, OAU and UI) had no significant difference with mean values of 2.9000, 3.4000, 3.5556 and 3.6000 with significant probability of 0.142 since the significant probability in all cases are greater than 0.05 level of significant on proficiency rate.

Table 4.4.1: DuncanPost Hoc Teston the Institutional Knowledge or Proficiency on BIM Softwares/tools in the physical planning unit

Institution	**N**	**Subset for alpha = 0.05**	
		1 (mean)	**2(mean)**
FUOYE	11	2.3636	
FUNAB	17	2.4118	
FUTA	10	2.9000	2.9000
UNILAG	15		3.4000
OAU	18		3.5556
UI	10		3.6000
Sig.		0.244	0.142

Table 4.4.2 showed that there is no statistical reason to reject the null hypothesis since the significant probability 0.827 and chi-square value of 2.856 with 6 degree of freedom greater than the alpha level 0.05. We therefore conclude that there is no significant difference on the Knowledge or Proficiency on BIM Softwares/tools by various professionals. The table further revealed that the engineer has the highest proficiency rate on BIM Softwares/tools with mean ranking of 44.54 closely followed by the builders with 42.03.

Table 4.4.2: Kruskal Wallis Test on the Knowledge or Proficiency on BIM Softwares/tools by Specialization

Area of Specialisation (Grouping Variable)	Mean Rank	Ranking	Chi-Square	df	Asymp. Sig.
Engineering	44.54	1	2.856	6	.827
Building	42.03	2			
Architecture	39.59	3			
Geo-informatics	38.00	4			
Urban & Regional Planning	38.00	4			
Estate Management	33.60	6			
Quantity surveying	33.81	7			

Table 4.5.0 showed that there is statistical reason to reject the null hypothesis since the significant probability 0.024 and chi-square value of 12.920 with 5 degree of freedom less than the alpha level 0.05. We therefore conclude that there is significant difference on the level of usage of BIM Softwares/tools in the physical planning unit of federal institutions in south west Nigeria. The table further revealed that UNILAG physical planning unit has the highest usability rate of BIM Softwares/tools with mean ranking of 52.80 closely followed by OAU with 49.89. Post Hoc analysis in table 4.5.1 further shows the level of significance difference on the uses of BIM Softwares/tools in various institutions.

Table 4.5:0 Kruskal Wallis Test on the level of Usage of BIM Softwares/tools in Federal University Physical Planning Unit

Institution (Grouping Variable)	Mean Rank	Ranking	Chi-Square	df	Asymp. Sig.
UNILAG	52.80	1	12.920	5	0.024
OAU	49.89	2			
UI	38.70	3			
FUTA	38.45	4			
FUNAB	32.00	5			
FUOYE	28.35	6			

Table 4.5.1 showed that there is no significant difference on the level of usage of BIM softwares/tools in (FUOYE, FUNAB, UI and FUTA) with significant probability of 0.231 similarly, (FUNAB, UI, FUTA, and OAU) with significant probability of 0.057 as well as (UI,FUTA, OAU, and UNILAG) with 0.124 were not significant since the significant probability in all cases are greater than 0.05 level of significant on usability rate.

Table 4.5.1: DuncanPost Hoc Test on the level of Usage of BIM Softwares/tools in Federal University

		Subset for alpha = 0.05		
Institution	**N**	**1 (Mean)**	**2(Mean)**	**3(Mean)**
FUOYE	10	2.2000		
FUNAB	18	2.3889	2.3889	
UI	10	2.7000	2.7000	2.7000
FUTA	10	2.8000	2.8000	2.8000
OAU	18		3.3333	3.3333
UNILAG	15			3.4667
Sig.		.231	.057	.124

Table 4.5.2 shows that there is no statistical reason to reject the null hypothesis since the significant probability 0.199 and chi-square value of 8.567 with 6 degree of freedom greater than the alpha level 0.05. We therefore conclude that there is no significant difference on the uses of BIM Softwares/tools by various professionals with Geo-informatics and Engineers having the highest mean ranking on the level of usage 94.00 and 48.04 respectively.

Table 4.5.2: Kruskal Wallis Test on the Level of Usage of BIM Softwares/tools by Specialization

Area of Specialisation (Grouping Variable)	Mean Rank	Ranking	Chi-Square	df	Asymp. Sig.
Geo-informatics	64.00	1	8.567	6	0.199
Engineering	48.04	2			
Architecture	39.56	3			
Building	39.42	4			
Estate Management	38.00	5			
Quantity surveying	29.20	6			
Urban & Regional Planning	20.50	7			

Table 4.6 identifies design and engineering, construction projects control, project planning, procurement and finance and accounting software has the information management software that were well known in the physical planning unit of university in south west Nigeria as over 50% of the respondents affirmed their awareness with Design and engineering softwares having the highest rate of awareness with 82.1%. While the rate of awareness on project bidding and marketing and workforce management tools were low as 29.8% and 34.5% of the respondents

affirmed to their awareness. The table also reveals the rate of awareness of all the softwares on institutional basis with OAU having the awareness rate above 50% in all the tools expect on workforce management of 42.1%. Similarly, design and engineering softwares were the only tool that has its rates above 50% in FUTA.

4.2.2 Awareness of Building Information and Communication

Table 4.6: Rate of Awareness of Softwares/Tools by Institutions (Objective 1)

Tools/softwares	Institutions						
	FUOYE	**FUNAB**	**UI**	**FUTA**	**OAU**	**UNILAG**	**Total**
Project Bidding and marketing	2(18.2)	2(11.1)	4(40.0)	2(18.2))	11(57.9)	4(26.7)	25(29.8)
Project Planning	9(81.8)	13(72.2)	5(50.0)	3(27.3))	13(68.4)	8(53.3)	51(60.7)
Procurement	5(45.5)	7(38.9)	7(70.0)	3(27.3)	15(78.9)	6(40.0)	43(51.2)
Design and engineering	8(72.7)	16(88.9)	9(90.0)	6(54.5)	19(100)	11(73.3)	69(82.1)
Construction project control	9(81.8)	16(88.9)	7(70.0)	1(9.1)	14(73.7)	7(46.7)	54(64.3)
Workforce management	4(36.4)	9(50.0)	5(50.0)	0(0)	8(42.1)	3(20.0)	29(34.5)
Finance and accounting	5(45.5)	7(38.9)	5(50.0)	2(18.2)	13(68.4)	10(66.7)	42(50.0)
None of the above	1(9.1)	2(11.1)	0(0.0)	2(18.2)	0(0)	3(20.0)	8(9.5)

Table 4.7 categorised BIM tools on the level of usage and shows that Design and engineering, Project planning and Construction project control with mean value of 3.651, 3.370, and 3.272 respectively as the major BIM softwares that are highly frequently used for project delivery in the physical planning units. The table also showed that Workforce management and project bidding tools with mean value of 2.532 and 2.342 were frequently used with their RII below 50% level of usage

Table 4.7: Level of Usage of Building Information Management Tools/softwares

Softwares	Response					Descriptive		
	1	**2**	**3**	**4**	**5**	Mean	Rank	RII (%)
Design and engineering	8	1	22	33	19	3.6506	1	71.08
Project Planning	10	6	22	30	13	3.3704	2	64.94
Construction project control	14	4	19	34	10	3.2716	3	61.98
Finance and accounting	15	12	18	24	10	3.0253	4	56.71
Procurement	14	12	28	19	3	2.8026	5	52.37
Workforce management	19	20	20	14	4	2.5325	6	45.71
Project Bidding and marketing	26	14	23	10	3	2.3421	7	40.00

Table 4.8 shows the mean value score of level of usage of communication channels in the physical planning units of institutions with upward and downward channels with a value of 3.683 and 3.139being highly frequently used, and horizontal and lateral channel with mean value of 2.299 and 2.234 are frequently used while others are were found to be seldomly used for project execution among team members.

Table 4.8: Level of Usage of Communication Channels in the Physical Planning Unit

Channels	Response					Descriptive		
	1	**2**	**3**	**4**	**5**	**Mean**	**Rank**	**RII (%)**
Upward Channel	7	6	21	20	28	3.6829	1	73.66
Downward Channel	15	12	14	23	15	3.1392	2	62.78
Horizontal Channel	27	17	18	13	2	2.2987	3	45.97
Lateral Channel	31	16	13	15	2	2.2338	4	44.68
Others	12	3	3	1	0	1.6316	5	32.63

Table 4.9 shows that the determinant values in each case is greater than the necessary value of 0.00001which indicates that all listed benefit of ICT to effective delivery of building projects correlate fairly well and non of the correlation coefficients are particularly large; therefore, there is no need to eliminating any of the benefits. The table also indicates a KMO values for time 0.843, cost 0.899 and quality 0.874 this analysis implies that factor analysis would yield distinct and reliable factors and is appropriate for these data since those values are close to 1 (see Hutcheson and Sofroniou, 1999). Similarly, Bartlett's test the null hypothesis that the original correlation matrix is an identity matrix indicates a highly significant ($p <0.001$), and therefore factor analysis is appropriate. Table 4.9.1 further indicates the eigen values associated with each factor represent the variance explained by particular linear components

Table 4.9.0:Kaiser-Meyer-Olkin Measure of Sampling Adequacy on Benefits of ICT for Effective Delivery of Building Projects with Respect to Time, Cost and Quality

Variables	**KMOSampling Adequacy**	**Bartlett's Test of Sphericity**			**Determinant**
		Approx. Chi-Square	**Df**	**Sig.**	
Time	0.843	354.525	28	0.000	0.006
Cost	0.899	306.983	28	0.000	0.011
Quality	0.874	261.418	28	0.000	0.018

Table 4.9.1 displays the eigen value in terms of the percentage of variance explained factor 1 explain 62.60%, 60.04%, and 54.84% on time, cost and quality of delivery projects. Similarly, factor 2 explains 13.04% on quality of projects. The table further shows that the first few factors explain relatively large amounts of variance (especially factor 1) whereas subsequent factors explain only small amounts of variance. Table 4.9.2 extracts all factors with eigen values greater than 1, which leaves us with 2 factors and each of the benefits of ICT that makes up of each factors were also displayed.

Table 4.9.1: Total Variance Explained by ICT Benefits on Effective Delivery of Building Projects

Variable		Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
Time	1	5.008	62.595	62.595	5.008	62.595	62.595
	2	.767	9.588	72.183			
	3	.570	7.130	79.313			
	4	.494	6.169	85.482			
	5	.412	5.153	90.636			
	6	.345	4.309	94.944			
	7	.266	3.329	98.273			
	8	.138	1.727	100.000			
Cost	1	4.803	60.039	60.039	4.803	60.039	60.039
	2	.815	10.183	70.222			
	3	.539	6.734	76.956			
	4	.513	6.415	83.372			
	5	.423	5.284	88.655			
	6	.399	4.982	93.637			
	7	.306	3.829	97.466			
	8	.203	2.534	100.000			
Quality	1	4.387	54.844	54.844	4.387	54.844	54.844
	2	1.043	13.038	67.881	1.043	13.038	67.881
	3	.643	8.041	75.922			
	4	.582	7.271	83.193			
	5	.478	5.971	89.165			
	6	.375	4.693	93.858			
	7	.260	3.246	97.103			
	8	.232	2.897	100.000			

Extraction Method: Principal Component Analysis**.**

Table 4.9.2 showed that ICT benefits accounted for a total variance of 62.60%, 60.04% and 67.88% respectively on time, cost and quality of delivery projects. This analysis implies that, the impact is more felt on quality of building project, out of the 67.88% benefits on quality of the project 13.04% were attributed to the reduction in time of data processing with 97%. While the least benefit was felt on cost of building projects with 60.04%.

Table 4.9.2: Component Matrix on the benefit of ICT to Effective Delivery of Building Projects

Time		Cost		Quality		
Benefit	Component 1	**Benefit**	**Component 1**	**Benefit**	**Component 1**	**Component 2**
Avoid circuitous means	.850	Coordination among construction participants	.864	Coordination among construction participants	.868	
Access to information and communication	.831	Efficient distribution of work	.825	Avoid circuitous means	.826	
Enhance construction productivity	.802	Enhance construction productivity	.787	Improve communication for decision making	.812	
Saves employee time	.786	Avoid circuitous means	.772	Efficient distribution of work	.770	
Coordination among construction participants	.776	Saves employee time	.758	Access to information and communication	.765	
Improve communication for decision making	.764	Reduce time of data processing	.755	Enhance construction productivity	.755	
Efficient distribution of work	.761	Access to information and communication	.716	Saves employee time	.737	
Reduce time of data processing	.755	Improve communication for decision making	.708	Reduce time of data processing		.970
% of Variance Explained	**62.60**	**% of Variance Explained**	**60.04**	**% of Variance Explained**	**54.84**	**13.04**

The Table 4.10 above categorized the major problems that could emanate from the adoption of ICT to effective delivery of building projectsin physical planning units of tertiary institution and it shows that fear of virus attack, lack of professional on site, fear of mass job loss in the Industry and fear of personnel abuse with an RII of 59.8%, 57.5%, 55.8% and 55.6% respectively. Other factor includes fear of ICT making professional redundant lack of sufficient jobs, inability of quantify process improvements and uncertainty of benefits of ICT, inadequate power supply and inadequate ICT content of construction education having their RII above 50%. These challenges were related to the existing construction culture which was against current innovation practices. Cultural environment has always been a major driver or barrier to the implementation of new ideas within the construction industry This became evident as most of the respondents were of the view that the construction culture in Nigeria does not encourage innovation encourage the implementation of BIM concept.

Lack of appreciation of ICT firm's management high cost of employing computer professional and high cost of software and hardware problems were not effective to ICT adoption in effective delivery of building project. The reason for not effective of cost was a result of the fact that BIM technology adoption in the early stages, the cost benefit effects are seen as the most significant impact as it reduces waste and increases profitability. As a new way of working among key stakeholders involved in a building project, BIM is seen as having cost efficiency benefits for the building industry.

4.2.3 Problems of adoption of ICT to effective delivery of building projects

Table 4.10: Problems of adoption of ICT to effective delivery of building projects (Obj 2)

Problems	Response					Rank	RII(%)
	1	**2**	**3**	**4**	**5**		
Fear of virus attack	15	20	18	17	11	1	59.8
Lack of Professional onsite	17	19	14	21	9	2	57.5
Fear of mass job losses in the industry	18	13	16	22	11	3	55.8
Fear of personnel abuse	14	23	14	23	7	4	55.6
Fear of ICT making professional redundant	11	20	20	21	7	5	54.7
Lack of sufficient jobs	15	20	15	24	7	6	54.6
Inability of quantify process improvements and uncertainty of benefits of ICT	8	16	30	19	7	7	53.8
Inadequate power supply	14	12	15	23	17	8	52.8
Inadequate ICT content of construction education	7	18	23	23	9	9	50.8
Lack of appreciation of ICT firm’s management	12	14	25	28	3	10	48.8
High cost of employing computer professional	6	10	28	28	8	11	44.5
High cost of software and hardware	6	7	26	30	11	12	42.3
Pooled							52.58

Table 4.11 shows the level of usage of BIM tools checklist by various institution in south west Nigeria with less than 50% usage rate in all the institutions in general. This indicates low level of usage of the software. However, individual institutions analysis shows that file formatting, type of models to be created, responsible party for creation of each model, schedule for delivery model, file naming and Object naming had a high level of usage in University of Lagos (UNILAG) and University of Ibadan (UI) as over 50% and above of the building practitioners affirmed to their usage of BIM implementation checklist in their respective institution. The table further shows that coordination and clash detection checklist had a high usage of 60% in UI.

4.2.4 Level of Usage of BIM Tools Implementation Checklists for by Institutions

Table 4.11 Level of Usage of BIM Tools Implementation Checklists for by Institutions (Objective 3)

Implementation Checklist	Institutions						
	FUOYE	FUNAB	UI	FUTA	OAU	UNILAG	Pooled
Type of models to be created	5(45.5)	7(38.9)	7(70.0)	5(45.5)	6(31.6)	12(80.0)	41(48.8)
Required card of detail	2(18.2)	0(0.0)	5(50.0)	3(27.3)	5(26.3)	7(46.7)	24(28.6)
Responsible party for creation of each model	3(27.3)	4(22.2)	5(50.0)	4(36.4)	8(42.1)	11(73.3)	35(41.7)
File formatting	2(18.2)	7(38.9)	5(50.0)	5(45.5)	6(31.6)	14(93.3)	39(46.4)
Schedule for delivery model	2(18.2)	5(27.8)	5(50.0)	3(27.3)	6(31.6)	12(80.0)	33(39.3)
File naming	5(45.5)	5(27.8)	5(50.0)	4(36.4)	3(15.8)	11(73.3)	33(39.3)
Object naming	2(18.2)	5(27.8)	5(50.0)	3(27.3)	4(21.1)	9(60.0)	28(33.3)
Interoperability of BIM tools	2(18.2)	6(33.3)	3(30.0)	4(36.4)	5(26.3)	5(33.3)	25(29.8)
Coordination and clash detection	2(18.2)	7(38.9)	6(60.0)	4(36.4)	8(42.1)	6(40.0)	33(39.3)
BIM website utilization	3(27.3)	3(16.7)	3(30.0)	3(27.3)	5(26.3)	4(26.7)	21(25.0)
All of the above	6(54.5)	6(33.3)	4(60.0)	0(0.0)	13(68.4)	3(20.0)	34(40.5)
None of the above	1(9.1)	0(0.0)	0(0.0)	3(27.3)	2(10.5)	1(6.7)	7(8.3)

Table 4.12 indicates that BIM implementation checklist were highly effective in UI and OAU with a mean score of 3.395 and 3.151 closely followed by UNILAG with a mean score of 2.850 and effective in FUOYE, FUNNAB and FUTA with a mean score of 2.70, 2.694 and 2.247 on a 5 point Likert scale of measurement. This will be of help in the proper monitoring of projects in the physical planning units.

Table 4.12: Effectiveness of Implementation Checklist of BIM Tools for Project delivery

Implementation Checklist	**Institutions**						
	FUOYE	**FUNAB**	**UI**	**FUTA**	**OAU**	**UNILAG**	**Pooled**
Type of models to be created	2.909	3.222	3.200	2.182	3.235	3.385	3.063
Required card of detail	2.727	2.278	3.000	2.091	3.294	2.818	2.697
Responsible party for creation of each model	2.727	2.611	3.000	2.455	3.471	3.083	2.911
File formatting	3.091	2.556	5.750	2.455	3.588	3.071	3.253
Schedule for delivery model	2.909	3.000	3.100	2.364	3.412	3.067	3.012
File naming	2.727	2.889	3.500	2.727	3.333	3.143	3.061
Object naming	2.727	3.056	3.500	2.200	3.250	3.077	3.000
Interoperability of BIM tools	2.364	2.389	2.800	2.273	2.529	2.083	2.405
Coordination and clash detection	2.455	2.500	3.100	2.000	2.588	2.500	2.519
BIM website utilization	2.364	2.444	3.000	1.727	2.813	2.273	2.455
Total	2.700	2.694	3.395	2.247	3.151	2.850	2.838

Table 4.13 depicts that cost and personnel analysis with 54.8% and 58.3% respectively were the only BIM implementation plan that has a high implantation plan in the effective delivery of building projects. However, individual institutions analysis shows that technology; cost and personnel analysis, process identification analysis, personnel changes and integration development requirements had a high level of usage in the execution of building projects University of Lagos (UNILAG) physical planning unit as 50% and above affirmed to the usability rate.

Table 4.13: Usage of BIM Implementation plan by Institutions

Implementation Plan	Institutions						
	FUOYE	FUNAB	UI	FUTA	OAU	UNILAG	Pooled
Process identification analysis	3(27.3)	8(44.4)	5(50.0)	3(27.3)	8(42.1)	10(66.7)	37(44.0)
Technology Analysis	3(27.3)	8(44.4)	5(50.0)	3(27.3)	11(57.9)	11(73.3)	41(48.8)
Cost Analysis	5(45.5)	9(50.0)	6(60.0)	5(45.5)	10(52.6)	11(73.3)	46(54.8)
Personnel analysis	5(45.5)	10(55.6)	6(60.0)	5(45.5)	12(63.2)	11(73.3)	49(58.3)
Timeline	3(27.3)	7(38.9)	5(50.0)	2(18.2)	11(57.9)	7(46.7)	35(41.7)
Personnel changes	2(18.2)	7(38.9)	5(50.0)	3(27.3)	9(47.4)	9(60.0)	35(41.7)
Training plan	4(3.4)	9(50.0)	6(60.0)	3(27.3)	10(52.6)	8(53.3)	40(47.6)
Integration requirements	4(3.4)	3(16.7)	4(40.0)	2(18.2)	3(15.8)	5(33.3)	21(25.0)
BIM packages	3(27.3)	1(5.6)	4(40.0)	2(18.2)	6(31.6)	3(20.0)	19(22.6)
BIM deliverables/protocols	1(9.1)	1(5.6)	5(50.0)	2(18.2)	3(15.8)	4(26.7)	16(19.0)
All of the above	8(72.7)	7(38.9)	6(60.0)	2(18.2)	10(68.4)	6(40.0)	39(46.4)
None of the above	0(0.0)	0(0.0)	2(20.0)	4(36.4)	0(0.0)	0(0.0)	6(7.1)

Table 4.14 shows that BIM implementation plan affect project delivery in the physical planning units of the institutions, the table revealed that cost, personnel and technology analysis ,Timeline and training plan of building projects with mean score of 3.241, 3.203, 3.141, 3.089 and 3.089were ranked to be the most prominent BIM implementation plan which indicated that it strongly affect the project delivery in PPU, personnel changes, process identification and analysis, integration requirement, BIM packages and BIM deliverables/ BIM protocols shows affected for BIM implementation. The table also indicates that BIM implementation plan had a little or no effect on BIM packages and BIM deliverables/BIM protocols with an RII less than 50% in each case and a mean value that is less than 2.5 on a 5 point likert scale of measurement. Table 4.14.1 further shows the level of significant of BIM implementation plan on project delivery.

Table 4.14: Effects of BIM Implementation Plan on Building Project (Objective 3)

BIM Implementation Plan	Response					Descriptive		
	1	**2**	**3**	**4**	**5**	**Mean**	**Rank**	**RII (%)**
Cost Analysis	7	6	33	27	6	3.2405	1	64.81
Personnel Analysis	6	5	36	31	1	3.2025	2	64.05
Technology analysis	8	5	37	24	4	3.141	3	62.82
Timeline	6	11	37	20	5	3.0886	4	61.77
Training Plan	8	12	30	23	6	3.0886	5	61.77
Personnel changes	11	9	38	17	4	2.9241	6	58.48
Process Identification and Analysis	13	10	30	21	4	2.9103	7	58.21
Integration Requirement	19	16	26	14	1	2.5	8	50.00
BIM Packages	22	22	22	7	2	2.3333	9	46.67
BIM Delivereables/ BIM Protocols	26	24	17	9	1	2.2078	10	44.16

Table 4.14.1 shows the chi-square value of 81.572 with 9 degree of freedom and asymptotic significant probability of 0.000 less than alpha value of 0.05. This analysis implies that BIM implementation had a significant effect on project delivery across the Federal Universities in South west Nigeria with the effects mostly felt on cost analysis, technology and personnel analysis with mean ranking of 6.45, 6.35 and 6.29 respectively.

Table 4.14.1:Friedman Test onEffects of BIM Implementation Plan on Building Project

Implementation Plan	Mean Rank	Df	Chi-Square	Asymp. Sig.
Cost Analysis	6.45	9	81.572	0.000
Technology analysis	6.35			
Personnel Analysis	6.29			
Training Plan	6.01			
Timeline	5.96			
Process Identification and Analysis	5.67			
Personnel changes	5.36			
Integration Requirement	4.67			
BIM Packages	4.22			
BIM Delivereables/ BIM Protocols	4.02			

Table 4.15 shows the mean value of variable that constitute the benefits derived from using BIM software for construction project, acceleration of projects, collaboration with the fragmented AEC industry and improved profitability, was the three prominent benefits of BIM software with mean score value of 4.122, 4.026 and 4.024 while better time management, reduced cost,

improved customer client relationship, speed up analysis cycle times, increased performance after the project i.e (facility management) phase, increases return on investment for the owner, reduces drawing coordination issues and variations, improved project planning, early clash detection between design team drawings, less waste, greater understanding of construction processes and less administration, reduced cost, travel and printing, with mean score values of 3.974, 3.952, 3.951, 3.941, 3.929, 3.928, 3.855, 3.845, 3.798, 3.716, 3.716, 3.786, 3.716 and 3.688 were agreed. The findings revealed that the level of agreement of using BIM software will help in the effective delivery of public building project to time, cost and quality in the AEC industry.However, the major benefit of BIM to project delivery among others in order of their important.

Table 4.15: Benefits of Using BIM software on Project Delivery

Benefits	**Response**					**Descriptive**		
	1	**2**	**3**	**4**	**5**	**Mean**	**Rank**	**RII (%)**
Acceleration	4	3	2	45	22	4.122	1	82.44
Collaboration with the fragmented AEC industry	1	12	9	47	11	4.0263	2	80.53
Improved profitability	2	5	9	48	19	4.0238	3	80.48
Better time management	3	9	8	40	23	3.9753	4	79.51
Reduce cost	1	10	5	43	24	3.9518	5	79.04
Improved customers client relationship	2	10	8	48	16	3.9506	6	79.01
Speed up analysis cycle times	1	9	1	49	24	3.9405	7	78.81
Increased performance after the project	1	10	2	51	20	3.9286	8	78.57

Table 4.15: Benefits of Using BIM software on Project Delivery Cont'd

Benefits	Response					Descriptive		
	1	2	3	4	5	Mean	Rank	RII (%)
(facility management) phase								
Increases return on investment for the owner	1	12	9	43	19	3.9277	9	78.55
Reduces drawing coordination issues and variations	4	5	6	47	22	3.8554	10	77.11
Improved project planning	2	2	8	42	28	3.8452	11	76.90
Early clash detection between design team drawings	3	8	9	43	21	3.7976	12	75.95
Less waste	4	8	7	50	12	3.7857	13	75.71
Greater understanding of construction processes	1	3	10	52	15	3.716	14	74.32
Less administration, reduced cost, travel, printing	3	4	7	45	22	3.6875	15	73.75

Table 4.16 identifies Revit architecture, Revit MEP, AutoCAD Architecture, Revit Structure,AutoCAD MEP, AutoCAD Civil 3D, ArchiCAD,Bentley BIM Suite, Digital Project, Fabrication for AutoCAD MEP,AutoSPRINK VR, Navisworks Manager &Scheduling ,ProjectWise andSynchro as the BIM tools that is mostly used in physical planning unit for project delivery with 50% and above usability rate. Similarly ViscoOffice were not used by any building profession. Visual simulation, Power civil, Vectorworks Designer, CAD-Duct, Vectorworks designer, Digital project MEP, systems routing, HydraCAD, RISA, SDS/2, Fastrak,

FireCAD, Cadpipe Commercial Pipe, DProfiler andCadpipe HVAC had less than 10% usability rate.

4.2.5 BIM Management Tools Used in the Physical Planning Units by Institutions

Table 4.16: BIM Tools Used in the Physical Planning Units by Institutions (Objective 4)

BIM Tools	Institutions						
	FUOYE	**FUNAB**	**UI**	**FUTA**	**OAU**	**UNILAG**	**Pooled**
Cadpipe HVAC	0(0.0)	1(5.6)	0(0.0)	2(18.2)	1(5.3)	2(13.3)	6(7.1)
Revit Architecture	5(45.5)	16(88.9)	9(90.0)	9(81.8)	16(84.2)	13(86.7)	68(81.0)
Revit MEP	4(36.4)	12(66.7)	8(80.0)	6(54.5)	15(78.9)	13(86.7)	58(69.0)
AutoCAD Architecture	9(81.8)	17(94.4)	10(100.0)	11(100.0)	19(100.0)	15(100.0)	81(96.4)
Revit Structure	5(45.5)	13(72.2)	8(80.0)	8(72.7)	18(94.7)	13(86.7)	65(77.4)
DProfiler	0(0.0)	3(16.7)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	3(3.6)
AutoCAD MEP	8(72.7)	11(61.1)	7(70.0)	5(45.5)	8(42.1)	13(86.7)	52(61.9)
Cadpipe Commercial Pipe	0(0.0)	4(22.2)	0(0.0)	2(18.2)	0(0.0)	1(6.7)	7(8.3)
Fastrak	2(18.2)	1(5.6)	0(0.0)	4(36.4)	0(0.0)	0(0.0)	7(8.3)
FireCAD	1(9.1)	2(11.1)…	0(0.0)	1(9.1)	0(0.0)	0(0.0)	4(4.8)
AutoCAD Civil 3D	9(81.8)	16(88.9)	9(90.0)	7(63.6)	17(89.5)	13(86.7)	71(84.5)
ArchiCAD	9(81.8)	15(83.3)	9(90.0)	6(54.5)	18(94.7)	14(93.3)	71(84.5)

Table 4.16: BIM Tools Used in the Physical Planning Units by Institutions (Objective 4) Cont'd

BIM Tools	Institutions						
	FUOYE	**FUNAB**	**UI**	**FUTA**	**OAU**	**UNILAG**	**Pooled**
SDS/2	1(9.1)	2(11.1)	1(10.0)	0(0.0)	0(0.0)	0(0.0)	8(9.5)
Bentley BIM Suite	1(9.1)	5(27.8)	1(10.0)	0(0.0)	0(0.0)	1(6.7)	48(57.1)
Digital Project	7(63.6)	9(50.0)	6(60.0)	3(27.3)	12(63.2)	11(73.3)	71(84.5)
Fabrication for AutoCAD MEP	4(36.4)	8(44.4)	6(60.0)	4(36.4)	11(57.9)	11(73.3)	44(52.4)
HydraCAD	0(0.0)	1(5.6)	1(10.0)	2(18.2)	0(0.0)	0(0.0)	4(4.8)
RISA	0(0.0)	1(5.6)	0(0.0)	0(0.0)	0(0.0)	1(6.7)	2(2.4)
AutoSPRINK VR	5(45.5)	6(33.3)	7(70.0)	4(36.4)	13(68.4)	9(60.0)	44(52.4)
Digital Project MEP, Systems Routing	0(0.0)	1(5.6)	1(10.0)	3(27.3)	2(10.5)	1(6.7)	8(9.5)
CAD-Duct	1(9.1)	0(0.0)	1(10.0)	2(18.2)	1(5.3)	1(6.7)	6(7.1)
Vectorworks Designer	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(6.7)	1(1.2)
Tekla Structures	0(0.0)	2(11.1)	0(0.0)	4(36.4)	1(5.3)	5(33.3)	13(15.5)
Duct Designer 3D, Pipe Designer 3D	1(9.1)	8(44.4)	8(80.0)	5(45.5)	9(47.4)	10(66.7)	41(48.8)
VicoOfice	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Power Civil	0(0.0)	0(0.0)	0(0.0)	3(27.3)	2(10.5)	1(6.7)	6(7.1)

Table 4.16: BIM Tools Used in the Physical Planning Units by Institutions (Objective 4) Cont'd

BIM Tools	Institutions						
	FUOYE	**FUNAB**	**UI**	**FUTA**	**OAU**	**UNILAG**	**Pooled**
Site Design, Site Planning	1(9.1)	2(11.1)	2(20.0)	1(9.1)	5(26.3)	8(53.3)	19(22.6)
Navisworks Manager & Scheduling	6(54.5)	10(55.6)	2(20.0)	6(54.5)	13(68.4)	12(80.0)	55(65.5)
Project Wise	5(45.5)	6(33.3)	7(70.0)	4(36.4)	10(52.6)	11(73.3)	43(51.2)
Digital Project Designer	2(18.2)	3(16.7)	8(80.0)	2(18.2)	2(10.5)	5(33.3)	16(19.0)
Synchro	6(54.5)	9(50.0)	8(80.0)	5(45.5)	13(68.4)	11(73.3)	52(61.9)
Visual Simulation	0(0.0)	4(22.2)	0(0.0)	0(0.0)	0.(0.0)	0(0.0)	4(4.8)
Solibri Model Checker	0(0.0)	4(22.2)	2(20.0)	4(36.4)	1(5.3)	4(26.7)	15(17.9)

Table 4.17 shows that there is no statistical reason to reject the null hypothesis since the significant probability 0.356 and chi-square value of 5.19 with 5 degree of freedom greater than the alpha level 0.05. We therefore conclude that there is no significant difference on the uses of BIMtools by various institutions with OAU and FUTA having the highest mean ranking on the frequency of usage 116.97and 101.32respectively.

Table 4.17:Kruskal Wallis Test on the Frequency of usage of the BIM Tools in Federal University Physical Planning Unit

Institution (Grouping Variable)	Mean Rank	Ranking	Chi-Square	Df	Asymp. Sig.
OAU	116.97	1			
FUTA	101.32	2	5.519	5	0.356
FUNAB	97.41	3			
UI	97.22	4			
UNILAG	96.24	5			
FUOYE	84.79	6			

Table 4.17.1 shows the mean score values of BIM tools, that are mostly used for effective delivery of construction projects considered in the physical planning units in this study. AutoCAD Architecture, Auto CAD Civil 3D, ArchiCAD and AutoCAD MEP with percentage of 78.80%, 72.44%, 69.63% and 68.64% ,was prominent BIM tools in the physical planning units of the study area are very highly frequently used.

This implied that Architect usage of BIM software to design will fasten up in the construction programme of work which will help in the effective delivery of project.

Revit Architecture, Revit structure, Revit MEP, MEP System routing, Digital project designer, AutoCAD MEP with percentage score of 66.59%, 59.51%, 58.48, 55.58% and 52.41% was the ten BIM tools that are very frequently used. This implied that the Engineers using these tools to design affect the effective delivery of construction programme of work to time, cost and quality.

The least rank BIM tools is Auto sprink VR, Fire CAD, and vico office with less than 50% . The most important BIM tools that are used in affecting the performance and effective delivery of construction projects are AutoCAD Architecture, Auto CAD Civil 3D, ArchiCAD and AutoCAD MEP AutoCAD and ArchiCAD.

Summarily, the use of BIM tools in construction project will lead to effective project delivery to time, cost and quality which will lead to project success.

Table 4.17.1: Frequency of usage of the BIM tools by Institutions

BIM Tools	Institutions (RII%)						
	FUOYE	FUNAB	UI	FUTA	OAU	UNILAG	Pooled
Cadpipe HVAC	28.00	30.91	25.00	37.14	36.25	28.33	31.25
Revit Architecture	48.00	77.65	74.00	65.45	64.21	65.33	66.59
AutoCAD Architecture	83.64	76.47	88.00	74.55	82.11	70.67	78.80
Revit Structure	41.82	67.50	72.00	63.64	71.58	58.67	63.41
Revit MEP	41.82	61.25	60.00	63.64	63.16	62.67	59.51
AutoCAD MEP	65.45	70.59	70.00	67.27	75.29	61.33	68.64
AutoCAD Civil	72.73	71.11	74.00	70.91	83.53	61.33	72.44

BIM Tools	Institutions (RII%)						
	FUOYE	FUNAB	UI	FUTA	OAU	UNILAG	Pooled
3D							
Cadpipe							
Commercial Pipe	23.64	36.25	20.00	27.50	36.67	28.00	30.13
DProfiler	23.64	28.89	22.00	20.00	34.12	21.33	26.08
Bentley BIM							
Suite	21.82	22.35	22.00	22.50	32.94	22.67	24.62
Fastrak	25.45	21.25	20.00	27.50	40.00	22.67	26.75
SDS/2	29.09	26.67	30.00	31.43	32.94	25.33	29.07
Fabrication for							
AutoCAD MEP	56.36	53.75	50.00	44.44	58.89	46.67	52.41
Digital Project	61.82	57.14	52.00	42.22	57.78	57.33	55.58
Digital Project							
MEP,Systems							
Routing	56.36	60.00	68.00	48.00	58.89	58.57	58.48
ArchiCAD	81.82	73.75	58.00	65.45	68.42	68.57	69.63
HydraCAD	21.82	26.25	36.00	33.33	33.33	32.00	30.38
AutoSPRINK VR	21.82	25.00	20.00	22.50	27.78	24.00	24.10
FireCAD	21.82	22.22	24.00	30.00	26.67	22.86	24.30
CAD-Duct	21.82	25.56	30.00	37.50	31.11	24.29	27.85
Vectorworks							
Designer	21.82	26.25	37.50	32.50	31.11	29.33	29.21

Table 5.17.1: Frequency of usage of the BIM tools by Institutions Cont'd

BIM Tools	Institutions (RII%)						
	FUOYE	FUNAB	UI	FUTA	OAU	UNILAG	Pooled
Duct Designer 3D, Pipe Designer	36.36	45.00	35.56	47.27	51.76	44.00	44.30
Tekla Structures	40.00	32.50	31.11	37.14	27.37	49.33	35.84
Affinity	21.82	22.50	20.00	27.50	28.89	24.00	24.42
VicoOfice	25.45	21.25	37.78	37.50	31.76	28.00	29.21
PowerCivil	25.45	28.75	44.00	40.00	40.00	38.67	36.00
Site Design, Site Planning	50.91	55.00	62.00	52.73	64.44	49.33	56.05
NavisworksManage,Navisworks	61.82	40.00	56.00	37.78	50.59	49.33	48.86
ProjectWise	34.55	36.47	42.00	33.33	40.00	44.00	38.75
Digital Project Designer	52.73	40.00	44.00	50.00	50.00	41.43	46.08
Visual Simulation	25.45	37.50	24.00	27.50	34.44	32.00	31.28
Solibri Model Checker	21.82	27.50	20.00	25.00	33.33	30.67	27.44
Synchro	25.45	33.75	20.00	25.00	31.11	25.33	27.69
Others	20.00	20.00	20.00	20.00	37.50	26.00	28.33

Table 4.18 reveals project planning, monitoring and cost estimation as the major possible outcomes of BIM tools on management of construction project delivery with RII of 84.5%, 79.8% and 78.6% respectively. Closely followed by Project visualization and coordination with RII of 72.6% and 70.2%. This implies that management of construction projects in the physical planning units of the study can be reached through any of the BIM tools outcomes.

Table 4.18: Possible Outcomes of BIM Tools on Management of Construction Projects by Institutions

Possible Outcomes	Institutions						
	FUOYE	FUNAB	UI	FUTA	OAU	UNILAG	Pooled
Project Visualisation	8(72.7)	15(83.3)	6(60.0)	7(63.6)	15(78.9)	10(66.7)	61(72.6)
Project Coordination	7(63.6)	15(83.3)	5(50.0)	7(63.6)	14(73.7)	11(73.3)	59(70.2)
Project Planning	11(100.0)	18(100.0)	7(70.0)	9(81.8)	16(84.2)	10(66.7)	71(84.5)
Project Monitoring	11(100.0)	18(100.0)	6(60.0)	8(72.7)	16(84.2)	8(53.3)	67(79.8)
Cost estimation	10(90.9)	16(88.9)	8(80.0)	6(54.5)	16(84.2	10(66.7)	66(78.6)
Record keeping	8(72.7)	16(88.9)	6(60.0)	5(45.5)	13(68.4)	8(53.3)	56(66.7)
Others	2.727	3.056	3.500	2.200	3.250	3.077	3.000

Table 4.18.1 shows the possible outcome of BIM tools on management of construction projects in this study. It revealed the mean score value of record keeping, project planning, project

monitoring, project coordination , cost estimation and project visualization with a mean score value of 3.805, 3.793, 3.768, 3.683, 3.667 and 3.420 respectively were highly frequently used. This implies that management of construction projects in the physical planning units of the study can be reached through any of the BIM tools outcomes.

BIM Implementation Plan	**Response**					**Descriptive**		
	1	**2**	**3**	**4**	**5**	**Mean**	**Rank**	**RII (%)**
Record Keeping	6	3	13	39	21	3.8049	1	76.10
Project Planning	4	2	20	37	19	3.7927	2	75.85
Project Monitoring	4	4	21	31	22	3.7683	3	75.37
Project Coordination	5	2	24	34	17	3.6829	4	73.66
Cost estimation	6	4	21	30	20	3.6667	5	73.33
Project Visualisation	8	6	20	38	9	3.4198	6	68.40

Table 4.19 shows the relationship between traditional approach and BIM approach and was explained as follows:

Safety management

Traditional approach using compliance with statutory laws, work ethics with a mean score of 2.556 was preferred while BIM approach incorporated into with a mean score of 3.017 was highly preferred for construction projects more than traditional method

Construction methodology

Traditional approach based on sequence of site activities and paper documentation with a mean score of 2.321 while BIM approach using digital visualization of site activities with a mean score of 4.024 was very highly preferred for construction operation for effective delivery of building projects.

Planning and scheduling

Traditional approach using schedule and bar chart with a mean score of 2.259 is preferred while BIM approach using link schedule to 3D model with a mean score of 3.976 is highly preferred. The BIM approach using planning and scheduling for construction operation processes in the physical planning unit will deliver building projects to time, cost and quality.

Construction progress tracking and control

Traditional approach using bar chart colouration and progressive representation with a mean score of 2.259 was preferred for construction operation while BIM approach using automation of models to reflect update and progress with a mean score of 4.121 are very highly preferred for effective delivery of building projects in PPU of their institutions.

Layout Planning and Site Management

Traditional approach based on compliance with statutory law work ethics with a mean score of 2.244 was preferred while BIM approach incorporated into the project models with a mean score of 4.024 was very highly preferred for construction operation in effective delivery by projects of projects to time more than Traditional method approach.

Project meeting and discussions

Traditional approach with a mean score of 2.232 will be preferred using paper documentation and chain information sharing with a mean score of 3.939 was highly preferred for construction project as proper dissemination of information will be done very fast and also it will be received to time and this will lead to effective delivery of building projects in their physical planning unit.

Targeted output Vs Actual output

Traditional approach with a mean score of 2.159 is not preferred using bar chart comparison while BIM approach using visual comparison of models with a mean score of 4.048 are very highly preferred for construction operation and in effective delivery of building projects in their physical planning units.

4.2.6 Relationship between Traditional (Conventional) Method and BIM on Site Construction Operation

Table 4.19.1: Relationship between Traditional (Conventional) Method and BIM on Site Construction Operation (Objective 5)

	Traditional Method								BIM Method							
Construction Operation	**Response 1**	**2**	**3**	**4**	**5**	**Descriptive Mean**	**Rank**	**RII(%)**	**Response 1**	**2**	**3**	**4**	**5**	**Descriptive Mean**	**Rank**	**RII(%)**
Safety management	26	14	21	10	10	2.556	1	51.11	3	7	21	22	29	3.817	11	76.34
Construction methodology	29	20	16	9	7	2.321	2	46.42	2	6	18	19	38	4.024	6	80.48
Planning and Scheduling	27	23	17	11	3	2.259	3	45.19	0	10	15	25	33	3.976	9	79.52
Construction progress tracking and control	27	23	17	11	3	2.259	4	45.19	2	5	12	26	38	4.121	4	82.41
Layout planning and site management	32	19	19	3	9	2.244	5	44.88	3	7	12	24	37	4.024	6	80.48
Project meeting and discussions	32	19	17	8	6	2.232	6	44.63	2	5	21	22	32	3.939	10	78.78
Targeted output vs Actual output	27	26	22	3	4	2.159	7	43.17	2	1	18	32	30	4.048	5	80.96
Project management	33	23	9	9	5	2.114	8	42.28	0	3	14	22	43	4.281	1	85.61
Claim analysis and dispute resolution	35	23	10	5	8	2.111	9	42.22	3	6	15	22	37	4.012	8	80.24
Project documentation	33	26	11	7	4	2.049	10	40.99	0	7	12	22	41	4.183	2	83.66
Overview of project plan	33	27	13	5	4	2.024	11	40.49	2	4	12	28	36	4.122	3	82.44
						2.212		44.23						4.050		80.99

Source: field survey (2018)

Project Management

Traditional approach leads to fragmentation among team members with a mean score of 2.114 was preferred for construction operation while BIM approach allows integration among project team members with a mean score of 4.281 was very highly preferred for effective delivery of building projects to time, cost and quality.

Claim analysis and dispute resolution

Traditional approach based on condition of contract with a mean score of 2.111 was preferred for construction operation while BIM approach based on collective responsibility with a mean score of 4.012 was very highly preferred for effective delivery of building projects.

Project Documentation

Traditional approach using analog with a mean score value of 2.049 was not preferred for construction projects while BIM approach using digital with a mean score of 4.183 was very highly preferred for construction projects than Traditional method in project delivery.

Overviews of project plan

Traditional approach using project network analysis with a mean score of 2.024 was preferred for project execution while BIM approach using digital representation of project network analysis with a mean score of 4.122 was very highly preferred for construction operation.

The findings revealed that the most preferred construction operation using BIM for project execution that affects the performance and delivery of projects are all the itemized construction operations while traditional approach least preferred construction operations are dispute resolution, project documentation and overview of project plan with mean score of 2.11, 2.049 and 2.024

The Table revealed that out of 11 itemized construction operation only safety management were preferred using the traditional method by the building professionals in physical planning units of various institutions with RII of 51.11% and a mean value of 2.556 on a 5 point likert scale of measurements while BIM were very highly preferred in all the itemized construction operations with their mean values ranges from 3.817 to 4.281 and RII of above 75%. The table further revealed in general that BIM were very highly preferred to Traditional Method with an RII of 80.99% to 44.23% as indicated by the respondents.Conclusively, using BIM approach will improve the rate of delivery of projects to time, quality and cost.

The Table 4.20 shows that there is relationship between traditional method and BIM. The traditional method has mean value of 25.081 with standard deviation of 5.10, while BIM has mean score of 30.15 with standard deviation of 13.53, r calculated is 0.395*. by implication, it is positive and there is high relationship between traditional method and BIM. (r = 0.395, SD = 5.10, $P<0.05$)

The positive relationship were statistically significant at 0.05 levels, the correlation coefficient for the significant result is 0.395.

Table 4.20 Pearson correlation of Traditional 2D (conventional method) and Building Information Modeling (BIM)

Sources of Variation	N	Mean	SD	r
Traditional Approach	82	25.081	5.100	0.395
BIM approach	82	30.150	13.530	

Table 4.21.1 shows the chi-square value of 3.655 with 5 degrees of freedom and asymptotic significant probability of 0.600 greater than alpha value of 0.05. This analysis implies that project factor were not significance on project delivery using Traditional Approach

Table 4.21.1:Friedman Test on Impact/significance of Project Factors on Project Delivery using Traditional Approach

Project Factor	Mean Rank	Df	Chi-Square	Asymp. Sig.
Individually managed project risk	3.77	5	3.655	0.600
Fragmentation of project team members	3.50			
Paper based communication	3.48			
Segregation of project process	3.45			
Analog technology	3.45			
Individually pursued reward/compensation	3.35			

Table 4.21.2 shows the chi-square value of 12.439 with 5 degree of freedom and asymptotic significant probability of 0.029 less than alpha value of 0.05. This analysis implies that project factor had a significance impact on project delivery using BIM approach with integration of project team members, digital technology and BIM based models of dimensional were mostly impact project delivery with mean ranking of 3.77, 3.74 and 3.64 respectively. The table also reveals that collectively pursued reward had the least impact with mean ranking of 3.18.

Table 4.21.2:Friedman Test on Impact/significance of Project Factors on Project Delivery using BIM Approach

Project Factor	Mean Rank	Df	Chi-Square	Asymp. Sig.
Integration of project team members	3.77	5	12.439	0.029
Digital technology	3.74			
BIM based models of dimensional/visual communication	3.64			
Concurrent project process	3.43			
Collectively managed project risk	3.24			
Collectively pursued reward/compensation	3.18			

4.2.7 Development of a framework for BIM based on computer software developed for adoption in the physical planning units of the Federal Universities in South West, Nigeria (objective 6).

Succar, (2015) in his framework explained BIM concepts with focus on its applicability and update within historic preservation in the AEC sector. The framework of Historic Building Information Modeling (HBIM) bridges the knowledge gap by articulating issues regarding the technology of surveying methodologies with other informational, technical, and organizational issues of BIM. However, the framework provides an initial background for developing more comprehensive study related to HBIM implementation in historic preservation and management where HBIM database is used to gather information and make it available to researchers, professionals, and other parties involved in historic building preservation.

The framework also demonstrates the vision that focus holistically on people, technology, processes, and policy to increase the impact of BIM on society and support management of historic buildings where a collaborative decision making is essential to a successful HBIM implementation. Thus, moving to HBIM is a much larger change, and thus requires both top-down and bottom-up approaches and the four pillars to be integrated simultaneously.

The research framework was adapted from existing framework and forms basis for this study as shown in Fig 2.4 on page 35.

The Research framework identified the result of the data analyzed through the three interlocking fields of BIM namely (i) Process Field, (ii) Technology Field and (iii) Policy Field to outline the findings of this research work for the physical planning units of the Federal Universities in South

West Nigeria.

4.2.7.1 Policy fields

The stakeholders are open to adopt BIM philosophy and their perception of it uses on execution of new projects management in the construction industry in Physical Planning UnitsBIM concept implementation into the physical planning units of the Federal Universities is very positive and encouraging. This innovative technology has the conviction that it will bring some kind of efficiency and effectiveness into the construction industry. Also, the idea of promoting sustainability in the construction sector will yield higher percentage in environmental consciousness and also transform the nation building infrastructures. The most important concern from the stakeholders, was that Government should take proactive steps to make policies and legislations that enforced the use of BIM software in order of achieving sustainable construction sector with near zero emission. On Construction management, the BIM tools will enhance constructability, project scheduling and the like which causes problems for companies in the industry.

4.2.7.2 Process fields

BIM improves project management team's collaboration, efficiency in information sharing, project scheduling and project delivery system for AEC/FM industry in Physical Planning Units

All the Process fields solve the problems related to organizational management and operational process due to poor technological tools and Human relation management except Finances. The days of traditional style of design process or building has come to end especially the construction sector in the Tertiary Institution. It will help the nation to compete in the global construction market to invest in innovative technology like BIM and also develop the human resource capital. Today's technology goes along side with human competencies and in turns yields higher productivity which brings good returned of investment for the company's business or boast the growth of the nation's Gross Domestic product (GDP). The BIM concept can address all fore mentioned main problems as shown in Table 4.9. BIM technology implementation can offer the Physical Planning Units most especially for the works of Architects, Engineers, Contractors, Facility managers among other professionals.

4.2.7.3 Technology fields

BIM tools are regarded as new innovation and technological advancement in the construction industry in South West. All the relevant key stakeholders in the construction sector are to promote its use. Secondly, there is the need to boost software and hardware investment in the construction industry as demonstrated by the government initiatives in United Kingdom and Denmark.

BIM concept adaptation and implementation can also thrive in the Nigerian construction industry even though there are some areas of challenges that require intensive education.

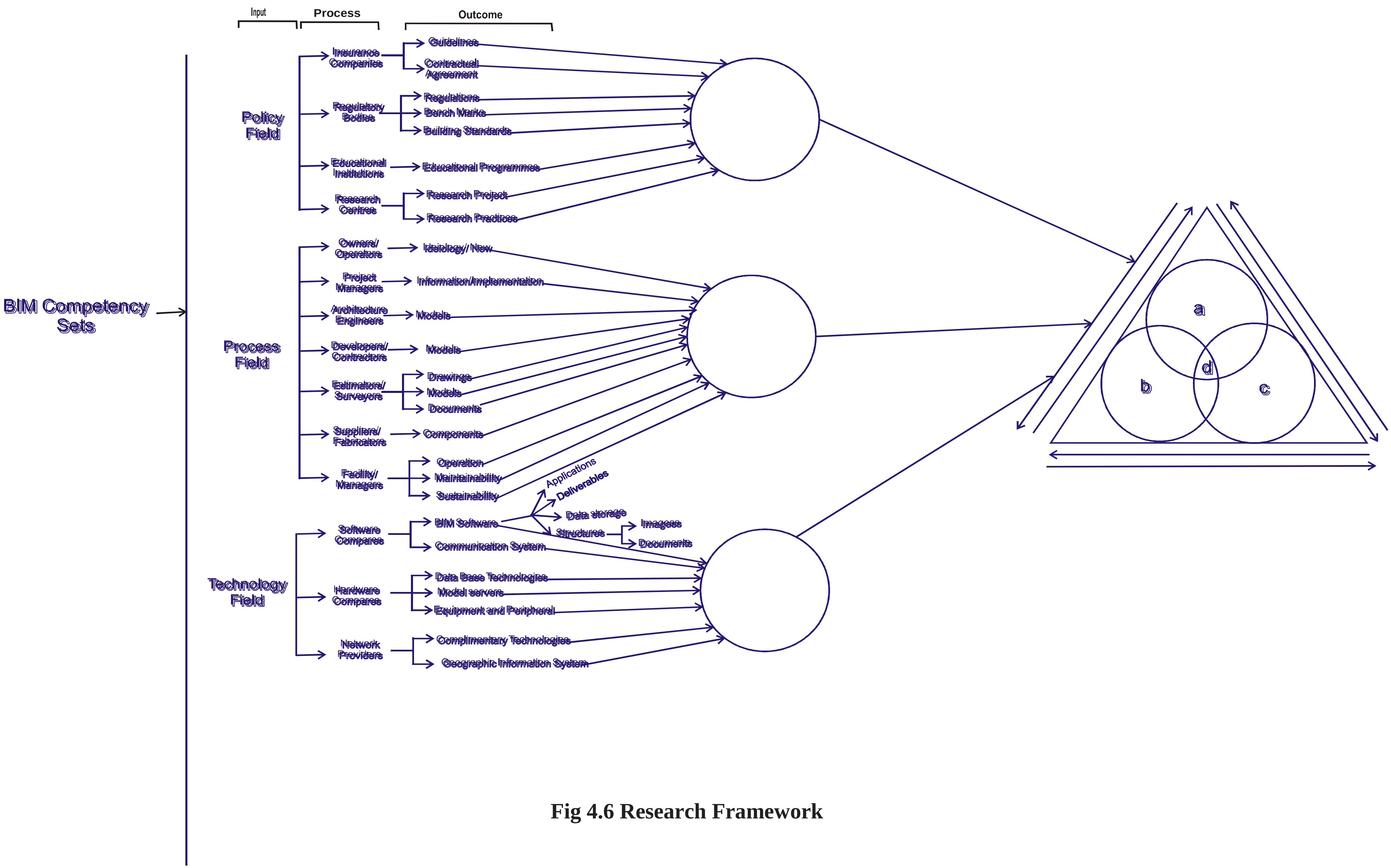


Fig 4.6 Research Framework

BIM Interactions

BIM Interactions are push–pull knowledge transactions occur-ring within or between fields and sub-fields. Push mechanism transfer knowledge to another field or sub-field while pull mechanisms transfer knowledge to satisfy a request by another field or sub-field. Sample transactions include data transfers, team dynamics and contractual relationships between fields and sub-fields. The identification and representation of these interactions are an important component of the Framework's deliverables.

Figure 4.7belowsummarized the three BIM Fields, lists the prominent playersand deliverables and identifies some interaction issues.

BIM field overlaps

The three fields overlap as they share players and deliverables. These overlap betweenfields occurs when:

(1) A deliverable requires players from two or more fields. The development and application of non-proprietary interoperable schemas (IFCs for example) require the joint efforts of Policy players (researchers and policy makers) as well as Technology players (software developers).

(2) Players pertaining to one field generate deliverables classified in another. For example, the Australian Institute of Architects is an 'industry body' whose members are Process players

(3) (Architects) generating Policy deliverables (guidelines and best practices) rather than Process deliverables (building designs and construction details).

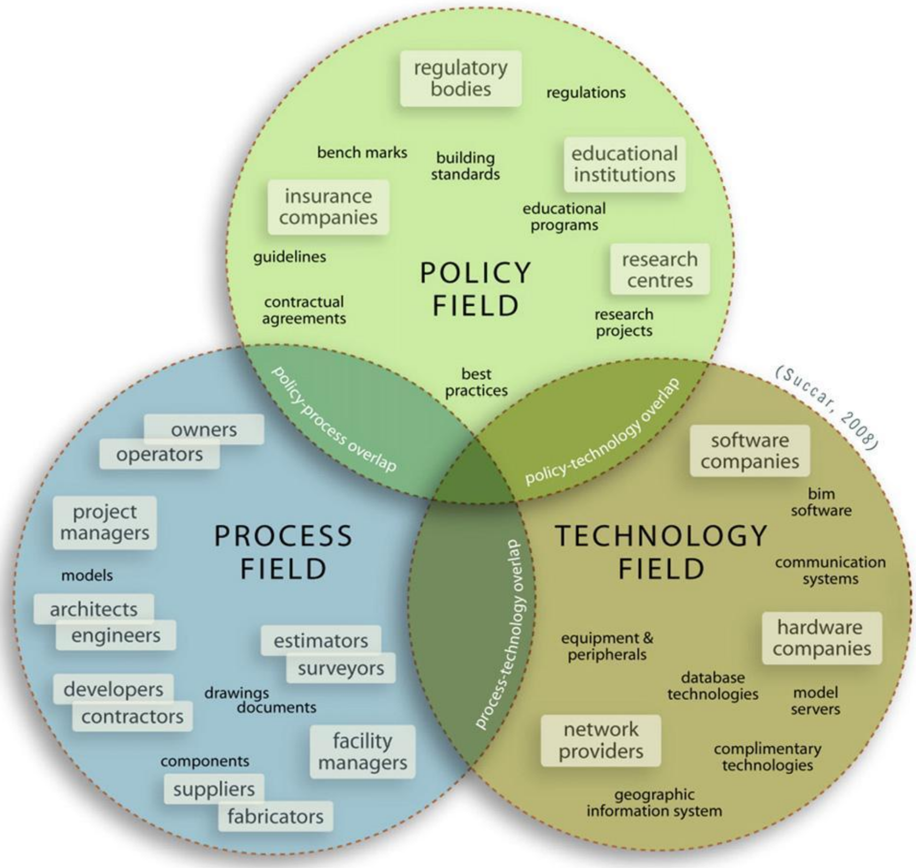


Fig 4.7 Three interlocking Fields of BIM activity — Venn diagram.

Adapted from Succar (2009)

BIM maturity stages

There are voluminous possibilities attributed to BIM representing an array of challenges which need to be addressed by Architecture, Engineering, Construction and Operations (AECO) stakeholders. Having identified the BIM Fields, this section identifies the multiple stages which delineate implementation maturity levels.

BIM Stages of the research framework identifies a fixed starting point (the status before BIM implementation), three fixed BIM maturity stages and a variable ending point which allows for unforeseen future advancements in technology. The researcher uses the term Pre-BIM to represent industry status prior to BIM implementation and Integrated Project Delivery (IPD) to denote an approach to or an ultimate goal of implementing BIM.

The BIM Framework identifies BIM maturity within organisations, projects and industry as a series of stages which stakeholders need to implement gradually and consecutively. Each of these stages is further subdivided into steps. What separates stages from steps is that stages are transformational or radical changes while steps are increment. BIM maturity includes TPP (technology, process and process)

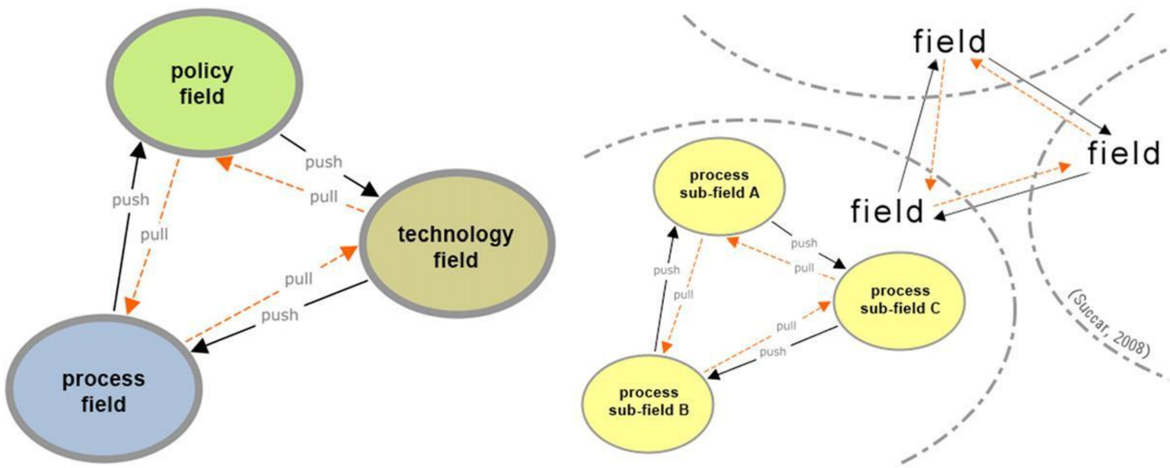


Fig. 4.8: BIM Interactions between and within Fields — combined view.

Source: (Succar, 2009)

Table 4.22: BIM Fields Interactions

	Policy Field	Process Field	Technology Field
Definition	Policies are "written principles or rules to guide decision-making"	Process is a specific ordering of work activities across time and place, with a beginning, an end, and clearly identified inputs and outputs: a structure for action"	Technology is the application of scientific knowledge for practical purposes.
Extended Field Definition	The field of interaction generating research, talents, standards and best practices for the purpose of safeguarding benefits and minimizing contestation between AECO Stakeholders	The field of interaction between design, construction and operational requirements for the purpose of generating and maintaining structures and facilities	The field of interaction between software, hardware, equipment and networking systems for the purpose of enabling or supporting the design, construction and operations of structures and facilities
Players (sub-field)	Governments, researchers, educational institutions insurance	Owners, operators, architects, engineers, estimators, surveyors,	Software, hardware, network and equipment companies plus their

Table 4.22: BIM Fields Interactions Cont'd

		Policy Field	Process Field	Technology Field
		companies and regulatory bodies, …	developers, contractors, sub-contractors suppliers, fabricators, facility managers, …	development and sales Channels
Deliverables (sub-field)		Regulations, guidelines, standards, best practices, bench marks, contractual agreements, educational programmes	Construction products and services including drawings, documents, virtual models/components, physical components, structures and facilities	Software, hardware, peripherals, network solutions, and office/ site equipment
Sample interactions between fields and sub-fields	Push into other fields	– Skilled graduates, standards, guidance into Process – Concepts, mathematical solutions into Technology	– Case studies into Policy – Feedback to Technology	Innovative solutions and new equipment into Policy and Process
	Pull	– Subject matter	– Development of solutions	– Standardisation efforts

Table 4.22: BIM Fields Interactions   Cont'd

	Policy Field	Process Field	Technology Field
from other fields	experts from Process – Interoperability from Technology	from Technology – Standards, guidelines and graduates from Policy	from Policy – Requirements and experiences from Process
Push –pull within the same field	Interchanges between research, education and accreditation boards	Architect's Instructions (AI-push) and Request Further Information (RFI-pull)	Hardware capabilities (push) and software requirements (pull)

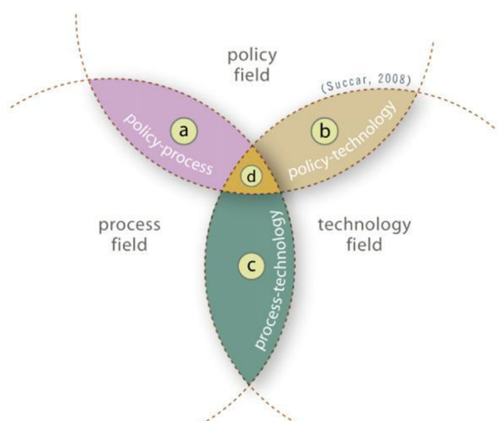


Fig 4.9:BIM Fields' overlapping players and deliverables — fan model.
Source : (Succar, 2009)

KEY

- (a) Sample **Policy-Process overlap**: Industry body *(BIM player)* and Continuous Professional Development (CPD) training *(BIM deliverable)*
- (b) Sample **Policy-Technology overlap**: Interoperability standards *(BIM deliverable)*
- (c) Sample **Process-Technology overlap**: Communities of Practice *(BIM player)*
- (d) Sample **Policy-Process-Technology overlap**: BIM Implementation *(BIM deliverable)*, BIM specialists ñ individuals and groups *(BIM players)*

Fig. 4.10:BIM maturity is subdivided into three stages — linear view.

Source (Succar, 2010)

4.2.8 Validation of Framework

The aim of this study was to develop a framework that will enhance effective public building project delivery in Nigeria. This was achieved by developing a computer software programme for Building Information Modeling for Public Use (BIMPU). Therefore, the study recommended external validation as area of further study to practicalize and validate this model.

Moons *et al (2012)* noted that it is not enough to demonstrate a reasonable or good performance of a developed model on the sample alone, but also essential to confirm that any developed model predicts well in any other circumstances and is genaralisable to ‘similar but different’ data-set. The more these other situations differ from the developed model, the stronger the test of genaralisability of the model.

For example, Gory *et al* (2012) in the critique of internal validation noted that internal validation does not make use of other than the development (analyzed) data and therefore will not provide the degree of heterogeneity that will be encountered in real-life applications of the model. Also, Vignoletti and Abrahamsson (2012) opined that fundamental issues in the design of validation studies have not been well explored, but in essence only requires documentation of the predictor and outcome values in new individuals. The study observed that model validation is not simply repeating the analytical steps applied in the development study in other individuals to see whether the same predictors and weights are found. Model validation is also not refitting the final developed model in the new individuals and checking whether the model performance (discrimination, calibration and classification) is different as was found in the development study.

Summarily, model validation is taking the original model with its predictors and assigned variables by measuring the predictor to generate outcome values in the new set of individuals. Hence, the justification for the use of external validation as area of further study to practicalize and validate this model.

4.2.9 Software Development

The software developed for this study was hinged on the threshold of Royal Institute of British Architects (RIBA) plan of work that categorized various phases of project life cycle. The various stages were used to reflect the collaboration and integration of all the stakeholders in the project life cycle. This was used to generate BIM technology platform. In the platform of BIM technology, all project stakeholders on the construction project share common information from the central BIM data source. This act fulfills the idea of BIM concept, where there is a free flow of information and shared responsibilities among integrated project teams without any obstacles. Whilst in the traditional team model, information flows from the building Owner to the Architects andthen spread to the various individuals or trades undertaken the proposed project. This has the tendency to have communication problems among project teams and it can ends up affecting the overall execution of the project results. Within the BIM platform, some of the activities that integrated teams engaged in are Modifying, extracting, collaborating, updating and inserting other relevant information to the constructed model database. The results of the integration of project teams on common database minimize cost, errors, time, and promote the quality of project works.

THE BIM PROJECT

To navigate down to the project, ensure that the local server is on, then type local host/bim in the address box. Then the navigation ends on the landing page where from you can access the rest of the project.

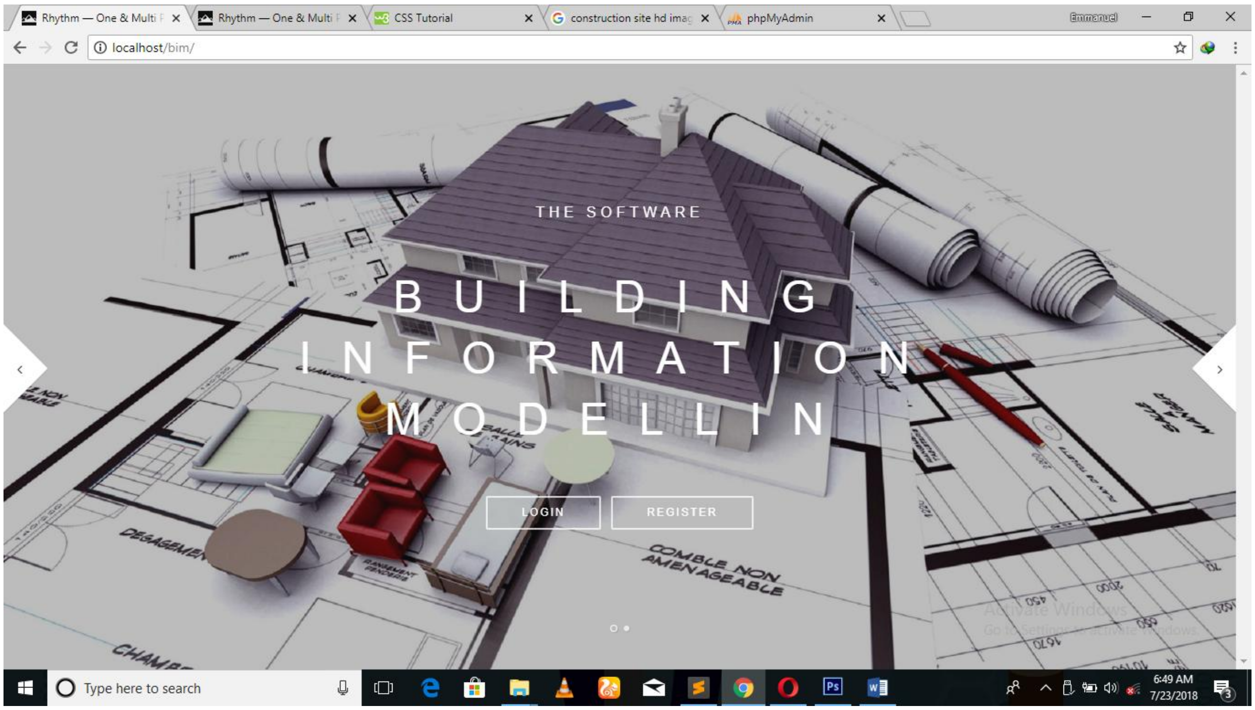
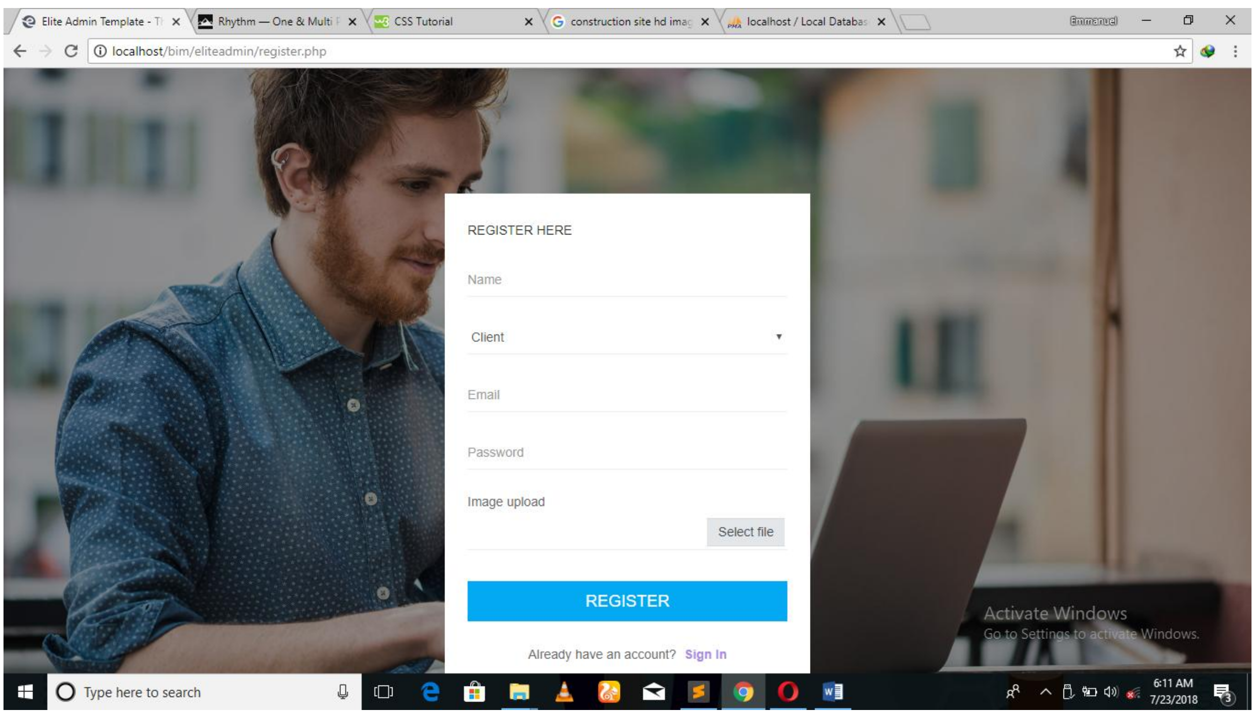


Fig 4.11:**Developed Software for Effective Communication**

The software features

Staff Registration:

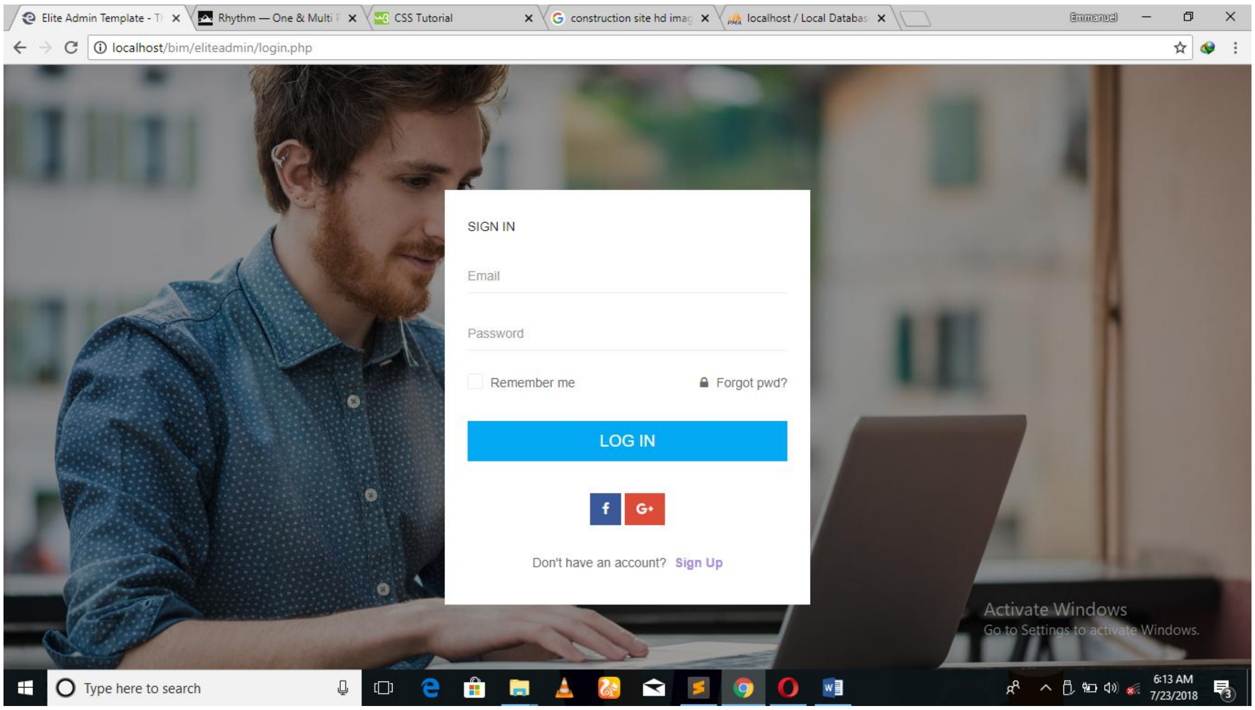
To use the solution, all it users must be registered on the system. so the register page is used to create new staffs on the system. The staff creation ranges across all the possible hands that can be involved in a project including clients.



Staff Login

Fig 4.12: Log in for Registration of New Staff

After the registration process is completed, each of the users of the system are required to login to use the system.



Staff Home

Fig.4.13: New Projects Creation

On a successful login situation, the staff is taken to its general home. This page contains option to create new projects, or join in on an ongoing discussion.

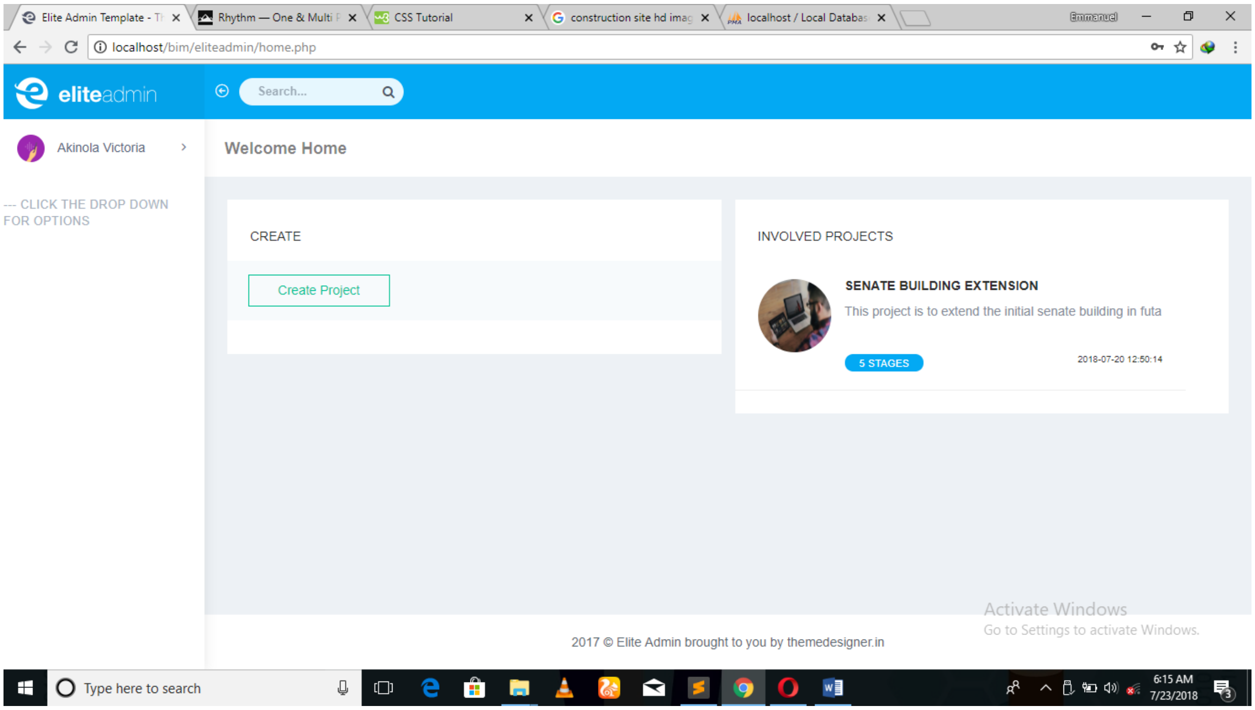


Fig 4.14: Admin Project Creation.

Any of the users of the system can initiate a project. That immediately gives the initiator the admin rights on the project. The project creation is completed in three stages, the first is to name the project and give it a general image for identification (like whatsapp group chat)

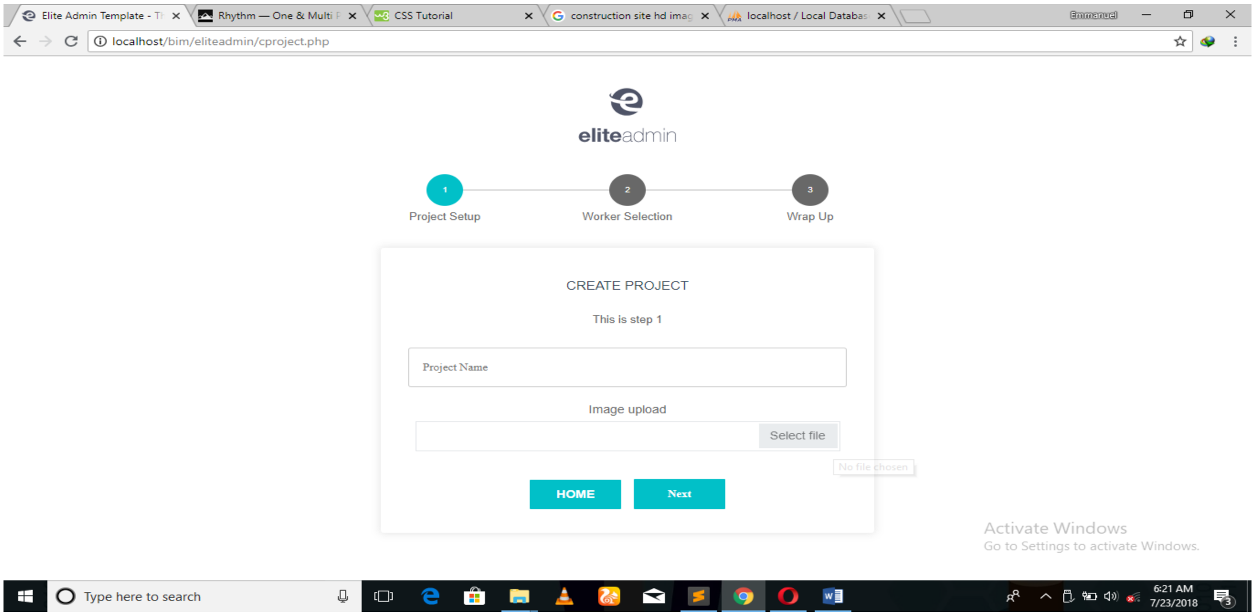


Fig 4.15: Required Projects Selected

Then the next stage involves worker selection. At this point, all the users of the system in different job professions that will be needed on the project are added.

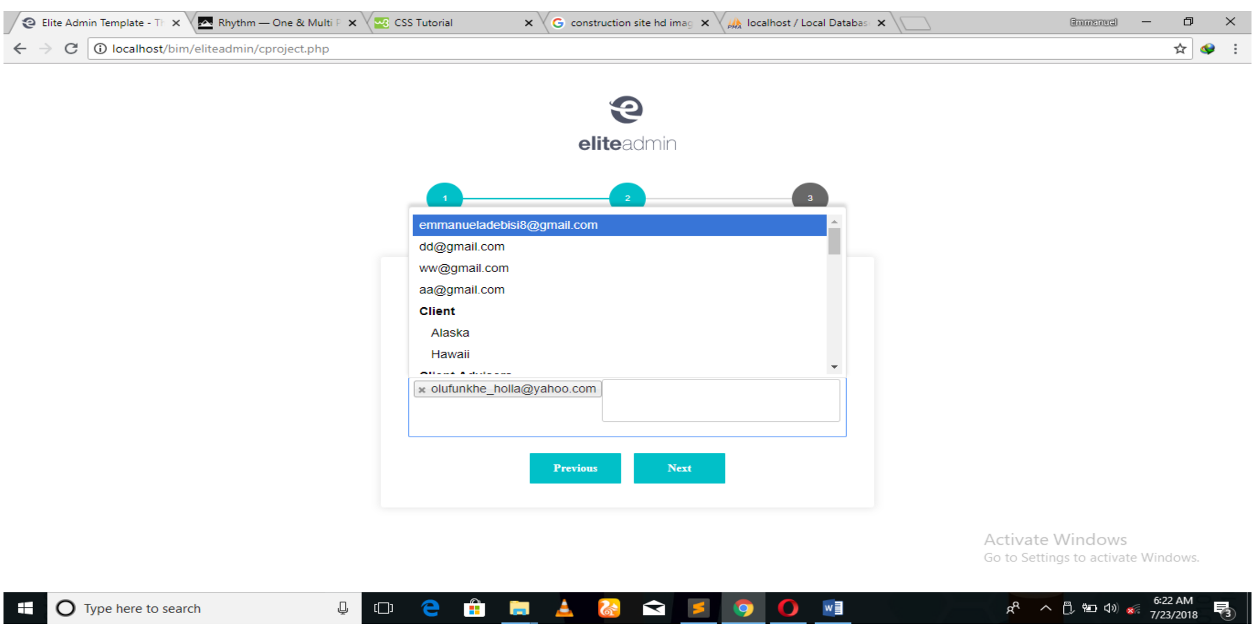


Fig 4.16: Registration of the Professionals for the Project

The last step in this stage is that, BIM is very flexible and tailored towards the requirement of different project needs hence, the admin is allowed to state the number of stages the work will be broken into. This decision can be changed later.

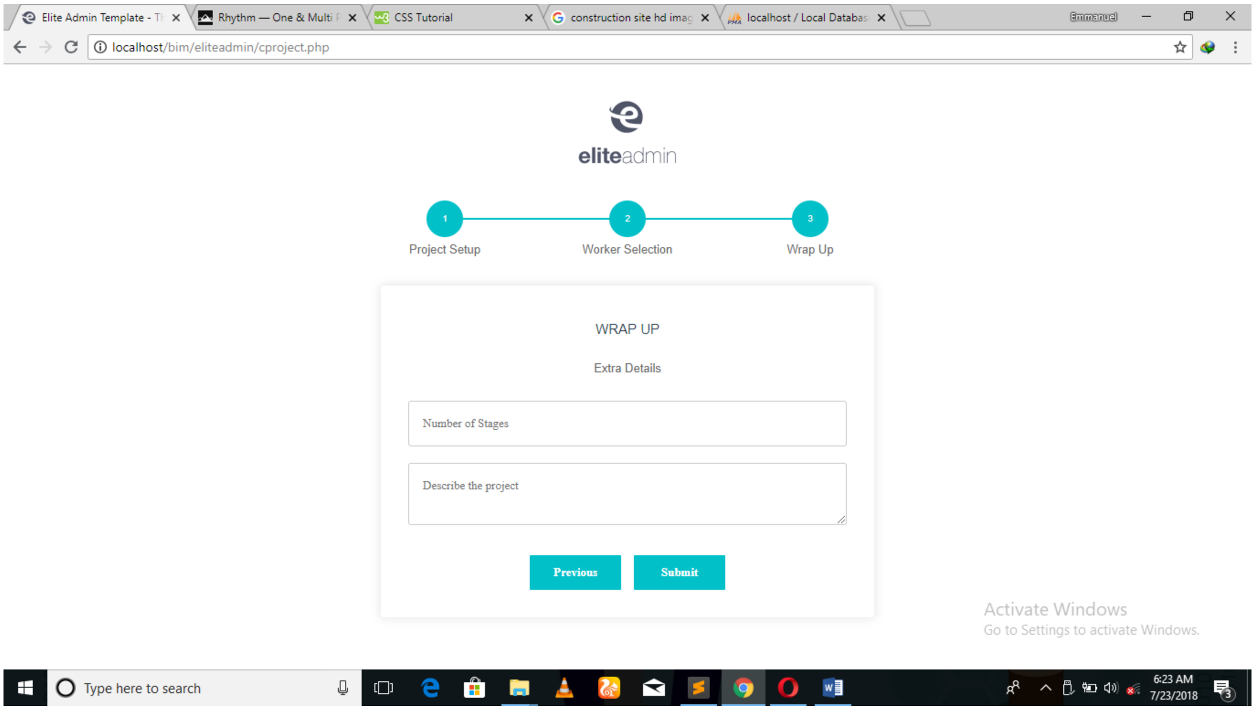


Fig 4.17: Integrated Stages of projects

Staff's group Discussion:

Once the project is created, the link to its discussion can be found on the admin page and every other worker selected (added) during its creation. So the link is followed to reach the discussion page.

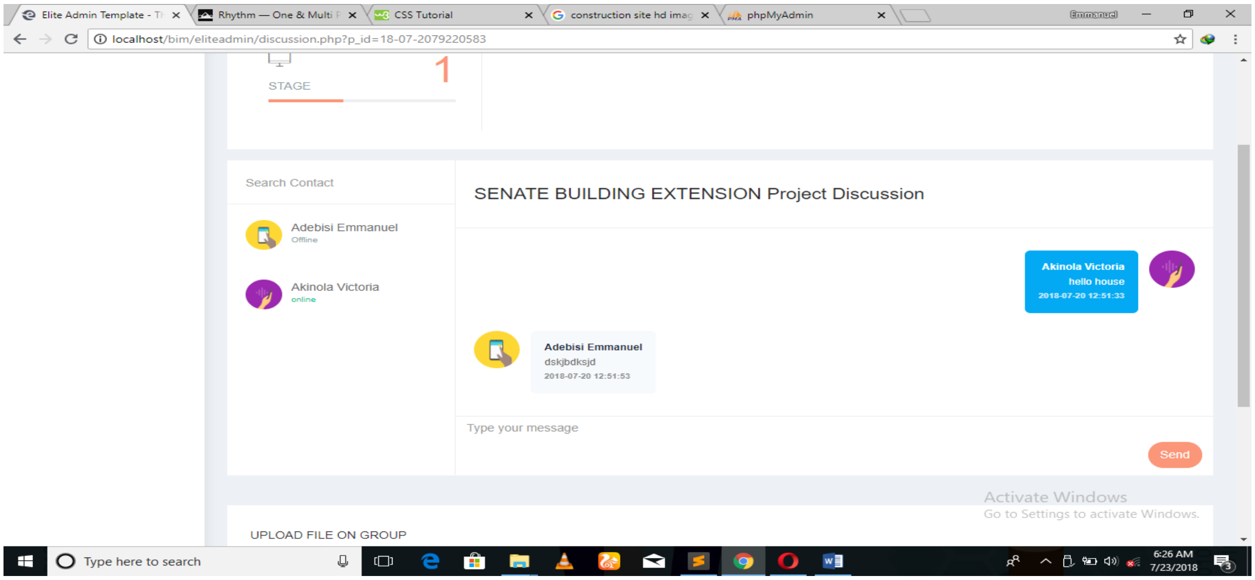


Fig 4.18: Staff's Group Discussion

On this page information about the stage of the project, the discussion timeline and Update progress pane (which can only be viewed by the administrator) is found.

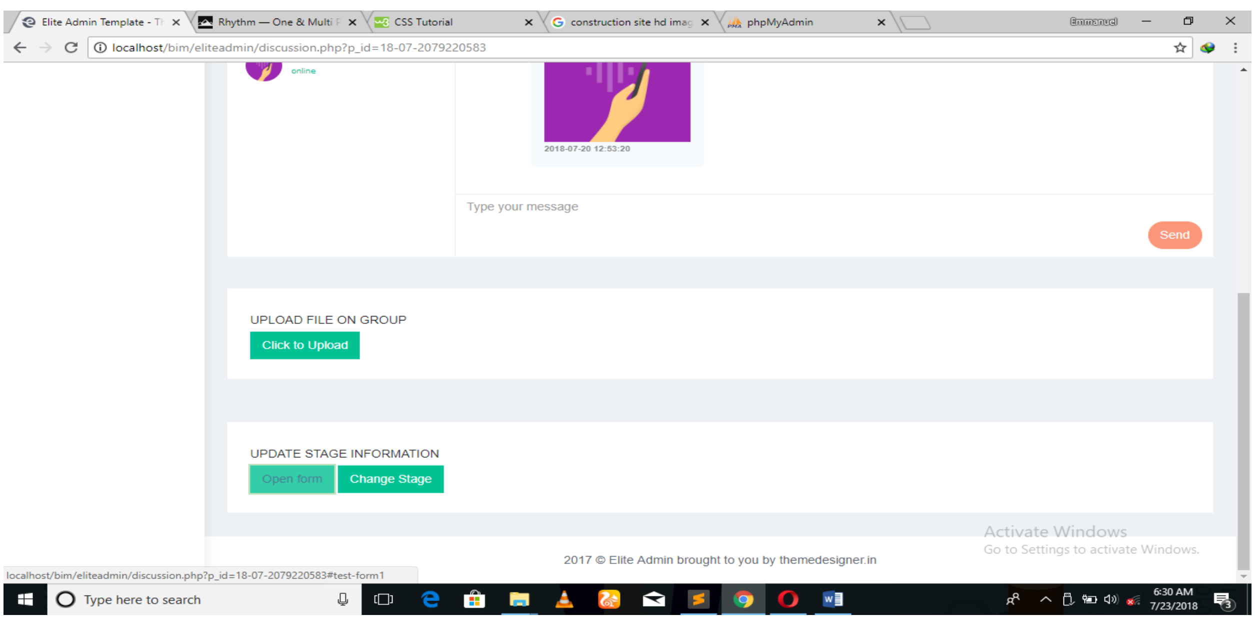


Fig 4.19: Project Update and Information Viewed only by the Administrator

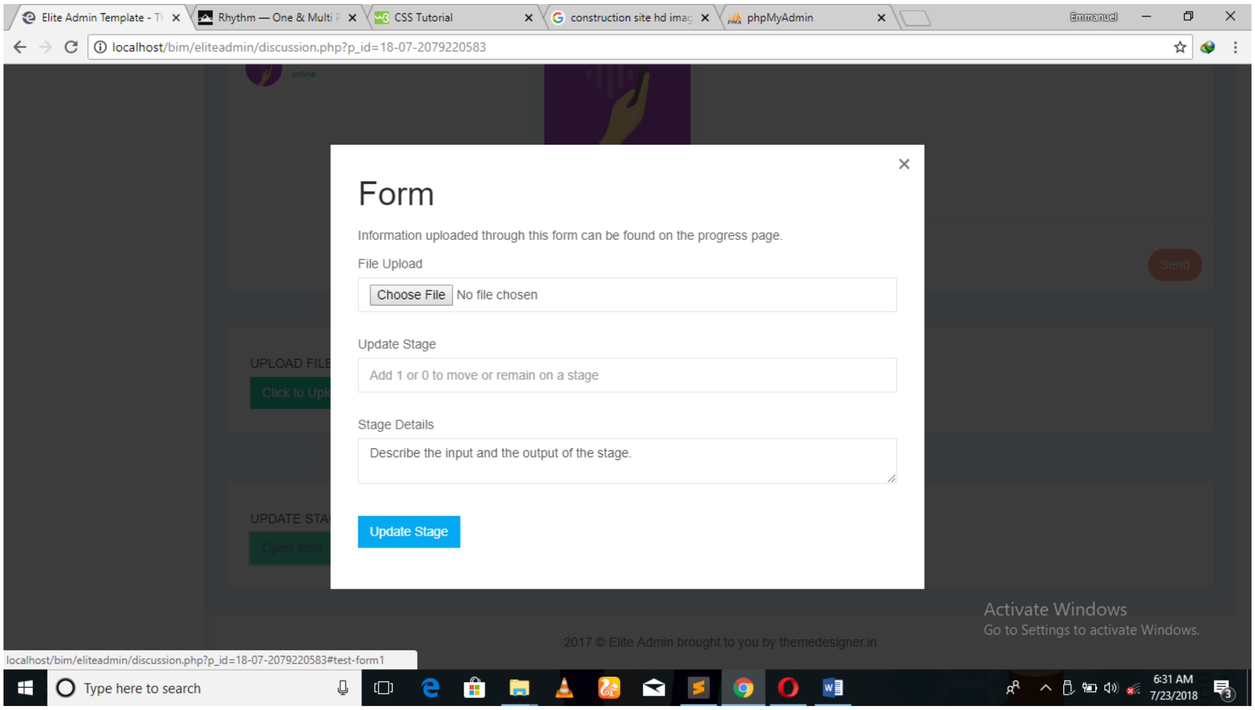


Fig 4.20: Project Uploaded / Stage Information

Project's progress page:

The final module of the software: This page includes the stacked outputs from the discussions on the group. The software stacks the different inputs of each stakeholder in a picture format so that every other involved parties on the project can contribute their views.

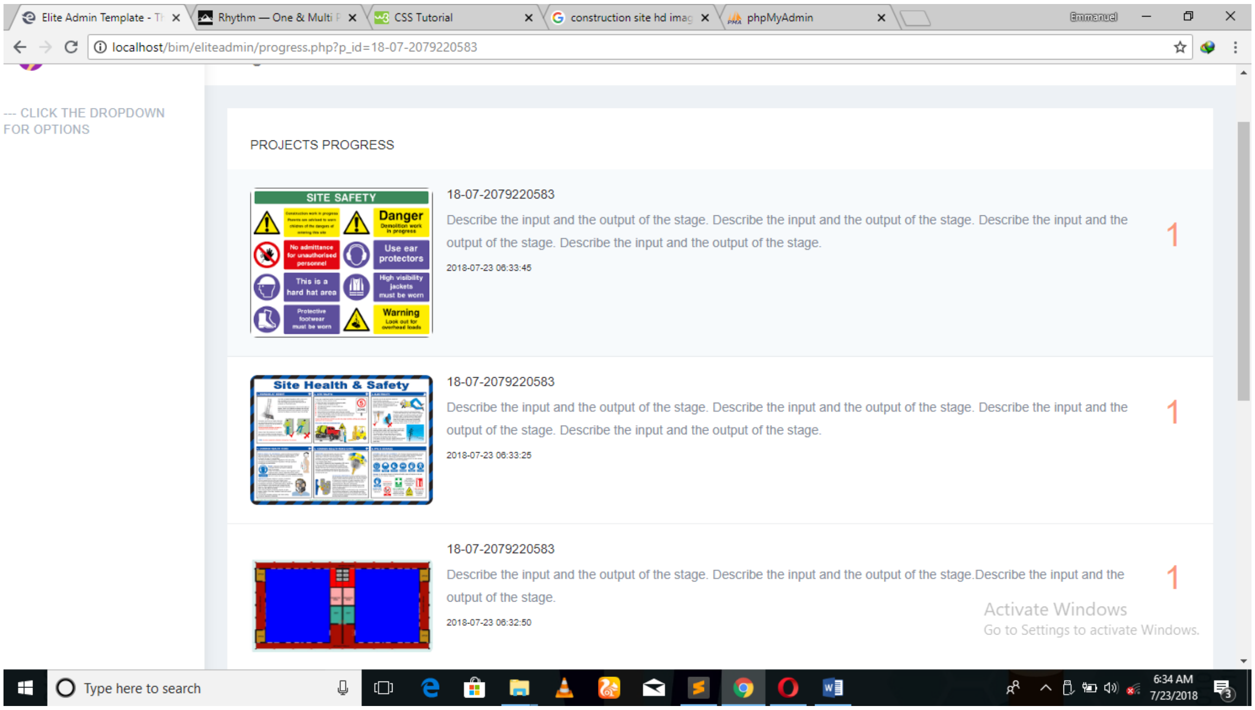


Fig 4.21: Projects Progress Page

4.2.10 Hypotheses Testing

Hypothesis 1

H_O: There is no significant relationship between effects of public building delivery and BIM management tools?

Table 4.22 shows the mean value of effect of public building as 24.90 and standard deviation of 6.83, while BIM management tools with mean value of 98.30 and standard deviation of 17.34, that *r* calculated (0.312) is greater than r tabulated (0.217) at 0.05 level of significant. Thus, the null hypothesis was rejected. This implies that there is significant relationship between effect of public building delivery and BIM management tools.

Table 4.23: Pearson Correlation of Effects of Public Building and BIM Management

Variable	N	Mean	SD	*R*cal	*R*tab
Effect of public building	82	24.900	6.83		
BIM management tools	82	98.300	17.34	0.312*	0.217

*significance $p<0.05$

Hypothesis 2

H_O: There is no significant relationship between traditional 2D (conventional method) and cost of implementation BIM

Table 4.23 shows the mean value of traditional 2D (Conventional method) as 13.81 ,with standard deviation of 15.61 while cost of implementation of BIM with mean value of 15.63 with standard deviation of 6.15, that *r* calculated (0.447) is greater than r tabulated (0.217) at 0.05 level of significant thus it reveals the level of significant. Thus, the null hypothesis was rejected. Therefore, there is significant relationship between traditional 2D conventional method and cost of implementation BIM.

Table 4.24: Pearson Correlation of Traditional 2D (Conventional Method) and Cost of Implementation BIM

Variable	N	Mean	SD	*R*cal	*R*tab
Traditional 2D conventional method	82	13.805	15.610	0.447*	0.217
Cost of implementation BIM	82	15.634	6.153		

*significant $p<0.05$

Table 4.25 shows that there is statistical reason to reject the null hypothesis since the significant probability 0.000 and Mann-Whitney U statistics of 0.000 less than the alpha level 0.05. We therefore conclude that there is significant difference between impact of BIM and Traditional method on construction operation to project delivery

Table 4.25: Mann-Whitney U Test on Relationship between Traditional Method and BIM

Method	**Mean Rank**	**Sum of Ranks**	**Mann-Whitney U Statistics**	**Z**	**Asymp. Sig. (2-tailed)**
BIM	59.50	3927.00	0.000	-7.444	0.000
Traditional	13.50	351.00			

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CHAPTER FIVE

5.0 SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 **Introduction**

Previous chapter had discussed the findings of analyzed data on the basis of each objectives stated for the study and related it to earlier studies that were germane to this study. This section therefore summarized the findings and drew out the conclusions and made recommendations based on the findings.

5.**2** **Summary of Findings**

(i) To appraise the awareness of building information and communication associated with construction project, seven BIM tools were considered.Design and engineering, Project planning, Construction project control, finance and Accounting with mean value of 3.651, 3.370, 3.272 and 3.025respectively as the major BIM softwares that werehighly frequently used for project delivery in the physical planning units of the Federal Universities. It was further revealed that Workforce management and project bidding tools with mean value of 2.532 and 2.342 were frequently used with their RII below 50% level of usage. This is in line with Tan (2007) that Design and engineering, and Project planning are the tools that are mostly used and it affects the performance of construction project delivery while workforce management, Project bidding and marketing are ranked as the least two factors and affects project cost, time and quality respectively. Also, it was observed that upward and downward channels with a mean value of 3.683 and 3.139 were highly frequently used, and horizontal and lateral channel with mean value of 2.299 and 2.234 are frequently used while others are were found to be seldomly used for project execution among team members in the physical planning units of the various institutions for executing projects.

(ii) Problems of adoption of ICT to effective delivery of building projects: The major problems that could emanate from the adoption of ICT to effective delivery of building projectsin physical planning units of tertiary institution shows that fear of virus attack, lack of professional on site, fear of mass job loss in the Industry and fear of personnel abuse with Relative Important Index of 59.8%, 57.5%, 55.8% and 55.6% respectively. Other problems includes fear of ICT making professional redundant lack of sufficient jobs,inability of quantify process improvements and uncertainty of benefits of ICT, inadequate power supply and inadequate ICT content of construction education having their RII above 50%.

(iii) The requirements for the implementation of BIM software/tools for projects delivery shows that BIM implementation checklist were highly effective in UI and OAU with a mean score of 3.395 and 3.151 closely followed by UNILAG with a mean score of 2.850 and effective in FUOYE, FUNNAB and FUTA with a mean score of 2.70, 2.694 and 2.247 on a 5 point likert scale of measurement. This will be of help in the proper monitoring of projects in the physical planning units.

(iv) Assessing BIM management tool for public building project delivery considered 34 BIM tools that were available for project delivery. Revit architecture, Revit MEP, AutoCAD Architecture, Revit Structure,AutoCAD MEP, AutoCAD Civil 3D, ArchiCAD,Bentley BIM Suite, Digital Project, Fabrication for AutoCAD MEP,AutoSPRINK VR, Navisworks Manager &Scheduling ,Project Wise andSynchro are the BIM tools that is mostly used in physical planning unit for project delivery with 50% and above usability rate. Similarly VicoOffice were not used by any building profession in the universities. Visual simulation, Power civil, Vectorworks Designer, CAD-Duct, Vectorworks designer, Digital project MEP, systems routing, HydraCAD, RISA, SDS/2, Fastrak, FireCAD, Cadpipe Commercial Pipe, DProfiler andCadpipe HVAC had less than 10% usability rate.

Furthermore, AutoCAD Architecture, Auto CAD Civil 3D, ArchiCAD and AutoCAD MEP with percentage of 78.80%, 72.44%, 69.63% and 68.64% ,were the prominent BIM tools that are mostly used in the physical planning units of the study area and are highly frequently used.

This implied that Architect usage of BIM software to design will fasten up the construction programme of work which will help in the effective delivery of project. Moreso Revit Architecture, Revit structure, Revit MEP, MEP System routing, Digital project designer, AutoCAD MEP with percentage score of 66.59%, 59.51%, 58.48, 55.58% and 52.41% were the BIM tools that were frequently used. This implied that the Engineers using these tools to design would affect the effective delivery of construction programme of work to time, cost and quality.

Summarily, the use of BIM tools in construction project will lead to effective project delivery to time, cost and quality which will lead to project success.

(v) Establishing the relationship between Traditional approach and BIM approach

Findings revealed that out of 11 itemized construction operation only safety management were the most preferred using traditional method by the building professionals in physical planning units of the various universities with Relative Important Index of 51.11% with mean value of 2.556 on a 5 point likert scale of measurements while BIM were very highly preferred in all the itemized construction operations with their mean values ranges from 3.817 to 4.281 and RII of above 75%. However, BIM were highly preferred to Traditional Method with Relative Important Index of 80.99% to 44.23% as indicated by the respondents.Conclusively, using BIM approach would improve the rate of delivery of projects to time, quality and cost.

(vi) The BIM software was developed for creation of project which involve different stages of operation with different stakeholders. And it was achieved with this process.

To navigate down to the project, ensure that the local server is up, then type local host/bim in the address box. Then the navigation ends on the landing page thereby from there you can access the rest of the project, to use the solution, all it users must be registered on the system. So the register page is used to create new staffs on the system. the staff creation ranges across all the possible hands that can be involved in a project including clients After the registration process is completed, each of the users of the system are required to login to use the system. On a successful login situation, the staff is taken to its general home. This page contains option to create new projects, or join in on an ongoing discussion. However, any of the users of the system can initiate a project. That immediately gives the initiator the admin rights on the project.

The project creation is completed in three stages, the first is to name the project and give it a general image for identification. The last step in this stage is that, BIM is very flexible and tailored towards the requirement of different project needs hence; the admin is allowed to state the number of stages the work will be broken into. This decision can be changed later. Once the project is created, the link to its discussion can be found on the admin page and every other worker selected (added) during its creation. So the link is followed to reach the discussion page. On this page information about the stage of the project, the discussion timeline and update progress pane (which can only be viewed by the administrator) is found. The final module of the software. This page includes the stacked outputs from the discussions on the group. The software stacks the different inputs of each stakeholder in a picture format so that every other involved parties on the project can contribute their views.

This software indicated that it will enhance quality of project delivery; increase client satisfaction of job and shortened time of project. This findings is in line with Khan *et al* (2014) submission that Building Information Modeling helps in project delivery to time , to cost and quality BIM .assist service would provider of organization to identify pertinent quality variables from the perspective of the professionals .

The P-value of the correlation coefficient at 95% confidence level indicates that there is significant relationship between BIM management tool and effective public building project delivery, therefore the null hypothesis is rejected.

6.3.Conclusion

This study had explored the strategic instinct that driven the professionals in the AEC industry to expand their horizon of professional practice and considered the requirements and implementation of Building Information Modeling on project delivery. This section presented the focus of the research by drawing out the conclusions and make appropriate recommendations to address some of the problems discovered in the study. This section also suggested areas of further research. The set objectives for this research have been achieved and the following conclusions were made on the basis of the findings.

Everyone manages information to some extent either personally or organizationally. However, when information is to be managed corporately, the perspective from which it was approached varies considerably according to the background of different participants or organization whose orientation may be behavioral, technological, managerial or educational. As the project unfolds and the design is conceptualized, information in the form of drawings, specifications and construction methods must be communicated. The analyzed data had shown that information management is concerned with communication and it covered acquisition, generation, preparation, processing, dissemination, evaluation and management of information resources. It could be concluded that different BIM tools/softwares were used for the delivery of public buildings and the level of usage of communication Channels in the physical planning units of the institutions with were upward and Downward channel with mean value of 3.683 and 3.139 while the benefits of ICT to effective project delivery with respect to time, cost and quality were enormous.

Furthermore, BIM implementation checklists required proper planning, patience and full commitment at all levels. It was however found that different sets of BIM softwares/tools impacted differently on construction project. Findings showed that all the BIM checklists were prominently used and highly effective for project delivery in the physical planning units of institutions. However, individual Institutions analysis showed that technology, cost and personnel analysis, process identification analysis, personnel changes and integration development requirements had a high level of usage in the execution of building projects. University of Lagos (UNILAG) physical planning unit as 50% and above affirmed to the usability rate.

However construction projects required good collaboration and information exchange between all involved actors due to the collaborative nature of the industry. Traditionally this exchange were made in the form of drawings and documents while the adoption of BIM ensured interface and effective information exchange between different actors and phases in the project. The use of

BIM tools in construction project would lead to effective project delivery to time, cost and quality which would lead to project success and reliable assessment to be developed

Finally, BIM were highly preferred with high relative important index to Traditional method. Conclusively, using BIM approachwould improved the rate of delivery of projects to time, quality and cost.

5.4 Recommendations

Based on the findings and conclusion drawn from the study, the following recommendations are suggested

(i) BIM tools/softwares should be used for the delivery of public building project from time to time and the communication channels should be used among project participants for project execution.

(ii) BIM implementation checklists and plan should be adopted for construction project among project participants/operators/stakeholders

(iii) BIM tools that are available should be used for construction projects among the professionals so as to lead to effective project delivery to time, cost and quality

(iv) BIM approach should be used for project execution so as to lead to project success and reliable assessment could be developed.

(v) BIM software developed would enhance good collaboration and communication among the project participants at the universities levels and construction operation industry which enhance effective delivery to quality, time and cost.

5.5 Contribution to Knowledge

Various researchers have worked on how to effectively utilize construction resources; most especially needed for BIM within the construction industry. Also,earlier studies have not identified the benefits of BIM then the industry remains fragmented and highly inefficient.

WhileBIM is perceived by some as the catalyst to eradicate these inefficiencies.

Therefore, this research work has contributed the following to the body of knowledge:

a. BIM framework Developed would enhance effective professional synergy /integration of professionals in the physical planning units of the Federal Universities. It will also promote good services in the construction sectors.

b. The BIM software developed would bring effective Communication / Collaboration/Synergy among the professionals in the Architecture, Engineering and Construction industry. These will fasten/ ease construction work to time, quality and cost. The software would enhance the project participants in the Federal Universities and AEC industry to disseminate information properly to one another and enhance good team work as a result of communication and collaboration among. Hence, it will enhance effective delivery of project to time, quality and cost.

5.6 Areas of FurtherStudies

(a) Practical Demonstration of Building Information Modeling to the Public

(b) Appraisal of BIM on AEC project in Nigeria.

(c) Assessment of BIM Knowledge management capabilities of AEC firms in Nigeria.

(d) Appraisal of BIM tools for stakeholders in the Built Environment in Nigeria.

(e) BIM approach a catalyst for effective delivery of project.

(f) Effective adoption of BIM Tertiary Education Curriculum in Nigeria.

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APPENDIX 1

QUESTIONNAIRE

Department of Building,

Faculty of Environmental Sciences,

Nnamdi Azikiwe University,

P.M.B. 2025, Awka,

Anambra State, Nigeria.

Dear Sir/Ma,

QUESTIONNAIRE IN AID OF Ph.D RESEARCH

The undersigned is conducting a Ph.D research on ‘’**DEVELOPMENT OF BUILDING INFORMATION MODELLING AS A MANAGEMENT TOOL FOR EFFECTIVE PUBLIC BUILDING PROJECT DELIVERY IN SELECTED FEDERAL UNIVERSITIES IN SOUTH WEST NIGERIA’’.** The questionnaire is structured to obtain information on requirements for the implementation of BIM Software and BIM management tools for public building project delivery in Nigeria.

Your kind assistance is required in filling the questionnaire and making relevant information available. Your feedback will provide insight and necessary modification to the framework to be developed in the course of this research.

I wish to assure you that the information so provided will be treated with strict confidence and strictly use for academic purpose only.

Thank you for sparing me your valuable time.

Yours faithfully,

AKINOLA, V. O. (MRS)

Research Student

(08065701490)

Kindly tick where appropriate and make comments where necessary.

SECTION A (DEMOGRAPHIC INFORMATION)

Q1. What is the name of your institution…………………………………………………

Q2 Is their Physical Planning Unit in your institution? Yes No

Q3. What are the various sections/units available in the physical planning unit of your institution?

Sections/units	Available	Not Available
Architecture		
Building		
Engineering		
Estate management		
Geo-informatics (Land Surveying)		
Quantity Surveying		
Urban & Regional Planning / Town Planning		

Others (specify) ……………………………………………………………………………..

Q4. What is your area or field of specialization?

Architecture ☐

Building ☐

Engineering ☐

Estate Management ☐

Geo-informatics / Land Surveying ☐

Quantity Surveying ☐

Urban & Regional Planning / Town Planning ☐

Others (specify) ……………………………………………………………………………………

Q5. What is your academic qualification?

HND

PGD

B.Sc

M. Sc

Ph.D

Others (kindly specify)………………………………………………………………………

Q6. What is your professional affiliation?

Grade of members	NIA	NIOB	NSE	NIEVS	NIS	NIQS	NITP
Member							
Fellow							

Others (kindly specify)………………………………………………………………………

Q7. What is your year of experience on the job?

1 – 5 years

6 – 10 years

11 – 15 years

16 – 20 years

Above 20 years

Q8. How could you rate based on a scale of 5, the use of BIM softwares/tools in the physical planning unit of your institution?

Very highly use (5)

Highly use (4)

Moderately use (3)

Seldomly/Rarely use (2)

Not use (1)

Q9. How could you rate based on a scale of 5, your knowledge or proficiency of the staff on BIMsoftwares/tools in the physical planning unit of your institution?

Very highly knowledgeable/proficient

Highly knowledgeable/proficient

Moderately knowledgeable/proficient

Rarely / Seldomly knowledgeable/proficient

Not knowledgeable/proficient

SECTION B **(CONCEPT OF ICT)**

Q10 what are the information management tools/softwares that are available for construction project?

(i) Project Bidding and marketing
(ii) Project Planning
(iii) Procurement
(iv) Design and engineering
(v) Construction project control
(vi) Workforce management
(vii) Finance and accounting

Others (Specify) ……………………………………………………………….

Q11 Which of this information management tools/softwares do you normally use to execute your project?

(i) Project Bidding and marketing
(ii) Project Planning
(iii) Procurement
(iv) Design and engineering
(v) Construction project control
(vi) Workforce management

(vii) Finance and accounting

Others (specify) ……………………………………………………………………….

Q12. How would you rate based on a scale of 5 the frequency of usage of these information management tools/softwares on your project?

	Source of Information Management	5	4	3	2	1
I	Project bidding and marketing					
Ii	Project Planning					
Iii	ProcurementDesign and engineering					
Iv	Construction project control					
V	Workforce management					
Vi	Finance and accounting					

Others (specify) …………………………………………………………………………

Q13 What are the communication channels among team members in construction firm.

(i) Upward Channel ☐
(ii) Downward Channel ☐
(iii) Horizontal Channel ☐
(iv) Lateral Channel ☐

Q14 Which of this communication channels do you normally use on your project?

(i) Upward Channel ☐
(ii) Downward Channel ☐
(iii) Horizontal Channel ☐
(iv) Lateral Channel ☐

Others (specify) ………………………………………………………………..

15 How could you rate based on a scale of 5 the frequency of usage of communication channels in your construction firm?

S/N	Communication Channels	5	4	3	2	1
I	Upward Channel					
Ii	Downward Channel					
Iii	Horizontal Channel					
Iv	Lateral Channel					

Others (specify) ……………………………………………………………………….

Q16. How can the benefits of ICT could lead to the effective delivery of building project with respect to time, cost and quality?

S/N	Benefits	**TIME**					**COST**					**QUALITY**				
		5	4	3	2	1	5	4	3	2	1	5	4	3	2	1
I	Improve communication for decision making															
Ii	Reduce time of data processing															
Iii	Saves employee time															
Iv	Avoid circuitous means															
V	Efficient distribution of work															
Vi	Access to information and communication															
Vii	Coordination among construction participants															
Viii	Enhance construction productivity															

Others specify (if any)…………………………………………………………………………

Q17 Indicate in your opinion the problems that could emanate in the adoption of ICT and the impacts to the effective delivery of building projects

S/N	Adoption of ICT	Level of Significance					Level of Impacts				
		5	4	3	2	1	5	4	3	2	1
I	lack of professional onsite										
Ii	Inability of quantify process improvements and uncertainty of benefits of ICT										
Iii	Inadequate power supply										
Iv	High cost of software and hardware										
V	High cost of employing computer professional										
Vi	Lack of appreciation of ICT firm's management										
Vii	Inadequate ICT content of construction education										
Viii	Fear of virus attack										
Ix	Fear of ICT making professional redundant										
X	Fear of personnel abuse										
Xi	Lack of sufficient jobs										
Xii	Fear of mass job losses in the industry										

SECTION C BIM SOFTWARE IMPLEMENTATION

Q18 what are the BIM software implementation that are available for use in your office?

(i) Type of models to be created ☐
(ii) Required card of detail ☐
(iii) Responsible party for creation of each model ☐
(iv) Schedule for delivery model ☐
(v) File formatting ☐
(vi) File naming ☐
(vii) Object naming ☐
(viii) Interoperability of BIM tools ☐
(ix) Coordination and clash detection ☐
(x) BIM website utilization ☐

Q19 which of this BIM tools implementation you carry out for project execution in your office/unit?

(i) Type of models to be created ☐
(ii) Required card of detail ☐
(iii) Responsible party for creation of each model ☐
(iv) Schedule for delivery model ☐
(v) File formatting ☐
(vi) File naming ☐
(vii) Object naming ☐
(viii) Interoperability of BIM tools ☐
(ix) Coordination and clash detection ☐
(x) BIM website utilization ☐

Q20. How can implementation of BIM software be effective for project delivery in your PPU office?

s/n	BIM software	5	4	3	2	1
I	Type of models to be created					
Ii	Required card of detail					
Iii	Responsible party for creation of each model					
Iv	Schedule for delivery model					
V	File formatting					
Vi	File naming					
Vii	Object naming					
Viii	Interoperability of BIM tools					
Ix	Coordination and clash detection					
X	BIM website utilization					

Q21 what is your level of agreement to the benefits you derive from using BIM software

s/n	Benefits of using BIM Software	5	4	3	2	1
I	Acceleration					
Ii	Collaboration with the fragmented AEC industry					
Iii	Improved profitability					
Iv	Better time management					
V	Reduce cost					
Vi	Improved customers client relationship					
Vii	Speed up analysis cycle times					
Viii	Increased performance after the project (facility management) phase					

ix Increases return on investment for the owner

X Reduces drawing coordination issues and variations

Xi Improved project planning

Xii Early clash detection between design team drawings

Xiii Less waste

Xiv Greater understanding of construction processes

Xv Less administration, reduced cost, travel, printing

SECTION D BIM AS A MANAGEMENT TOOL

Q22. What are the BIM tools or software that is available for practice in your firm?

i. Cadpipe HVAC ☐
ii. Revit Architecture ☐
iii. AutoAD Architecture ☐
iv. Revit Structure ☐
v. Revit MEP ☐
vi. AutoCAD MEP ☐
vii. AutoCAD Civil 3D ☐
viii. Cadpipe Commercial Pipe ☐
ix. DProfiler ☐
x. Bentley BIM Suite (MicroStation, Bentley Architecture, Structural, Mechanical, Electrical, Generative Design) ☐
xi. Fastrak ☐
xii. SDS/2 ☐
xiii. Fabrication for AutoCAD MEP ☐
xiv. Digital Project ☐
xv. Digital Project MEP, Systems Routing ☐
xvi. ArchiCAD ☐
xvii. HydraCAD ☐
xviii. AutoSPRINK VR ☐
xix. FireCAD ☐
xx. CAD-Duct ☐
xxi. Vectorworks Designer ☐
xxii. Duct Designer 3D, Pipe Designer 3D ☐
xxiii. RISA ☐

xxiv. Tekla Structures ☐
xxv. Affinity ☐
xxvi. VicoOfice ☐
xxvii. PowerCivil ☐
xxviii. Site Design, Site Planning ☐
xxix. Navisworks Manage, Navisworks Scheduling ☐
xxx. ProjectWise ☐
xxxi. Digital Project Designer ☐
xxxii. Visual Simulation ☐
xxxiii. Solibri Model Checker ☐
xxxiv. Synchro ☐

Q23. What are the BIM tools in use in your physical planning units / office?

i. Cadpipe HVAC ☐
ii. Revit Architecture ☐
iii. AutoAD Architecture ☐
iv. Revit Structure ☐
v. Revit MEP ☐
vi. AutoCAD MEP ☐
vii. AutoCAD Civil 3D ☐
viii. Cadpipe Commercial Pipe ☐
ix. DProfiler ☐
x. Bentley BIM Suite (MicroStation, Bentley Architecture, Structural, Mechanical, Electrical, Generative Design) ☐
xi. Fastrak ☐
xii. SDS/2 ☐
xiii. Fabrication for AutoCAD MEP ☐
xiv. Digital Project ☐
xv. Digital Project MEP, Systems Routing ☐
xvi. ArchiCAD ☐
xvii. HydraCAD ☐
xviii. AutoSPRINK VR ☐
xix. FireCAD ☐
xx. CAD-Duct ☐
xxi. Vectorworks Designer ☐
xxii. Duct Designer 3D, Pipe Designer 3D ☐
xxiii. RISA ☐
xxiv. Tekla Structures ☐
xxv. Affinity ☐

xxvi. VicoOffice
xxvii. PowerCivil
xxviii. Site Design, Site Planning
xxix. Navisworks Manage, Navisworks Scheduling
xxx. ProjectWise
xxxi. Digital Project Designer
xxxii. Visual Simulation
xxxiii. Solibri Model Checker
xxxiv. Synchro

Others (specify) ……………………………………………………………………….

Q24 What is the rate of usage of the BIM tools in your physical planning units?

S/N		5	4	3	2	1
i.	Cadpipe HVAC					
ii.	Revit Architecture					
iii.	AutoAD Architecture					
iv.	Revit Structure					
v.	Revit MEP					
vi.	AutoCAD MEP					
vii.	AutoCAD Civil 3D					
viii.	Cadpipe Commercial Pipe					
ix.	DProfiler					
x.	Bentley BIM Suite (MicroStation, Bentley Architecture, Structural, Mechanical, Electrical, Generative Design)					
xi.	Fastrak					
xii.	SDS/2					
xiii.	Fabrication for AutoCAD MEP					
xiv.	Digital Project					

xv. Digital Project MEP, Systems Routing

xvi. ArchiCAD

xvii. HydraCAD

xviii. AutoSPRINK VR

xix. FireCAD

xx. CAD-Duct

xxi. Vectorworks Designer

xxii. Duct Designer 3D, Pipe Designer 3D

RISA

xxiii. Tekla Structures

xxiv. Affinity

xxv. VicoOfice

xxvi. PowerCivil

xxvii. Site Design, Site Planning

xxviii. Navisworks Manage, Navisworks Scheduling

xxix. ProjectWise

xxx. Digital Project Designer

xxxi. Visual Simulation

xxxii. Solibri Model Checker

xxxiii. Synchro

Kindly state other BIM tools or software that you use in your physical planning unit office ………

SECTION E

TO ESTABLISH THE RELATIONSHIP BETWEEN TRADITONAL METHOD (CONVENTIONAL) AND BIM

Q25. Kindly show how the relatives of Traditional method and BIM

	Benefits	Traditional					BIM				
S/N		5	4	3	2	1	5	4	3	2	1
I	Better design										
Ii	Faster and effective processes										
Iii	Control life costs										
Iv	Control environmental data										
V	Better production quality										
Vi	Automated assembly										
Vii	Life cycle plan										
Viii	Integration of planning										
Ix	Implementation processes										
X	Effective and competitive industry										
Xi	Long term sustainable regeneration projects										

Q26 How could you rate based on a scale of 5 the frequency of usage of construction operation (Traditional approach) method in your firm?

S/N	CONSTRUCTION OPERATION	5	4	3	2	1
1.	Planning and Scheduling					
2.	Baseline vs. Actual Analysis					
3.	Construction progress tracking and control					
4.	Look ahead plan					
5.	Progress meeting					
6.	Claim analysis and dispute resolutions					
7.	Construction Methodology					
9.	Crane Safety and location studies					
10.	Layout Planning and Management					
11.	Construction Project Documentation					
12.	Project Management					

Q27 How could you rate based on a scale of 5 the frequency of usage of construction operation (BIM approach) method in your firm?

S/N	CONSTRUCTION APPROACH	5	4	3	2	1
1.	Planning and Scheduling					
2.	Baseline vs. Actual Analysis					
3.	Construction progress tracking and control					
4.	Look ahead plan					
5.	Progress meeting					
6.	Claim analysis and dispute resolutions					
7.	Construction Methodology					
9.	Crane Safety and location studies					
10.	Layout Planning and Management					
11.	Construction Project Documentation					
12.	Project Management					

Q28 Which option of approach (between **traditional** approach and **BIM** approach) would you prefer if you are to apply/adopt only one of the two approaches on on-site construction operation? (Hint: Distribute a mark of 100% between the **preferred**approach relative to **not preferred** approach).

S/N	Construction Operation	Operation Approach	Mark Distribution of 100%	Total % distribution
1.	Planning and Scheduling	Traditional approach : using schedule and bar chart		
		BIM approach: link your schedule to 3D model for better understanding of the project		
2.	Baseline vs. Actual Analysis	Traditional approach: using bar chart comparison in minutes in 25 A3 page paper		
		BIM approach: using visual comparison in 2 minutes video		
3.	Construction progress tracking and control	Traditional approach: Inaccurate layout coloring and progressive representation		
		BIM approach: Export the 4D model to your iPad(go to the site, update it, go back to office, link it to the pc) and automatically update your progress		
4.	Look ahead plan	Traditional approach: Inaccurate and dummy look ahead		
		BIM approach: Very clear look ahead presentation		
5.	Progress meeting discussions	Traditional approach: wasting time to explain problems and make decisions		
		BIM approach: very easy to solve any problems and make decisions		
6.	Claim analysis and dispute resolutions	Traditional approach: Very hard to prove who is responsible for the delay and acquired to so much time and money		
		BIM approach: very easy to prove who is responsible for the delay and what is the expected outcomes in the future using simply one video		
7.	Construction Methodology	Traditional approach: Representing the construction methodology in 300 pages paper		
		BIM approach: Representing the construction methodology in 2 minutes video		
8.	Safety Management	Traditional approach: Has so many documents and complicated plans		
		BIM approach: 2 minutes video representing the hazards and the safety plan visually		
9.	Crane Safety and	Traditional approach: Dummy layout		

	location studies	BIM approach: 2 minutes video representing all you need about the crane safety		
10.	Layout Planning and Management	Traditional approach: so many layouts		
		BIM approach: 2 minutes video representing the dynamic layout and access roads		
11.	Construction Project Documentation	Traditional approach: so many documents and data storage		
		BIM approach: 1 4D model file could save schedule +3D model+ Notes + Pictures		
12.	Project Management	Traditional approach: Can you imagine the amount of mistakes, duplication, loosing data and wasting time		
		BIM approach: 1 integrated shared model		