KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY,

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Building Information Modeling (BIM) Adoption and Implementation in Ghana

by

Emmanuel Osei Bonsu

BSc. (Hons.) Civil Engineering

(PG9188217)

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DECLARATION

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which to a substantial extent has been accepted for the award of any other degree or diploma at Kwame Nkrumah University of Science and Technology, Kumasi or any other educational institution, except where due acknowledgment is made in the thesis.

Emmanuel Osei Bonsu …… … ……..……
(PG 9188217) Signature Date
(Name and PG)

Certified by:
Dr. Alex Acheampong …… … ……..……
(Supervisor) Signature Date

Certified by:
Prof. Bernard K. Baiden …… … ……..……
(Head of Department) Signature Date

ABSTRACT

Building Information Modeling (BIM) has been in the Architectural Engineering and Construction (AEC) industry over the world for the past decade and has gain roots in the developed countries. Countries who have advanced in the use of BIM have already benefited from its advantages which include productivity, reduction of errors and value for money. In developing countries and for that matter Ghana, the awareness and use of BIM is very low, therefore having a negative effect on the AEC industry. There is therefore the need to promote BIM awareness in the country. This thesis looks at the advantages of BIM, BIM patronization among AEC professionals and how to help increase BIM adoption and implementation among professionals. Professionals within the AEC industry of Ghana were identified. These professionals included Civil Engineers, Architects, Quantity Surveyors, and Mechanical / Electrical / Plumbing Engineers; who are members of their respective professional bodies such as Ghana Institute of Engineers, Ghana Institute of Architects, Ghana Institution of Surveyors and others. Snowball sampling was used in identify these professionals. A sample of 30 professionals was obtained from Kumasi including those in the private and public sectors. These professionals were selected on the bases of their experience and the complexity of the projects they are handling or have handled. Survey questionnaires were distributed among these professionals where they provided answers to the questionnaires which served as the source of data. Snowball sampling method was used in collecting data from these professionals. The data collected was analyzed using descriptive statistics and Relative Importance Index method. From the analysis it was established that the usage of BIM among the AEC professionals is low. The challenges to the low patronization of BIM in Ghana was looked and the challenges included lack of BIM experts within the industry, poor technological edge, resistance at the operational level, cultural resistance, limited BIM knowledge, lack of financial resources,

lack of demand from clients, management perceiving no need for BIM, no collaboration with other professionals and the procurement system. Measures to overcome these challenges were also discussed in this thesis and the following recommendations were made; participation of relevant professional bodies, government support through legislation, integration of BIM into the academic curricular and making BIM softwares / tools available.

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LIST OF ABBREVIATION

2D	Two Dimensional – X, Y
3D	Three Dimensional – X, Y, Z
AEC	Architectural, Engineering and Construction
BIM	Building Information Modeling
BEP	BIM Execution Plan
CAD	Computer-Aided Design
CDE	Common Data Environment
CII	Confederation of Indian Industry
COBie	Construction Operations Building Information Exchange
EDMS	Electronic Document Management System
EIR	Employers Information Requirement
IFC	Industry Foundation Class
MEP	Mechanical, Electrical and Plumbing
UK	United Kingdom
USA	United States of America
RII	Relative Importance Index

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CHAPTER 1

1.1.INTRODUCTION

Building Information Modeling (BIM) is an intelligent 3D model-based process that gives architecture, engineering and construction (AEC) professionals the insight, information and tools to more efficiently plan, design, construct, and manage buildings and infrastructure. (Autodesk, 2018)

There is a common misconception that BIM is the same as 3D design. BIM goes beyond ta 3D design. BIM uses 3D models to achieve its objectives. BIM is a process where by all the information on a project are managed; before construction, during construction and after construction. The output of this process is the Building Information Model (3D models) which is the digital description of every aspect of the built asset. (Oracle, 2018).

Table I below shows the advantages of BIM throughout the building lifecycle; design, construction, operations and maintenance

BENEFITS OF BUILDING INFORMATION MODELING (BIM)
PRE-CONSTRUCTION STAGE
• Conceptual design, feasibility studies and actual design. • Increased building performance and quality. • Creating time-based simulation of construction activities.
DESIGN STAGE
• Earlier collaboration of multiple design disciplines. • More accurate visualization of design changes.

- Reduction in errors in generating construction drawing.
- Early insight to design errors & omissions.
- Early extraction of more accurate cost estimation & bill of quantities
- Improved energy efficiency & sustainability.
- Blending geospatial and building information for planning.
- Information available earlier within the project.
- Improved information delivery; can be reused, repurposed, reviewed, revised, corrected, controlled, checked and validated

CONSTUCTION STAGE

- Synchronization of design & construction revealing potential problems & possible improvements.
- Clash detection.
- Reduction in errors in generating construction drawing.
- Improved coordinated approach between participating designers and contractors.
- Using design model as basis for fabricated components.
- Better implementation and lean construction techniques.
- Substantial cost savings, time saving and waste on site.
- Enhanced coordination.
- Enhanced productivity.
- Enhanced business operations.
- Flexibility of output documentation.
- Quick simulations.

• Use of digital product data in manufacturing and assembly of structural systems
POST-CONSTRUCTION STAGE
• Better managed and operated facilities after completion. • Streamlined approach where data is shared in a collaborative approach. • Savings in design coordination, drawing production, information management & exchange. • Improved design quality, sustainability and client communication. • Reduces information loss when handing over project from design team to construction team to owner. • Controlled whole-life cost and environmental data.

[Source: Mandhar, & Mandhar, (2013)]

The use of BIM has been adopted in some countries and has been made compulsory for public projects because of its advantages. These countries include USA, UK, Norway, Denmark, South Korea, China, Finland, Singapore, Germany, Sweden and France. (Singh, 2017).

The use of BIM in the developed countries has helped improve communication in collaborative works. Sharing of information and collaborations are very essential throughout the AEC industry. However, collaborative working has led to a number of problems in the past because of the different aspects of design project. With the help of BIM, professionals have access to every relevant information whenever necessary. Essentially, BIM has helped to streamline and coordinated communication and collaboration between teams. (Bethany, 2017).

The knowledge of BIM in Ghana is very low and therefore many professionals of the AEC industry in the country do not use BIM in their works. Few architects have adopted the use of BIM and they normally use it at the initial stage for design concepts and presentation purposes only.

1.2. **Problem Statement**

Comparing the AEC-industry to the other industries in terms of productivity, it can be concluded that the AEC-industry has a low rate of productivity. One vital remedy to attend to this issue is the BIM which has been already introduced, but still the adoption rate of BIM has not been encouraging. (Lindblad, 2013). The move to adopt Building Information Modeling in Ghana's AEC-industry has been very slow. Only few professionals have been using it but purposely for only 3D modelling and presentations. This is unfortunate because it is being underutilized. (Alufohai, 2013).

According to the Economist, 2000, there is up to 30% construction waste due to inefficiencies, mistakes, delays, and poor communication. These wastes have created a cost increment in the construction industry as a whole. Almost all the budget for a construction projects in Ghana is been exceeded. According to CII USA, 10% project cost is spent on reworks. There is therefore the need to reduce the waste and inefficiencies in the construction industry of Ghana. Introducing BIM to the AEC – industry of Ghana will help reduce these wastes and thereby reducing the overall cost of construction projects in Ghana to enhance productivity.

1.3. Research Questions

- What are the requirements in the adoption and implementation of BIM in the AEC industry of Ghana?

- What is the level of application of BIM in Ghana?
- What are the challenges of implementing BIM in Ghana?
- What are the benefits of BIM to the AEC industry in Ghana?

1.4. Aim and Objectives

1.4.1. Aim

The aim of this research is to examine BIM as a concept for enhancing productivity in the Ghanaian Construction Industry.

1.4.2. Objectives

The following objectives were identified to be of paramount importance in achieving aforementioned aim:

- Identify the current state of the use of BIM in the Ghanaian AEC industry
- Identify the challenges of BIM implementation in the Ghanaian AEC industry
- Identify measures to overcome the challenges of BIM implementation in Ghana

1.5. Significance of Study

The study is intended to identify the maturity level of BIM adoption and implementation by Ghanaian professionals in the AEC industry and to establish the challenges and hindrances associated with BIM. Furthermore, to discover the benefits Ghana as a country and its construction professionals stands to achieve from it. And also to recommend measures that can help promote BIM adoption and

implementation in the AEC industry of Ghana. The research will also help in contributing to the knowledge of BIM to the educators in the building industry which will help in improving the industry.

1.6. Scope of Study

This research focuses on Building Professionals in the Architectural Engineering and Construction industry of Ghana, to know their level of knowledge in BIM and also their level of BIM usage. This include professionals in both the private and government sector.

CHAPTER 2

2.0. LITERATURE REVIEW

2.1. The stages of BIM

BIM is classified into stages or levels. These levels describe the extent of maturity in BIM. The levels are also known as maturity levels. The levels have been categorized within a range from 0 to 3, with 0 being the lowest use of BIM and 3 being the highest use of BIM.

2.1.1. Level 0

With this level of BIM usage, only 2D CAD drafting is utilized and does not involve much collaborative work. Information output and distribution is basically through paper and electronic prints. Majority of the AEC industry in Ghana use this BIM level.

2.1.2. Level 1

This comprises of using both 3D and 2D CAD. Normally the 3D CAD is used for conceptual works whiles the 2D is for drafting and documentation purposes. CAD standards are managed to BS 1192:2007, and electronic sharing of data is carried out from a common data environment (CDE), which has its own manager. (McPartland, BIM Levels Explained, 2018).

To achieve Level 1 BIM, the Scottish Futures Trust states you should achieve the following:

- Agreement should be made on all roles and responsibilities.
- Adoption of name conventions.
- Proper planning must be done to create and maintain the project specific codes and project spatial co-ordination.

- A "Common Data Environment" (CDE) for example a project extranet or electronic document management system (EDMS) should be created. This will help the flow of information among all members in the project team.
- An information sharing ranking order should be put in placed which goes in line with the concepts of the Common Data Environment and the document repository

2.1.3. Level 2

Collaborative working is what make BIM Level 2 unique. BIM level 2 requires "an information exchange process which is specific to that project and coordinated between various systems and project participants" (Scottish Futures Trust). BIM level 2 describes when information should be made, when that information should be shared. It describes what information should be made available and how the information should be shared and managed.

All softwares been used by the project team parties must be capable of exporting to one of the common file formats such as IFC (Industry Foundation Class) or COBie (Construction Operations Building Information Exchange). This is the method of working that has been set as a minimum target by the UK government for all work on public-sector work. (McPartland, BIM Levels Explained, 2018).

2.1.4. Level 3

Level 3 has not yet been fully defined, however the vision for this is outlined in the UK Government's Level 3 Strategic Plan. Within this plan, they set out the following 'key measures' to be secured with further funding:

- The creation of a set of new, international ‘Open Data’ standards which would pave the way for easy sharing of data across the entire market.

- The establishment of a new contractual framework for projects which have been procured with BIM to ensure consistency, avoid confusion and encourage, open, collaborative working.
- The creation of a cultural environment which is co-operative, seeks to learn and share.
- Client in the public sector must be trained in the use of BIM concerning data requirements, contractual operations.
- Driving domestic and international growth and jobs in technology and construction.

2.2. The impact of BIM and outcomes

Construction activities have been experiencing low productivity compared to other industries. This problem is basically caused by poor planning and communication. Building Information Modeling (BIM) is a process use to resolve these problems by simulating physical space and graphically depicting design, giving a clearer picture of design conflicts or constructability issues so that they are resolved before commencement of the construction. BIM practices are implemented to reduce rework and idle time and hence increasing productivity rate. (Chelson, 2010).

Various case studies of projects where BIM is being practice show increase in productivity from about 5% to 40%. And this is dependent on how the whole process is being handled. There are some indicators which shows increased productivity when monitoring and measuring the productivity rates in BIM projects. Among these indicators of increased productivity include the amount of rework, reduction in Request for Information, compliance with schedule and change orders due to plan conflicts. Each of these indicators has its own influences on the various members of the project team, but in all affects the total project cost which can more than 10% savings. BIM projects can cause about 10% reduction in RFI which in turn increases productivity. The prefabrication and automation capabilities of site processes are also significant advantages of using BIM by specialized contractors. The most important savings are attributed

to the clash detection process that eliminates conflict in the field. (Chelson, 2010). These findings prove that BIM contributes to the success of projects and also helps increase productivity.

2.3. The challenges of BIM

Regardless of the various advantages obtained from BIM, there are still some challenges that makes it difficult for its full adoption and implementation. Most smaller firms are finding it difficult switching to the whole BIM process because of these challenges. The National Building Specification listed the top five reasons why organizations haven't adopted BIM fully in 2004, and the reasons included the following (Lymath, 2014):

1. **Client demand.** Most of the smaller companies with very small number of staff ranging from 1 t0 10 staff members cited that there is on demand of BIM from the client side. And because of this reason they see no need in investing in BIM.
2. **Relevancy.** Most smaller firms feel their type of project or work they are involved in does not demand the involvement of BIM. They feel the workload is not so much to warranty the use of BIM. However, some small projects can be very complex.
3. **Cost.** Although shifting to BIM brings a lot of benefit which included an overall reduction in cost. However, adopting BIM also brings some additional cost which include cost on softwares, computer hardwares, training and seminars, and cost on human resources.
4. **Project size.** It is falsely believed that BIM is only effective for big projects. BIM can actually work on any size from a domestic project upwards. Benefits can still be realized even in smaller projects.

5. **In-house skills.** Some contractors and firms expressed the concerning of not having the staff with current BIM knowledge or skills to fully be involved in BIM.

2.4. Reasons for not using BIM on projects

Investigations were made into some of the reasons why BIM were into used on projects around the world and the following reasons were identified from literatures

1. Lack of experts within the project team. (Ku & Taiebat, 2011).
2. Lack of experts within the organizations as a whole. (Ku & Taiebat, 2011).
3. Lack of demand from the client. (Birkeland, 2009).
4. Cost of Investment. (Azhar, 2011).
5. Cultural Resistance. (Dawood & Iqbal, 2010).
6. Resistance at the operational level. (Bender, 2010).
7. Lack of additional Finance to support BIM. (Birkeland, 2009)

2.5. Implementation Strategy of BIM

For a BIM adoption to be successful, there must be tactical strategies in place to maintain the check of its implementation. Arayici, et al., (2011) outlined seven tactics of BIM implementation and these include

1. Elimination of excess
2. Intensifying response
3. Postpone resolutions to realize unanimity
4. Speedy delivery
5. Reliability
6. Provide resources to the stakeholders

7. Strict management

A global strategic plan was created through a brainstorming session from top managers. (Magee, 2017). The following five goals were determined as priority:

- Goal A—EDUCATE Staff of Programs
- Goal B—PROMOTE the use of BIM both internally and externally
- Goal C—DEVELOP content for BIM softwares
- Goal D—Improve documentation QUALITY
- Goal E—Upper management and staff to provide SUPPORT for the strategic plan

2.6. BIM Application Softwares

The BIM concept has come to gain roots in the construction industry and rapidly rising. There are new BIM application softwares been produced every day and existing BIM softwares are also been enhanced day in and day out. Not without standing the many software coming up every day, it can be very challenging in finding the right software that will suit your kind of work as a professional in the industry. This challenge is not dependent on the software only but also on the other factors and package as a whole which includes services, training and price. In choosing the right BIM software / tool there are a lot of factors to consider and questions to answer and these include how to nurture your inspiration and manifest it in a visual image, the amount of time to spend on learning and design, the format or output to present the final design, your expectations and priorities. The functionality of all BIM softwares are not the same. Although, there are a lot of BIM software on the market which exhibit the core BIM functionalities but some function better in other areas than others. Below are some of the BIM softwares which are popularly

known for their best functionalities and user friendliness, and has been chosen by some Engineering and Architectural firms around the world for their projects.

2.6.1. Autodesk

Autodesk is a company that develops software for the architecture, engineering and construction industry with its headquarters in San Rafael in California, USA. It was founded on January, 30, 1982 in Mill Valley, California, USA. Autodesk develops softwares for designing, planning, drafting, modeling, visualizing, simulating, rendering, constructing, managing and running engineering analysis. They have softwares specifically for almost any task or work line in the construction industry. The company is very famous because of its free educational versions if its software they make available at no cost to qualified students. The company central focus is on 2D and 3D design software, and has arguably become best-known due to its flagship computer-aided design software AutoCAD. Their softwares run on both Windows and Mac operating systems. They also have android versions of some of their softwares.

2.6.2. AutoCAD Architecture

AutoCAD Architecture is a subsidiary of the AutoCAD software with some key functionalities and tools designed specially to suit architectural works. It started as AutoCAD Architectural Desktop with its first release in October, 1998 and name AutoCAD Architectural Desktop 1. Other versions like AutoCAD Architectural Desktop 2, AutoCAD Architectural Desktop 2i, AutoCAD Architectural Desktop 3 and AutoCAD Architectural Desktop 3.3 followed until in 2003 the name changed to Architectural Desktop and the versions name was replaced with the year in which it was released plus one, Architectural Desktop 2004. Architectural Desktop 2005, Architectural Desktop 2006 and Architectural Desktop 2007 were released in 2004, 2005 and 2007 respectively. In March, 2018, the new platform was launched with a new name as AutoCAD Architecture 2008. This new and enhanced version continued down the years with a

release every year accompanied with improved performance and added functionalities till the recent one which was released in March, 2018 as AutoCAD Architecture, 2019.

AutoCAD Architecture is based on AutoCAD. It uses DWG file just as AutoCAD with the same feel as working in AutoCAD. Aside its 2D feature, it has 3D objects for BIM solutions. The objects inter-relate with each other intelligently. For example, there is a relationship between a wall and a door in that wall. When the wall is deleted or its position is moved it affects the door accordingly. These objects can also be represented in 2 dimensional form. (Agustsson, 2007).

2.6.3. Autodesk Revit

Autodesk Revit is a BIM software specially designed for all professions in the building industry. Architects use it for architectural designs, structural engineers also use it for structural modelling and structural analysis with the aid of third party softwares as add-ons. It can also be use by landscape architects and MEP Engineers as well as Quantity Surveyors for taking off and for bill of quantity.

Revit (then Revit Technology Co-operation) was purchased from Massachusetts by Autodesk in 2002 for $ 133 million. After the purchase, Autodesk developed more research into the software to make it the number one BIM software. Autodesk then released several versions of it as Revit Architecture, Revit Structures and Revit MEP in 2004 to 2013, after which all the other disciplines was moved into one product as Revit.

Revit enables users to design building and structures in 3D format and also allows the designs to be represented in 2D format documentations. Revit is parametric in nature. That is to say when you edit any part of the design whether in the 3D model or in a 2D view it react accordingly in all other views. For example, if a window size is changed or the window is deleted, all other views showing the window will also be modified accordingly. Aside it parametric nature, 2D drafting can also be made without necessary

affecting all other views. Revit is structured in a way that all other professionals, for example, architect, MEP engineer, landscape designer, structural engineer, can be working on the same design at the same time on a network. This feature in Revit is called “collaboration”. Revit has also been made in a way such that other third-party applications can be designed and added as plug-ins and add-ons to enhance other features and functionalities in it. An example of such plug-in is Robot Structural Analysis plug-in which allows structural elements in designed in Revit to be exported to Robot Structures for structural analysis and reports. There are many of these plug-ins which makes Revit inter-probability with other softwares very easy. Revit also has BIM based objects which is known as Revit families. These Revit families can be modified to suit the user’s preference or it can be created from scratch by the user. The Revit families ranges from architectural families, structural families, electrical families, plumbing families, mechanical families and other general families.

Most firms around the world are using or have used Revit as a tool in executing their projects. Examples of these firms include Skidmore Owings and Merrill LLP (SOM), one of the world’s leading architectures and engineering firms. SOM designed the Freedom Tower Project (also known as One World Trade Centre) which is intended to be built in New York, USA with Revit. This 541-meter-high building will be monumental as it will be the first construction made on the former World Trade Centre Site. SOM chose to use Revit in designing the building to minimize construction errors and to increase productivity. (Wikipedia, 2018).

2.6.4. Bentley Systems

Bentley Systems Incorporated provides software for the Design, construction, and operation of the world's infrastructure. The company provides softwares for the building, plant, civil and geospatial designs. They softwares can be used in designing, constructing and well as managing mega projects which includes plants, roadways, railways, utility networks and bridges. The company was founded in 1984, about 34

years ago, in Exton, Pennsylvania, USA, where its headquarters is, although it has other departments in over 51 countries around the world. (Wikipedia, 2018).

Bentley Systems produces three main software types. And these software types are:

- MicroStation
- ProjectWise
- AssetWise

MicroStation

MicroStation is a powerful CAD software which revolves round DWG and DGN file formats. Aside these file format it also can read and write other file format which include media file formats (JPEG, BMP, AVI). It was initially used for producing construction drawings but has evolved to the inclusion of producing 3D models and also for rendering. MicroStation can be used for both architectural and engineering designs. The current version of MicroStation is the CONNECT Edition. MicroStation operate on the windows platform. (Wikipedia, 2018).

ProjectWise

ProjectWise also operates on the windows platform (Windows 7, 8 and 10). ProjectWise is a suit designed for project collaboration. It helps professionals to interact and collaborate easily in a project team. Bentley systems acquired this product from Opti inter-Consult. They initially started a partnership relationship with Opti inter-Consult in 1995 and later in 1996 Bentley Systems took over the shares of Opti inter-Consult. In that same year Bentley Systems released the first version of ProjectWise known then as TeamMate 96. In 1998 the name TeamMate was changed to ProjectWise. ProjectWise 3.xx was released

in 2000, and subsequent release yearly with the last version released in July, 2018 with the name ProjectWise CONNET Edition (Update 3.1). (Wikipedia, 2018).

AssetWise

AssetWise provides informed decision support from capital planning through proactive asset maintenance, enabling you to mitigate risk, increase operational efficiency, and ensure regulatory compliance. With improved information flow and interoperability, you can collect, analyze, and control relevant asset information. AssetWise delivers actionable information that supports your business processes and drives the performance of your infrastructure assets. (Wikipedia, 2018).

2.6.5. Nemetschek Group

Nemetschek provides BIM softwares for building professionals to enable them plan ahead, share information and work more closely together. Nemetschek industry cut across from Architecture, Engineering and Construction to the Multimedia. Nemetschek serves customers in over 142 countries. It was founded in Munich, Germany in 1963 with the name Ingenieurburo fur das Bauwesen (translated in English as “engineering firm for the construction industry”) and employs over 1,925 people today. Their first focus was on only structural designs and started distribution its software Statik 97/77 for engineering purposes in 1977. In 1984 they launched one of its major products for architects and engineers, Allplan. This was a 3D CAD based software which allowed its users to create models. Nemetschek Group has a lot of subsidiaries and the biggest of them includes:

- Allplan
- Graphisoft

- Vectorworks
- Data Design System
- Scia
- Maxon

2.6.6. Graphisoft ArchiCAD

ArchiCAD is an architectural BIM software designed for architects. Initially ArchiCAD operated on only Apple Macintosh and later the Windows operating system was added as one of the platforms for the software to operate on. ArchiCAD, which many believe is the first BIM software, because of its ability to create both 2D and 3D at the initial released was launched in 1987. Its development started in 1982, five years before it was finally released. (Wikipedia, 2018).

ArchiCAD is a complete architectural suit which can be used for both 2 dimensional and 3 dimensional drafting, modeling and visualization. It is an integration of a variety of architectural design applications which meets the following architectural needs:

- 2D Drafting: It is a tool for creating accurate and detailed 2D drawings.
- Modelling: it has a 3D interface for creating 3D models of any form. ArchiCAD uses a geometric description language (GDL) to create the models. Plans, elevations and sections are generated from the 3D model and are constantly updated when objects are modified.
- Rendering: it has an inbuilt rendering engine which enables designers to render and visualize their designs to produce photo-realistic images and videos.
- Documentation
- BIM Compliant.

2.6.7. Nemetschek Allplan

Another BIM product from Nemetschek Group is the Allplan software. The first release of this software was 2005 and the recent release in 2018, Allplan 2018. The Allplan software has two variations.

- Allplan Architecture
- Allplan Engineering

Allplan is a BIM software that offer designers complete creativity and project control. Allplan has been made to produce detailed design drawings. It covers the design process from conceptual phase to documentation phase. The software enables its users to design both in the 2D and 3D environment. Allplan allows users to share all kinds of BIM model data to any project team member without any losses. It is parametric in nature, when an object is modified it adjust itself automatically in all views to suit the modification accordingly. Furthermore, Allplan boasts of excellent drafting tools, functions that easily match any other CAD tool on the market. And with its companion product for engineering purposes, the Allplan Architecture software is more than capable of delivering a profound BIM solution to its users. (Agustsson, 2007).

2.6.8. Digital Project

Digital Project is one of the competitors to Revit and ArchiCAD interterms of BIM application softwares. Gehry Technologies are the producers of Digital Project. Digital Project maiden release was in January, 2013. It was built on CATIA which was developed by the French Company, Dassault Systemes and procured by Gehry Tecnology. Digital Project was used in designing the Guggenheim Museum Bilbao in Spain. This project was completed within budget and time. Other projects which have used this software includes Ray and Maria Stata Centre and Walt Disney Concert Hall Digital Project has an input functionality which allows the designer to send information direct to the manufacturer. Digital Project has no boundaries to designs of irregular shapes. It can be used to model free-style surfaces. (Wikipedia, 2018)

2.7. BIM Execution Plan

PAS 1192-2:2013 defines BIM Execution Plan (BEP) as a plan which give detailed information on how the information modelling aspects of a project will be executed. The BIM Execution plan is prepared by the supplier. It ensures that every project team member working on the project is on the same page, cooperating and collaborating. The BEP is there to help all parties and teams involved in the project to stay on course. In events that there are setbacks or minor details that need changing, the overall plan of execution for construction is clear and can be carried out. The benefit of this is it helps the people involved keep on track with what they are doing within the project. A properly implemented BEP ensures clarity in the project. (Zigurat, 2017).

The BEP is prepared during both pre- and post- contract. At the pre-contract or tender stage, an intended supplier prepares the BEP with the aim of demonstrating their approach, capacity and competence in meeting the Employer's Information Requirements (EIR). After a contract has been awarded, the winner (supplier) submits a secondary BIM Execution Plan, which confirms the supply chain's capabilities. A Master Information Delivery Plan is also submitted which sets out when project information is prepared across the project, who is responsible for the preparing the information and the protocols and procedures that will be used to develop the information. (McPartland, What is a BIM Execution Plan (BEP)?, 2017).

The Computer Integrated Construction Research Program (2010) outlined the information that should be included in a BIM Execution Plan for a project as follows:

1. **BIM Project Execution Plan Overview Information**:

   The reasons for creating the Project Execution Plan must be listed.
2. **Project Information**: All project information such as critical schedules, stakeholders, project number, location and a description of the project must be documented for referencing.
3. **Key Project Contacts**: All necessary contract information must be included in the BIM

Execution Plan.

4. **Project Goals / BIM Objectives**: The BIM objectives on the project defined is documented in this section.
5. **Organizational Roles and Staffing**: This section requires the identification and definition of roles. The coordinators of the BIM execution plan process and his roles are spelt out clearly. All the staff required to carry out the implementation plan are also identified.
6. **BIM Process Design**: This section should clearly illustrate the execution process through the use of process maps which are developed in the second step of the planning procedure.
7. **BIM Information Exchanges**: The model elements and level of detail required to implement each BIM Use should be clearly defined in the information exchanges requirements.
8. **BIM and Facility Data Requirements**: The owner's requirements for BIM must be documented and understood.
9. **Collaboration Procedures**: The team should develop their electronic and collaboration activity procedures. This includes the definition of model management procedures (e.g., file structures, and file permissions) as well as typical meeting schedules and agendas.
10. **Model Quality Control Procedures**: a system to ensure and control the requirements of the BIM execution planed should be developed.
11. **Technology Infrastructure Needs**: The hardware, software and network infrastructure required to execute the plan should be defined.
12. **Model Structure**: structures for naming files, model structures and standards, coordinate system types must be documented.
13. **Project Deliverables**: All project deliverables should be documented.
14. **Delivery Strategy / Contracts**: This section should define the delivery strategy which will be

used on the project. The delivery strategy, e.g., design-build vs. design-bid-build, will impact implementation and it will also impact the language which should be incorporated into the contracts to ensure successful BIM implementation.

CHAPTER 3

3.0. RESEARCH METHODOLOGY

This chapter focuses on the research methodology and the steps taken to arrive at the aims of the study. The chapter considers the background and reasons for choosing the research method, research design, research procedure, target group, population size, sample determination, sources of data and questionnaire development.

3.1. Population size and Sample Determination

Professionals within the AEC industry of Kumasi were identified to represent Ghana as a whole. These professionals included Civil Engineers, Architects, Quantity Surveyors, and Mechanical / Electrical / Plumbing Engineers; who are members of their respective professional bodies such as Ghana Institute of Engineers, Ghana Institute of Architects, Ghana Institution of Surveyors and others. Snowball sampling was used in identify these professionals. A sample of 30 professionals was obtained from Kumasi including those in the private and public sectors. Information regarding to the number of registered professional firms (Architectural, Engineering and Quantity Surveying firms) was obtained from the various professional bodies in the country. Registered Engineering firms were about 104 and that of Architectural and Quantity Surveying firms were 106 and 75 respectively. An assumption of an average of three professionals within a firm was made which attributed to a total population of 855 professionals. Using Yamane (1967:886) simplified formula, $n = \frac{N}{1+N(e)^2}$ where n is the sample size, N is the population size, and e the level of precision, 25 sample size was obtained (assumption of 20% precession made). However, 50 questionnaires were distributed to the professionals for data collection and 30 questionnaires were retrieved. These professionals were selected on the bases of their experience and the complexity of the projects they are handling or have handled. Snowball sampling method was used in collecting data from these professionals. They provided the answers required to the questionnaires.

3.2. Sources of Data

To ensure reliability and informed research study, adequate literature review was conducted in relation to the thematic area of the study based on the research objectives. Notable among these were BIM concept, the stages of BIM, the impact of BIM and outcomes, the challenges of BIM, Implementation strategy of BIM, BIM Application softwares, BIM Execution Plan. The review on these delicate topical areas and the variables identified during the literature review served as the source of information for the questionnaire development. This provided comprehensive fundamental basis for designing the questionnaires which was distributed to respondents during the field survey.

3.3. Questionnaire Development

The questionnaire started with a preamble which gave a little introduction about the researcher and his intention. An overview of the questionnaire was also stated; outlining the study theme, research aims, objectives and the significance of the research. It also explained to the responded what the information solicited from them will be used for. This was to assure the respondents of their confidentiality in whatever information that is been solicited for. Finally, on the preamble, the contact details of the researcher were made available for any further enquires, recommendations and contributions.

Adequate instructions given in basic English language in aiding respondents in providing answers to the questions demanded in the questionnaires. Closed-ended questions were asked in the questionnaire to make it easy for respondents to answer just by ticking the right answers on a Likert scale.

The questionnaire was structured into four (4) sections and there are as follows:

Section A – Demography.

Section B – Current State of the use of BIM.

Section C – Challenges of BIM adoption and implementation.

Section D – Measures to overcome the challenges of BIM adoption and implementation.

Section A gathers information on the demographic features of the intended respondents. This is to ensure the respondent falls within the scope of study i.e. a professional (Civil Engineer, Quantity Surveyor, Architect, MEP Engineer, Project Manager, etc.) in the AEC industry of Ghana. This section also solicited for the number of years of experience of the respondent, the size of the respondent's organization, the sector in which the respondent carries out his/her works (private or public).

Section B looked out for information concerning the current usage of BIM in Ghana from the respondents. It was to know how respondents have been informed about BIM and also to know whether the respondents were well engaged in the usage of BIM and to what level of BIM they are using. Questions on the usage of BIM application softwares asked to know the personal involvement of the respondents when it comes to the application of BIM.

Section C focused on the challenges of BIM adoption and implementation. Questions were developed with the help of information resulting from literature review; and common challenges associated with BIM were captured and listed with a Likert-type scale for the respondents to answer. This was to ensure the respondents enjoys answering the questions during the data gathering process. The respondents were

also given the option to list their own perceived challenges associated with BIM adoption and implementation which was not listed in the questionnaire.

Section D was on the measures to overcome the challenges of BIM adoption and implementation. Recommended measures from literatures were listed for respondents to answer by ticking on a Likert-scale from a range of 1 to 5. This was intended to measure opinions of the respondents in ascending order, significance, efficacy and severity on the recommended measure to overcome BIM adoption and implementation challenges.

3.4. Distribution of Questionnaires

The questionnaires were self-administered to the target group or respondents. This was to ensure that the questionnaires where answered in full and also to make retrieving much easier and faster.

3.5. Research Procedure

The method used for this research was reviewing of literature, collection of data, analyzing, discussing and interpreting the data. In the literature review, contributions relating to the topic, both past and current issues, were assessed to obtain the necessary information relating to the study. Based on the information obtained from the literature review, questionnaires were developed and the method of sampling was done to obtain the intended respondents to the questionnaires. Information was then obtained from the respondents which served as the source of data for processing and analyzing.

Descriptive statistical analysis and Relative Important Index (RII) methods where used in the analysis where the formula for the RII is stated below:

$$RII = \frac{1n_1 + 2n_2 + 3n_3 + 4n_4 + 5n_5}{5[n_1 + n_2 + n_3 + n_4 + 1n_5]}$$

Where n_x = number of respondents selecting options with the "x" choice.

And 1, 2, 3, 4, and 5 representing the level of the respondent agreeing to the question asked in an increasing order, with 1 strongly disagreeing and 5 strongly agreeing.

Interpretations of the data was made and the necessary recommendations was also made which served as the conclusion of this research study.

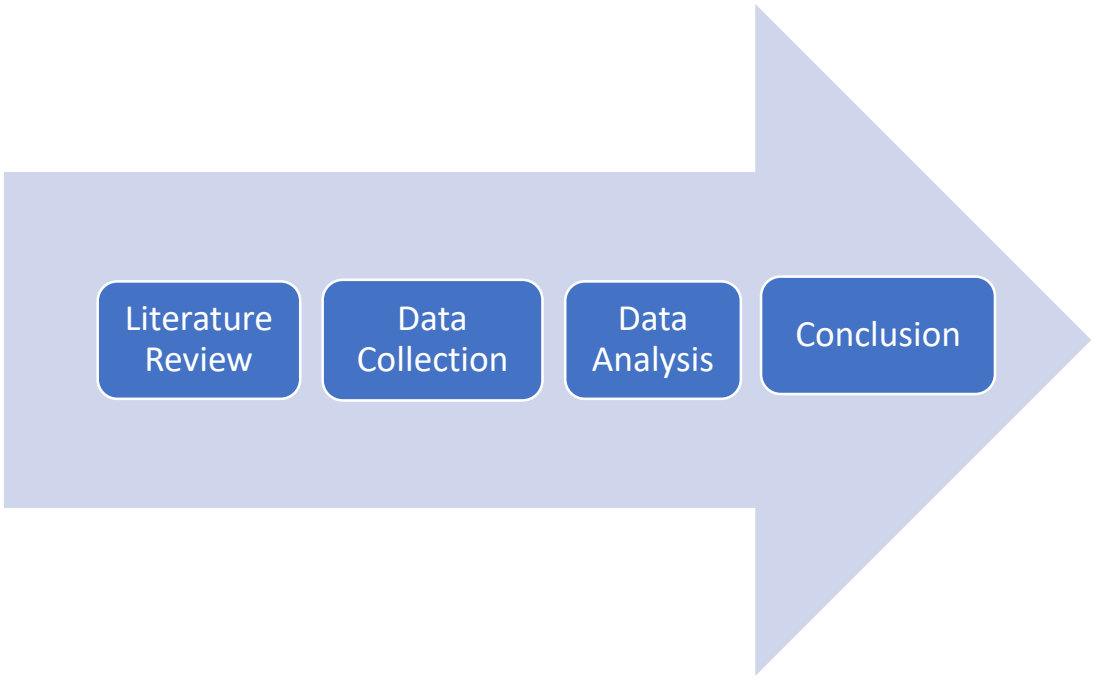

Figure 3.1: Research Procedure Process Chart

CHAPTER 4

4.0. RESULTS AND DISCUSSIONS

This chapter discusses in details the results of the data gathered from the respondents in the survey questionnaire.

4.1. Demographic and Characteristics of Respondents

The demographic data of the respondents were analyzed using descriptive analytical method which is been represented in Table 4.1 below.

Table 4.1: Demographic nature of respondents

		Absolute Numbers	**Percentage**
Professional Background	Architect	4	13%
	Civil Engineer	6	20%
	Quantity Surveyor	7	23%
	Project Manager	6	20%
	MEP Engineer	4	13%
	Structural Engineer	2	8%
	Other (Maintenance Engineer)	1	3%
	Total	**30**	**100%**
Years of Experience	Under 5 years	13	43%
	6 – 10 years	14	46%
	11 – 15 years	3	10%
	Total	**30**	**100%**
Type of Organization	Client	2	7%

	Contractor	17	57%
	Consultant	11	36%
	Total	**30**	**100%**
Level of Education	Post Graduate	8	27%
	First Degree	22	73%
	Total	**30**	**100%**
Sector of Works	Private	8	27%
	Public	6	20%
	Both Private and Public	16	53%
	Total	**30**	**100%**
Size of Organization in terms of number of staffs	1 – 10 people	10	33%
	11 – 20 people	7	23%
	21 – 50 people	5	17%
	51 – 100 people	4	13%
	101 – 500 people	2	7%
	Greater than 500 people	2	7%
	Total	**30**	**100%**

The professional background of the respondents shows that 27% of the respondents were Quantity Surveys who topped the chart followed by Civil Engineers and Project Managers who equally constituted 20% each of the respondents and Architects and MEP Engineers who also equally constituted 13% each of the respondents. The remaining were Structural Engineers who constituted 7% and other profession,

maintenance officer, who constituted 3%. Fig. 4.1 below is a pie chart which shows the distribution of respondents according to their professional background.

The bar chart as shown in figure 4.2 below describes distribution of respondents based on their years of experience. About 47% of the respondents have practiced their profession for a period of 6 to 10 years and 43 % have practiced for less than 6 years whiles a few have practiced for more than 10 years who constituted 10% of the respondents. None of the respondents had practiced their profession for more than 15 years.

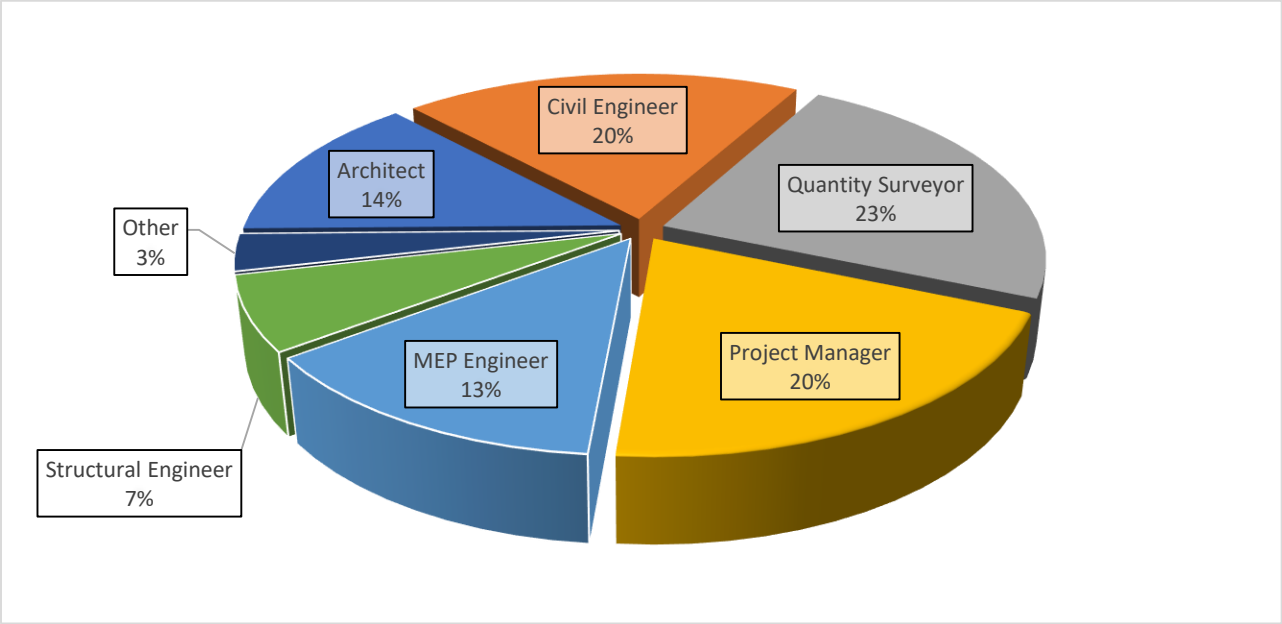

Figure 4.1 : Professional Background of Respondents

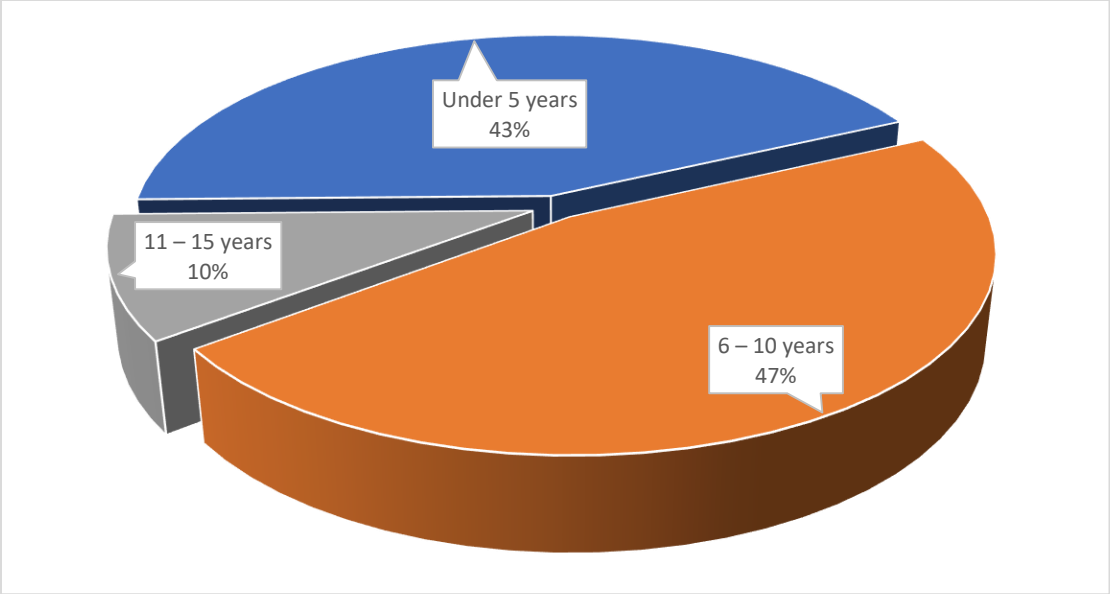

Figure 4.2 : Years of Professional Experience of Respondents

A considerable number of the respondents work on behalf of the contractor who constituted about 57%. About 37% of the respondents work on behalf of the consultant and the few remaining percentage works on behalf of the client.

Solicitation of works from the respondents' firms were also considered. From the study is was revealed that most of the respondents' firm solicited for both private and public works. As high as about 53% of the respondents' firm solicited for works from both private and public sectors. 27% of the respondents' firm solicited for only private works and only 20% of the respondents' firm solicited for only public works. Fig. 4.3 below shows a Venn diagram distribution of the respondents' firms on the sector of works they solicit for.

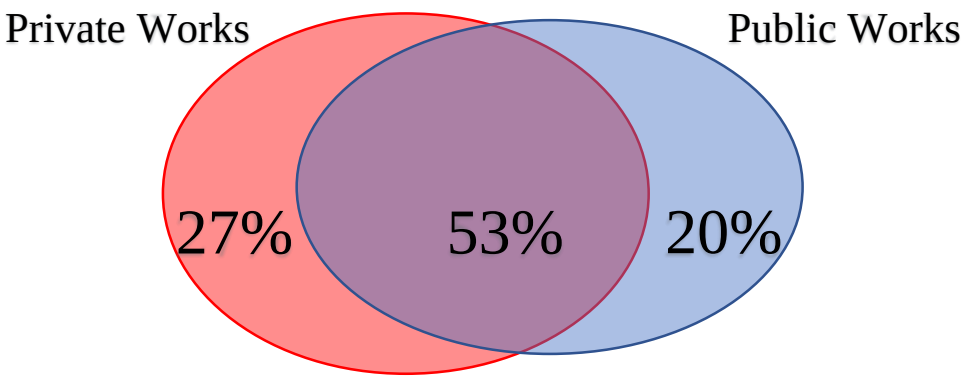

Figure 4.3: Venn Diagram Distribution on Works (Private, Public or Both) being solicited for by respondents' firm.

The organizational size in terms of total number of staffs of the respondents were evenly distributed from less than 10 people to more than 500 people, although firms with less than 10 staff members topped the chart with about 33%. Second on the chart were firms with staff in a range of 11 – 20 people, who constituted 23%. Firms with staff members in the range of 21 – 50 people were about 17% and that of 51 – 100 people were about 13%. Firms with staff members in the range of 101 – 500 people and that of more than 500 staff members constituted about 7% each. Fig. 4.4 below shows a bar chart representation of the size of the organizations in terms of the number of staff members of the respondents' firm.

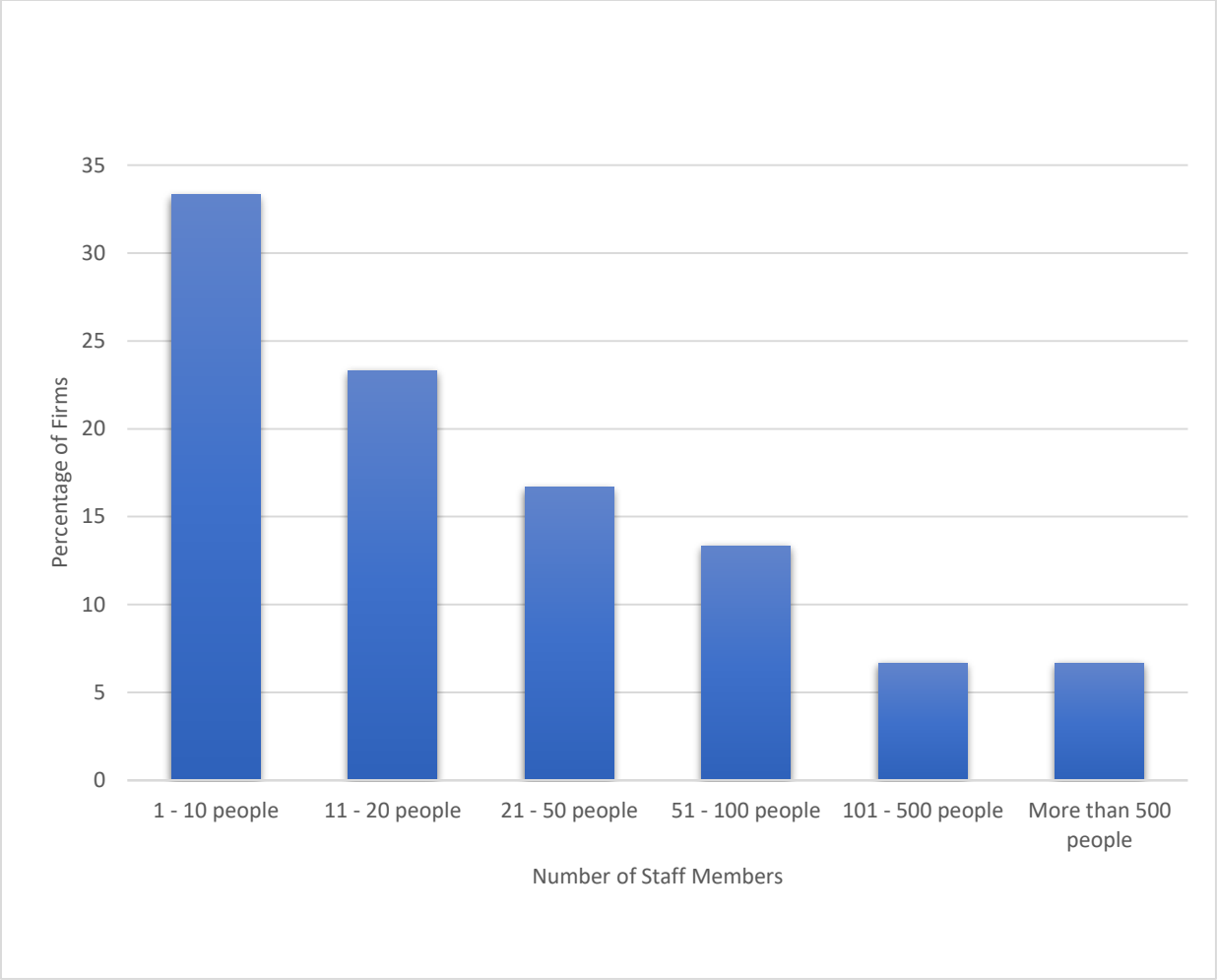

Figure 4.4 : size of the organizations in terms of the number of staff members

4.2. Current State of BIM Usage

The bar chart as shown in fig. 4.5 below describes the distribution of respondent's BIM awareness. It can be seen that about 27% of the respondents have been using BIM. Surprisingly, about 23% of the respondents had no clue on what BIM entails, other 23% of the respondents had fair knowledge about BIM and 27% of them also were well informed about BIM but had no practical exposure of BIM. In all about 73% of the respondents do not use BIM at all in their work whiles only 23% use BIM. This is confirmed by, Bentein & Pittman (2004) that the adoption of BIM is always in a slow pace, whereas the rate of adoption differs per country (McGraw-Hill, 2009; 2007).

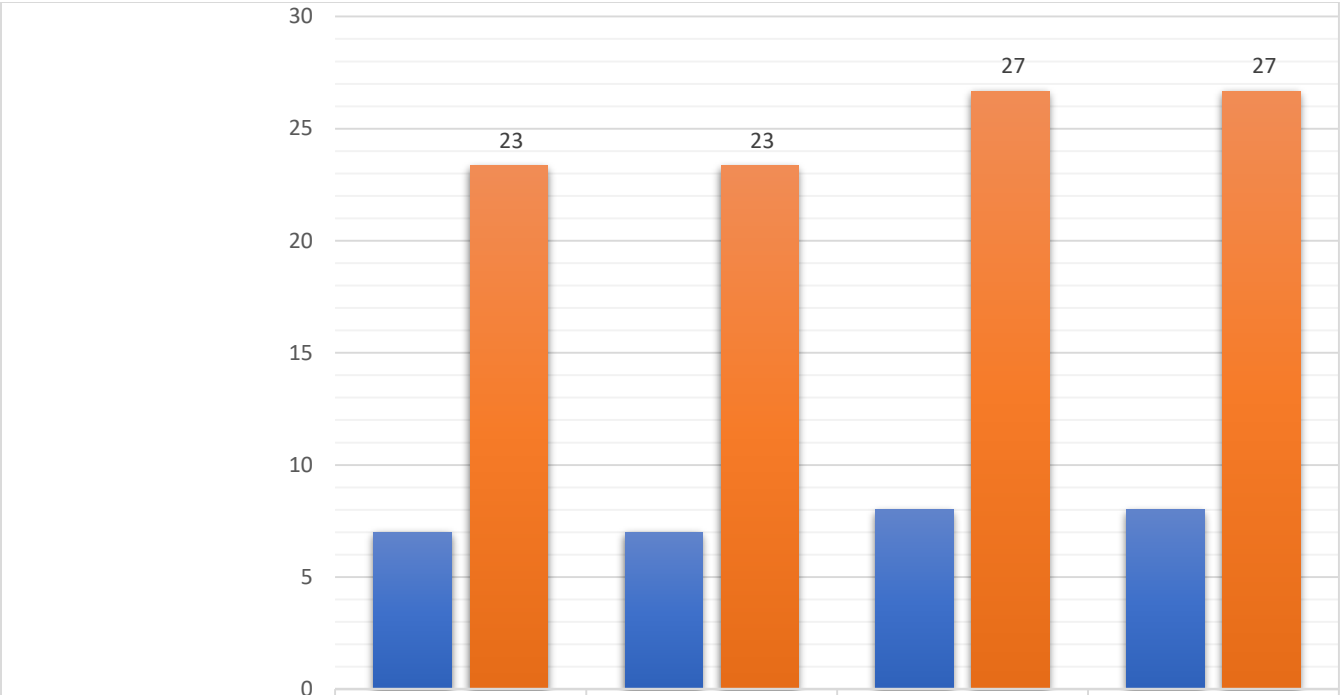

Figure 4.5 : Level of Awareness of BIM

The studies also revealed that about 57% respondents' (17 respondents) firms do not use BIM at all and the other 43% (13 respondents) firms are using BIM or planning to use BIM. Fig. 4.6 below shows a pie chart distribution of firms who do not use BIM and firms who use BIM or are planning to use BIM.

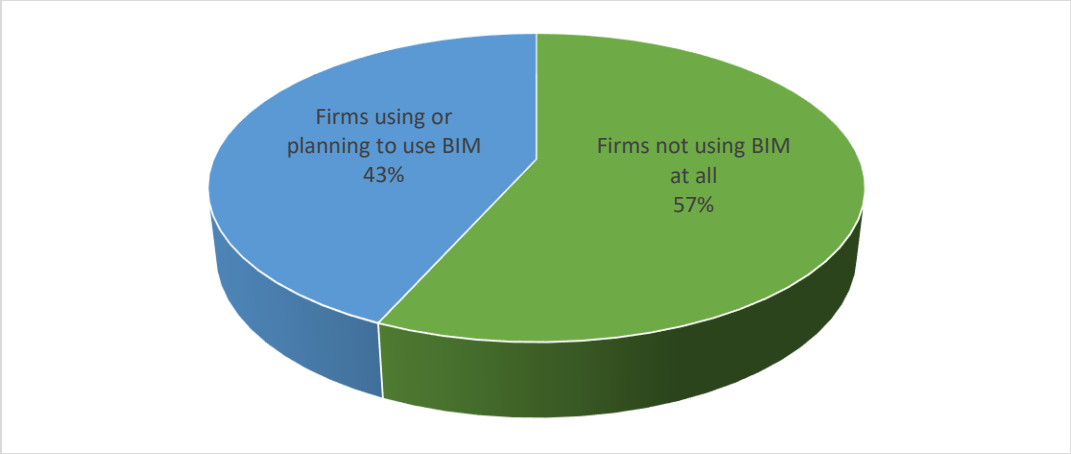

Figure 4.6: Firms using BIM

Even though the percentage of the respondents who used BIM was 57%, most of the respondents believed that firms who do not adopt BIM early enough will be left behind or struggle to survive in the industry. And that constituted 83% of the respondents as indicated in Fig. 4.7 below.

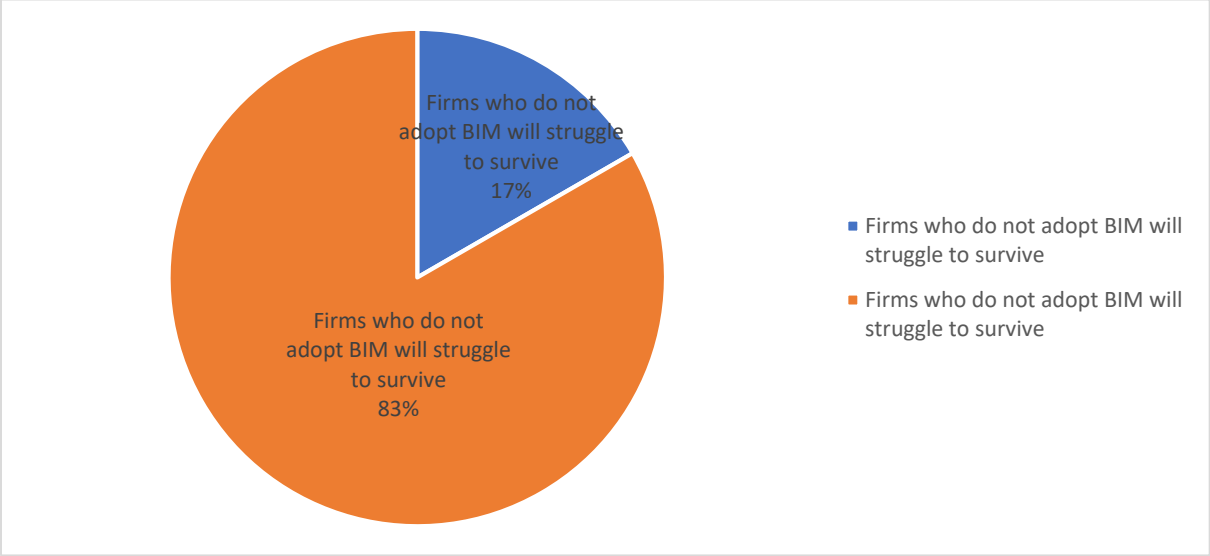

Figure 4.7: Views on firms who do not adopt to BIM early enough

4.2.1. Extent of BIM Software Usage

Table 4.2: BIM Softwares used by respondents

BIM SOFTWARE	No. of Respondents					Total	Relative Importance Index (RII)	Rank
	5	4	3	2	1			
AutoCAD Architecture	7	10	8	5	0	30	0.73	1
Revit	4	3	8	11	4	30	0.55	2
ArchiCAD	1	2	9	13	5	30	0.47	3
Robot Structures	1	2	4	14	9	30	0.41	4
Naviswork	1	2	4	11	12	30	0.39	5
Etabs	1	2	4	8	15	30	0.37	6
Orion	0	3	3	11	13	30	0.37	6
Quantity Takeoff	0	1	1	17	11	30	0.35	8
Bentley Systems	0	0	4	13	13	30	0.34	9
Allplan	0	0	3	13	14	30	0.33	10
Nemetschek	0	0	1	9	20	30	0.27	11
MicroStation V8XM Edition	0	0	1	7	22	30	0.26	12
Digital Project	0	0	0	4	26	30	0.23	13
Synchron	0	0	0	4	26	30	0.23	14
Gehry Technologies	0	0	0	2	28	30	0.21	15

In measuring the BIM Softwares commonly used, some common BIM softwares or tools were extracted from literature. Among these common BIM softwares / tools included the following; AutoCAD Architecture, Gehry Technologies, Synchron, ArchiCAD, Revit, Robot Structures, Naviswork, Etabs, Orion, Quantity Takeoff, Bentley Systems, Allplan, Nemetschek, MicroStation V8XM Edition, and Digital Project. In measuring the softwares used by the respondents, Relative Importance Index were used. This measure revealed the weight of each of the software in relation to others. The indexes were ranked from the most used to the least used software. The study revealed the most common BIM software often utilized by the respondents is AutoCAD Architecture (Ranked 1st), followed by Revit Architecture (ranked 2nd) and ArchiCAD (3rd). This is confirmed by Ryal-net (2015) that the most common BIM

software often utilized by the professionals in Nigeria (a sub-Saharan country which has a lot in common with Ghana in the construction industry) are AutoCAD Architecture, Revit Architecture and ArchiCAD.

In table 4.3, ten purposes of using BIM that were identified through literatures were answered by respondents and analyzed using relative importance index method. From the table, it clearly shown that "Construction Drawings" was ranked first with index of 63%. This variable was observed to be highly significant since it was scaled as very important purpose for using BIM Software in the Ghanaian AEC industry.

The second ranked significant is "3D Modeling / Presentation" with index of 57%. This is followed by "As-built drawings" with index of 56%, and "Engineering analysis" and "Budget" with the same rank of 45% each.

Table 4.3: Purpose of using BIM Softwares by respondents

PURPOSE OF USING BIM SOFTWARES	No. of Respondents					Total	Relative Importance Index (RII)	Rank
	5	4	3	2	1			
Construction Drawings	3	10	9	4	4	30	0.63	1
3D modeling / presentation	5	3	11	5	6	30	0.57	2
As Built Drawings	3	6	10	4	7	30	0.56	3
Engineering Analysis	5	1	3	9	12	30	0.45	4
Budget	0	8	5	3	14	30	0.45	4
Quantity Takeoff	1	6	4	3	16	30	0.42	6
Proramme Scheduling	0	3	5	7	15	30	0.37	7
Clash Detection	1	4	2	4	19	30	0.36	8
Master Planning	0	4	4	3	19	30	0.35	9
Maintenance Programme	0	2	2	6	20	30	0.31	10

4.2.2. Challenges to BIM Adoption and Implementation

The challenges to BIM adoption and implementation to AEC industry in Ghana was also measured. Relative Importance Index was used in measuring the challenges. From Table 4.4, the challenged that was ranked highest was "Lack of BIM experts within the firm" with RII of 0.77 followed by "BIM Knowledge" also with RII of 0.75. "Poor technological edge", "Resistance at the operation level", "Cultural resistance" and "Lack of financial resources" were ranked 3rd, 4th and 5th with RII's of 0.79, 0.69 and 0.68 respectively. The remaining challenges followed from 6th rank to 10th rank as shown in table 4.4 below. This agrees with R. Eadie et al. conclusion on the main reason for not using BIM, which is lack of expertise within the project team and organizations and hence the reason why the benefits of 3D modelling and BIM have not been fully realized in construction in a similar way to that documented in other industries such as car manufacturing and machinery design. (R. Eadie et al., 2013)

Table 4.4 : Challenges to BIM Adoption and Implementation

BIM Challenges	No. of Respondents					Total	Relative Importance Index (RII)	Rank
	5	4	3	2	1			
Lack of BIM experts within the firm	9	12	5	3	1	30	0.77	1
BIM Knowledge	8	13	4	4	1	30	0.75	2
Poor technological edge	7	13	5	4	1	30	0.74	3
Resistance at the operational level	6	8	10	5	1	30	0.69	4
Cultural Resistance	5	10	9	4	2	30	0.68	5
Lack of Financial resources	3	11	6	8	2	30	0.63	6
Lack of Demand from Client	3	10	9	4	4	30	0.63	7
Management see no need for BIM	2	6	12	7	3	30	0.58	8

No collaboration with other professionals	2	6	7	11	4	30	0.54	9
Procurement systems	2	5	5	11	7	30	0.49	10

4.2.3. Measures to BIM Adoption and Implementation Challenges

In measuring the measures to the challenges of BIM adoption and implementation, the respondents highly recommended "Government support through legislation" which was ranked 1st with RII of 0.75. However, Hore et al. suggest that if adoption becomes a requirement then training must be subsidized by the Government to facilitate implementation. "Full integration of BIM into the academic curricular" was ranked 2nd with RII of 0.72. The 3rd rank measure was "Participation of relevant professional bodies" which had RII of 0.69. "BIM Software availability" was the least ranked among the four measures that was extracted from literatures. Even though "BIM Software availability" was ranked last it had a high RII of 0.64.

Table 4.5: Recommended Measures to BIM Challenges

Measures to BIM Challenges	No. of Respondents					Total	Relative Importance Index (RII)	Rank
	5	4	3	2	1			
Government support through legislation	14	4	5	6	1	30	0.75	1
Full integration into academic curricular	8	8	9	4	1	30	0.72	2
Participation of relevant professional bodies	4	11	11	2	2	30	0.69	3
BIM softwares availability	5	7	10	6	2	30	0.64	4

CHAPTER 5

5.0. CONCLUSION AND RECOMMENDATION

5.1. Review of objectives

5.1.1. Identify the current state of the use of BIM in the Ghanaian AEC industry

The objective to identify the current state of BIM usage in the AEC industry of Ghana was achieved. From the analysis of the survey questionnaire, it was realized that only 27% of the respondents were actively using BIM and 23% also did not have any clue about BIM.

It was also realized from the analysis that few of the respondents were actively making full use of the BIM softwares / tools that were obtained from literatures and enlisted in the questionnaire. About 23% of the respondents (7 respondents) were actively using AutoCAD Architecture and as low as 13% (4 respondents) were actively using Revit. The other BIM Softwares / tools enlisted recorded 0 percent high usage with the exception of four of them (i.e. ArchiCAD, Autodesk Robot Structures, Navisworks and Etabs) recording as low as 3% high usage. On the whole, it was only AutoCAD Architecture and Revit which had a relative importance index of greater than 0.5.

Also pertaining to the purpose of using these BIM Softwares / Tools, it was realized that few of the respondents were actively using the BIM Softwares / Tools for 3D modeling and Engineering analysis only, each recording 17% of the total respondents (see table 4.3).

From the analysis it can be concluded that the BIM maturity levels of the professionals in the AEC industry of Ghana is very low which is within BIM level 0 and 1.

5.1.2. Identify the challenges of BIM adoption and implementation in the Ghanaian AEC industry

This objective to identify the challenges of BIM adoption and implementation in the Ghanaian AEC industry was achieved through the response from the survey questionnaire and its analysis. The challenges encountered was not different from the other BIM adoption and implementation around the world which was realized from literatures. Lack of BIM experts with the firms, limited BIM knowledge and Poor technological edge were the top 3 ranked challenges being faced in the AEC industry with high RII of .77, 0.75 and 0.74 respectively (see table 4.4). The other challenges included; resistance at the operational level, cultural resistance, lack of financial resources, lack of demand from clients; which were all ranked above 0.6. The least challenges from the respondents were; procurement systems, no collaboration with other professionals and management perceiving no need for BIM; which were ranked 0.49, 0.54 and 0.58 respectively.

In general, the challenges were averagely ranked higher which concludes that these challenges have high impact on the adoption and implementation of BIM in the Ghanaian AEC industry.

5.1.3. Identify and propose measures to overcome the challenges of BIM implementation in Ghana

The third objective which was identifying measures to overcome the challenges of BIM adoption and implementation was also highly achieved. The analyzed enlisted measures in the questionnaire was highly ranked by the respondents with an average RII of 0.7.

5.2. Conclusion

The following conclusions were made base on the research findings:

1. The full adoption and implementation of BIM in the Ghanaian AEC industry will play a vital role by helping to increase productivity.
2. The BIM maturity levels of the professionals in the AEC industry of Ghana is very low which is within BIM level 0 and 1.
3. The fundamental challenges of BIM adoption and implementation in the Ghanaina AEC industry include lack of BIM experts within the organization, limited BIM knowledge and poor technological edge.

5.3. Recommendations

From the analysis of the survey questionnaire analyzed in table 4.5, the following recommendations can be made:

1. Participation of Relevant Professional Bodies

To promote and create BIM awareness, the various professional bodies, ie. Ghana Institute of Engineers, Ghana Institute of Architects, Ghana Institution of Surveyors, Ghana Institution of Construction etc. should involve themselves by organizing seminars and workshops on BIM.

2. Government support through legislation

It is recommended that the government set laws to regulate the adoption of BIM in the country. This can be done by setting up regulatory bodies who will ensure that guidelines and timelines are set for BIM adoption and implementation especially on government projects.

3. Integration of BIM into academic curricular

One way in which BIM awareness can be promoted is by integrating the study of BIM as a course into the academic curricular of the building related programs such as Civil Engineering, Architecture, Construction Management, Quantity Surveying etc. at the various universities and polytechnics across the country.

4. Availability of BIM Softwares / Tools

It is recommended that the various professional bodies together with the academic institutions across the country partner with the firms that produce BIM Softwares / tools in making available the softwares at a subside and also training professionals and students in their softwares.

5.4. Recommendation for future studies

It is recommended further studies will be done on designing Building Information Modelling (BIM) Execution Plan to be used as a standard in Ghana.

5.5. Limitations

There were some challenges encountered whiles doing the research. Most of the respondents were feeling reluctant in answering the questionnaires, which delayed the collection of data. Finding literatures on BIM adoption in the Sub-Sahara African countries were a challenge since much research work has not been done in this area, even though, there are a lot of literatures of BIM adoption around the world. Also, accessing the location of the respondents was a challenge since the respondents were spread across the nation.

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APPENDICES

APPENDIX 1

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

COLLEGE OF ARCHITECTURE AND PLANNING

DEPARTMENT OF CONSTRUCTION TECHNOLOGY AND MANAGEMENT

QUESTIONNAIRE FOR PROFESSIONALS WITHIN THE ARCHITECTURE, ENGINEERING & CONSTRUCTION (AEC) INDUSTRY ON BIM ADOPTION AND IMPLEMENTATION

PROJECT TOPIC: **BUILDING INFORMATION MODELING (BIM) ADOPTION AND IMPLEMENTATION IN GHANA**

Preamble

I am Emmanuel Osei Bonsu and pursuing Master's Degree in Construction Management at the DEPARTMENT OF CONSTRUCTION TECHNOLOGY AND MANAGEMENT, KNUST. I am conducting a Postgraduate research with the title ***"Building Information Modelling (BIM) adoption and implementation in Ghana."*** Please find a questionnaire to be completed by professionals in the AEC industry of Ghana.

For further enquires, recommendations and contributions to this research, please contact the researcher below.

Thank You.

Emmanuel Osei Bonsu,

DEPARTMENT OF CONSTRUCTION TECHNOLOGY AND MANAGEMENT, KNUST.

Email: lordemma2007@gmail.com

Mobile: 0246138462

Section A: Demography

1. **What role do you perform within your firm?**

Please, tick the appropriate space provided	
Architect	
Civil Engineer	
Quantity Surveyor	
Project Manager	
MEP Engineer	
Structural Engineer	
Other, Specify	……

2. **How many years have you practiced this profession?**

Please, tick the appropriate space provided	
Under 5 years	
6 – 10 years	
11 – 15 years	
16 – 20 years	
Over 20 years	

3. **Who do you work on behalf of?**

Please, tick the appropriate space provided	
Client	
Contractor	
Consultant	

4. **What is your level of Education?**

Please, tick the appropriate space provided	
Post Graduate	
First Degree	
Higher National Diploma	
Construction Technician Cert.	
Advance in Construction Cert.	
Technical	
Other, Specify ……	

5. **In which sector does your company seek construction work?**

Please, tick the appropriate space provided	
Private	
Public	
Both	

6. **What is the size of your organization in terms of number of staffs?**

Please, tick the appropriate space provided	
1-10	
11-20	
21-50	

51 - 100	
101 - 500	
More than 500	

Section B: Current State of the Usage of BIM

1. **What is your level of knowledge on BIM?**

Please, tick the appropriate space provided	
Not heard of it	
Fair knowledge about BIM	
Well informed about BIM but no usage	
I have been using BIM	

2. **Does your company currently use BIM, or is it intending to use BIM in the near future?**

Please, tick the appropriate space provided			
Yes		***No***	

3. **What is your level of usage of the following BIM Software/Tool?**

Please, tick the appropriate space provided					
1 – Not heard of it **2** – No usage **3**- Average usage **4** – High usage **5** – very high usage	Level of Software Usage				
	1	**2**	**3**	**4**	**5**
AutoCAD Architecture					
Revit					
Bentley Systems					
Micro Station V8 XM Edition					
Nemetschek					
Graphisoft ArchiCAD					
Allplan					
Gehry Technologies					
Digital Project					

Autodesk Naviswork					
Quantity Take off					
Synchron					
Etabs					
Orion					
Robot Structures					
Others (Specify) ……					
Others (Specify) ……					
Others (Specify) ……					
Others (Specify) ……					

4. For what purpose do you use BIM Application Software for?

Please, tick the appropriate space provided					
1 – not at all **2** – rarely **3**- some times **4** – often **5** – very often	Level of Software Usage				
	1	**2**	**3**	**4**	**5**
3D Modeling/ Presentation					
Construction Drawings					
Engineering Analysis					
As-Built Drawings					
Budget					
Clash Detection					
Maintenance Programme					
Master Planning					
Programme Scheduling					

Quantity Take-off					
Others (Specify) *……*					
Others (Specify) *……*					
Others (Specify) *……*					
Others (Specify) *……*					

5. Do you forecast companies will be left behind and/or struggle to survive if they do not adopt BIM quickly enough?

Please, tick the appropriate space provided			
Yes		***No***	

Section C: Challenges of BIM adoption and implementation

1. **Which of the following challenges do your firm face in the adoption and implementation of BIM?**

Please, tick the appropriate space provided					
1 – Not a challenge at all **2** – No challenge **3 -** Neutral **4** – Critical challenge **5** – Very critical challenge	Level of Software Usage				
	1	**2**	**3**	**4**	**5**
Lack of BIM experts within the firm					
Lack of demand from the client					
Cultural Resistance					
Lack of Financial resources					
Resistance at the operational level					
No collaboration with other professionals					
Procurement systems					
BIM Knowledge					
Poor Technological edge					
Management see no need for BIM					
Others (Specify) …….					
Others (Specify) …….					
Others (Specify) …….					
Others (Specify) …….					
Others (Specify) …….					

Section D: Measures to overcome challenges of BIM adoption and implementation

1. **Which of the following measures will help your firm to overcome the BIM adoption and implementation challenges they are facing?**

Please, tick the appropriate space provided					
1 – Not at all **2** – not likely **3** – likely **4** – certainly **5** – most certainly	Level of Software Usage				
	1	**2**	**3**	**4**	**5**
Participation of relevant professional bodies					
Full Integration into academic curricular					
BIM Software availability					
Government support through legislation					
Others (Specify) ……					
Others (Specify) ……					
Others (Specify) ……					
Others (Specify) ……					
Others (Specify) ……					