KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

COLLEGE OF ART AND BUILT ENVIRONMENT

DEPARTMENT OF BUILDING TECHNOLOGY

GUIDELINE FOR BUILDING THE CAPACITY OF CONTRACTORS FOR ADOPTION AND IMPLEMENTATION OF BUILDING INFORMATION MODELING (BIM) IN GHANA

BY

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DECLARATION

I hereby declare that this work is original research has neither in whole nor in part been prescribed by another degree elsewhere. All references to other works have been accordingly cited.

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ABSTRACT

Presently BIM adoption by Construction firms has received widespread attention. The importance of BIM remains very eminent particularly at the construction stage. It provides higher efficiency and reduces variation in design. It is best cordial for offsite pre-fabrication of structural elements, ease project documentation with better precision, provides quality management of work during the entire project life, saves a lot of time and identifies clashes in programming before construction begins. The system estimates quantities of materials and provides financial benefits. In this paper the nature and constrains facing Ghanaian Contractors and possible guidelines to support capacity building of contractors to adopt BIM in Ghana have been highlighted. Among these guidelines are inclusive of leadership and management, vision and mission, assessment and collaboration, funding of project, legislation, execution plan of BIM, collaboration of data, monitor matrix and finalization of execution plan. Capacity building in these areas will go a long way to help in the adoption of this new technology- BIM. The research adopted quantitative approach in its data collection. Non-probability sampling technique namely purposive and snowball were adopted which gave a sample size of 35 respondents. In generating and gathering data, structured questionnaires based on the literature review were used. SPSS version 20, programme was used to accumulate data and later conveyed into the Microsoft Excel 2010 for comprehensive analysis using descriptive statistical tool made up of tables; mean and standard deviation; Relative Importance Index (RII); factor analysis and standard deviation for the degree of reliability of responses from respondents. It was found out that the fundamental requirements for BIM adoption and implementation include trained or qualified experts in BIM, working space, hard and software applications, repository library and screens. Also, it was realised that the level of adoption of BIM by Ghanaian contractors was low. .Some of the benefits of BIM adoption by Ghanaian contractors include

elimination of variation in design, it saves a lot of time, and it controls quality. Sadly, these benefits are not fully achieved due to the following found challenges: high set up cost of BIM such as hardware, software and personnel training. Finally on the findings, it was realised that for full BIM implementation in Ghana the following capacity building factors should be considered such as management decision, technology and training , planning and execution, quality assurance and control, regulation and legislation and lastly data collaboration. Though BIM adoption level is very low, it can be implemented to achieve high level. To do this, it is recommended that the guideline factors for full BIM adoption should be implemented by Ghanaian contractors backed by government regulations.

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DEDICATION

This thesis is dedicated to my beloved wife Mrs. Victoria Yankson -Akwaah and to the memory of my late Parents.

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LIST OF ABBREVIATIONS

2D	Two Dimensional- X,Y
3D	Three Dimensional- X,Y,Z
4D	**4** D + Time
5D	**5** D + Cost
AEC	Architectural, Engineering and Construction
AGC	Associated General Contractors
AIA	American Institute of Architects
AISC	American Institute of Steel Construction
ARCH	Architect
BIM	Building Information Modeling
BIS	Business Innovation and Skills
BPMs	Building Product Manufacturers
BPR	Business Process Re-engineering
CAD	Computer-Aided Drafting
CIG	Construction Industry of Ghana
CPD	Continuous Professional Development
ENG	Engineer
GBI	Ghanaian Building Industry
GCI	Ghanaian Construction Industry
GDP	Gross Domestic Product
GFCF	Gross Fixed Capital Formation
GhIE	Ghana Institute of Engineers
GhIS	Ghana Institute of Surveyors
GIA	Ghana Institute of Architects
GSA	General Service Administration

ICT	Information Communication Technology
IP	Intellectual Property
IPD	Integrated Project Delivery
ISSER	Institute of Statistical, Social and Economic Research
IT	Information Technology
KMO	Kaiser-Meyer-Olkin
MWrWH	Ministry of Water Resources Works and Housing
NPD	Non-Positive Definite
QS	Quantity Surveyor
RFI	Request for Information
RII	Relative Importance Index
SMEs	Small-Medium Enterprises
SPSS	Statistical Package for Social Science
UNESCO	United Nations Educational, Scientific and Cultural Organization

CHAPTER ONE

INTRODUCTION

1.1 Background of the Research

Building Information Modeling (BIM) usage has seen an increased within the circles of the construction industry in the past five (5) years as reported by McGraw-Hill (2012). There are several benefits in adopting BIM technology which includes; time saving, and reduction of requests for information (RFI) etc. during project delivery. Also, the system profits all stakeholders of the project team and permits smoother and well thought planned construction process that lessens the latent for faults and struggles through integrated project delivery (IPD) (Ahzar *et al.*, 2012; Autodesk, 2010).

According to McGraw-Hill (2009), closely 50% of the building industry is practicing BIM in US; its acceptance is expected to increase with positive returns from the usage. Researchers predicted BIM to have reached an echelon in North America in 2008, though the adoption rate by that period was merely 28%. As at 2012, about 71% of Architects, Engineers, Contractors and owners where practicing BIM in one way or the other (McGraw-Hill Construction Report, 2012). From 2008 to 2012 BIM usage had reached about 75%, an increase of 47%, over the last five years (McGraw-Hill construction report, 2012) in US. This further confirmed National BIM report (2014) by showing that most buildings are being put up with BIM technology providing a better opportunity to enhance interaction and information exchanges concerning a building.

Currently, BIM is gaining grounds in most developed countries within the last five years due to its positive prospects (Young *et al.*, 2009). A number of studies acknowledged (Eastman *et al.*, 2011; Azhar *et al.*, 2008; Howell & Batcherler, 2005; Fisher & Kunz, 2004) that the implementation of BIM have not been rapid as anticipated. However, knowledge and know-how for its adoption and implementation are extensively available and emerging (Fisher & kunz, 2004). However, large research (Wong *et al.*, 2011; Gu & London, 2010; Hartmann & Fischer, 2008) maintain that absence of individuals with BIM skills and knowledge is an important matter hampering the effective use of BIM hence its adoption.

The construction industry is vital in sustaining every economy through job creation and infrastructural development. It is fragmented in nature and brings multidisciplinary work forces to collaboratively execute a project (Isakdag *et al.*, 2007). The industry is conservative to change. According to Smith (2013), the long practice of the traditional approach to procurement and project delivery contribute to the industries conservative nature. The last three decades have witnessed an improvement of output from the industry and is believed to be linked to the advancement of information technology. This has led to the birth of many automated aided software for the building industry. Eastman *et al.*, (2011) claims BIM is a recognized as an emerging IT tool with the capability to co-ordinate the building industry and realizing the four- dimension (time) and the five- dimension (cost) (Smith 2013).

Some traditional procurement systems like design-bid-build among others, limits the contractors contribution at the onset of design and sometimes to complete; whereas they could have contributed significantly through Integrated Project Delivery (IPD) where all professionals work together from start by making the best use of BIM as a collaborative tool (Lee & Hollar, 2013). However, BIM technology comes with a significant learning curve for any firm willing to adopt. Because transition is not easy, virtually every procedure and business connection is subjected to some variation with the view to exploit opportunies BIM offers (Lee & Hollar, 2013).

In an effort to address these conditions, this research delves into providing guideline to support the adoption and implementation of BIM by contractors in Ghana.

1.2 Problem Statement

The fragmented nature of the construction industry throughout the world and for that matter in Ghana has created increased cost of construction activities and autonomy of players in the industry. This leads to unsynchronized nature of construction operations with delay in project delivery (Isakdag *et al*., 2007)

In addition to the above problem plaguing the construction industry; Alshani and Inginge (2003) noted that the traditional construction tools for Architectural, Engineering and Construction (AEC) practitioners continue to make construction activities increasingly complex and very cumbrous and therefore necessitate a positive change hence the need for BIM.

Whereas BIM is a fast growing technology within countries that have successfully adopted and implemented it. Developing countries such as Ghana are lagging behind in the implementation of BIM which has been acclaimed to be the panaceas to the mounting problems of the construction industry notably delay delivery of project, cost management *inter alia*. Nonetheless, many stakeholders especially within construction companies do not have profound understanding of what BIM is all about then its requirements, just as the Ghanaian counterparts. They have not taken note of the abilities and benefits offered by BIM. This accounts for low patronage of this new technology (Georgios & Olafur , 2013) of which Ghana is not an exception. It is also perceived by stakeholders to be expensive, difficult to use with uncertain outcome (Khosrowshahi & Arayici, 2012). This has accounted for the slow pace of its acceptance. Berntein & Pittman (2004) confirms the adoption of BIM to be significantly slower than expected and the rate of adoption differ from country to country (McGraw Hill Construction report, 2009).

Globally, efforts made by countries to adopt BIM in changing construction procurement include promulgation of legislations, introduction of regulations, strategies and systems. Countries that have adopted BIM trust its ability to increase understanding and predictability of construction. They are of the view that BIM provides less waste by improving efficiency for better value. They argue that it integrates and coordinates construction activities to give rise to fewer problems during project implementation (Smith, 2013). The National BIM report (2014) espouse that 61% of operators consent that BIM carried efficiency, 52% inveterate that it increased the speed of delivery and 45% accepted that it surge in output. According to Smith (2013), 20% cost savings was gained during construction of early BIM demonstration projects, and is expected to increase to about 33% in both building and operational cost of a project during its life-span.

Ghana as a country yet developing in infrastructural and economic wise need a lot of infrastructural development to fully attain the level of a developed nation. However, with the extent of benefits BIM bring to the construction industry and generally to improving economies, the GCI must look at how BIM might be exploited in full by all stakeholders in the industry to enable better management of the industry. To achieve this, developing a guideline to help build the capacity of construction firms (contractors) in Ghana for adoption of BIM is necessary.

Finally, in order to avoid problems with decrease in productivity, poor collaboration and fragmentation of construction activities associated with the AEC industry, there is the need for BIM adoption. This has the ability to provide better information sharing system to improve collaboration with result to increased productivity (Yusuf *et al.*, 2012) to the GCI.

1.3 Research Questions

I. What are the fundamental requirements for the adoption and implementation of BIM by contractors?

II. What is the state of BIM implementation by construction firms in Ghana?
III. What are the relevance's of BIM implementation by contractors in Ghana?
IV. What are the barriers to BIM implementation by contractors in Ghana?
V. What are the factors necessary for building the capacity of contractors in Ghana for BIM adoption and implementation

1.4 Aim and Objectives of the Research

1.4.1 Aim

The aim of this research is to develop guidelines for the adoption and implementation of BIM by Ghanaian contractors.

1.4.2 Objectives of the study

In an attempt to achieve the above stated aim, the following specific objectives are set:

I. To identify the fundamental requirements for the adoption and implementation BIM of by contractors.

II. To determine the state of BIM implementation in Ghana by construction firms.

III. To identify the relevance of BIM implementation to construction firms in Ghana

IV. To identify the challenges of BIM implementation to construction firms in Ghana.

V. To identify the factors necessary for building the capacity of contractors in Ghana for BIM adoption and implementation.

1.5 Justification of the Study

The research is purposely to identify the maturity level of BIM adoption by Ghanaian construction companies and to establish the challenges and barriers thereof. It additional assistance to discover the profits Ghana as a country and its construction players stands to achieve and to rationalize guidelines, tactics desired to advance the capacity of Ghanaian construction companies for the adoption of BIM. The research was to further offer knowledge and skills to be delivered by the educators within the building industry. It is however, anticipated that the study will afford useful lesson on the knowledge base of Building Information Modeling (BIM) in the construction industry of Ghana which will serve as basis for improving the industry.

1.6 Scope of the Study

This research focuses on registered building contractors working in Accra, the foremost city of Ghana. The choice of Accra is based the fact from the datum that construction events are extremely slanted to Accra (Amoah, *et al.*, 2011). It is worth noting however that even though most firms are based in Accra they work in various parts of the country.

Furthermore, the study was limited to D1K1 contractors per the contractor classification of Ministry of Water Resources Works and Housing in Ghana. These contractors must be well-structured in their operations and have been in active business for the past 5-years to possibly meet the structures required in BIM implementation.

1.7 Research Methodology

This research was conducted based on a review of appropriate literature on the development of BIM, the work processes of BIM and advantages of BIM. This provided a thoughtful insight and knowledge in the domain of the study. Qualitative and quantitative study methods were used. Research procedure adopted involves review of literature, data collection and data analysis.

Purposive sampling and snowball sampling technique were considered. It was used to identify the main respondents for the study. To ensure the reliability of the study, adequate literature review was conducted in relation to the thematic area of the research objectives.

The data was analyzed with the help of SPSS version 20, and Microsoft Excel 2010.

In addition to this descriptive statistical tool made up of tables; mean and standard deviation; Relative Importance Index (RII), factor analysis and standard deviation were employed.

1.8 Research Organization

This research report was prepared laterally on five (5) main chapters. The first chapter dealt with overview and background of the study. It similarly highlights the research aims and objectives. Furthermore Research questions, purpose and scope of the study were addressed by this chapter.

The second chapter is solely for literature review which considered empirical and theoretical literature applicable to the problem under consideration. Critique of the existing literature relevant to the study is to be looked at. Findings of researchers are to be highlighted together with the methodology used. Finally, the chapter is to deliberate on the conceptual theoretical framework for capacity development and adoption of the area being studied.

The third chapter outlines the methodology considered for the research. It indicates the type of research and justification by citing expert. Matters of populace and target populace are moreover justified. Finally info collection technique, info processing and scrutiny are all highlighted.

The fourth chapter dedicated to research conclusions and deliberations. The primary data from the field and secondary data from literature are presented and discussed guided by the methodology considered.

The final chapter which is the fifth chapter considers the summary, conclusion and commendation resulting from the studies.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Building Information Modeling is a conceptualized device meant to enhance project information sharing among Architects, Engineers, Contractors, Subcontractor as well as other project team members (Aazar *et al.*, 2009). The Associated General Contractors (AGC) of United states (US) describes BIM for example supercomputer model software intentionally developed to mimic production and action of a building (Construction Industry Council, 2013). According to Vanlande *et al.*, (2008); Woo *et al.*, (2010); Zuppa *et al.*, (2009) BIM is designed to work geometrically containing physical information, measurements and properties of building features, estimations, material records and project schedule. BIM is an evolution from the traditional twodimension and three-dimension graphic modeling, inculcating four-dimension time model and five-dimension cost model Furthermore, six-dimension facility management model and seven-dimension physical performance model are all developed models that make it unique to previous modeling software (Deutsch, 2011).

BIM which was started in the late-eighties (Eastman, 1992) has been in operation and under consideration for almost three (3) decades now. Practically, BIM has a rich database and digitally present the facilities in a form which provides appropriate and useful information to various user needs in project delivery (Ashurst, 2014). Large body of research shows that BIM will possibly succeed the computer-aided drafting (CAD) which was started four (4) decades ago and has developed from twodimension to three-dimension due to the positive prospects of BIM to projects delivery (Aalami & Fischer, 1998; Aalami, 1998; Cherneff *et al.*, 1991; ZozayaGorostiza *et al.*, 1988).

According to Bazjanac (2008) BIM which is digitized depicts the physical and functional appearances of the structure. It has a base progress of three-dimension and with an increasing level of functionality base on the needs of the users. It also possesses the ability to produce, store, handle, swap and share construction information and facts in an interoperable environment and repeatable used mode (Woo, *et al.*, 2010; Zuppa *et al.*, 2009; Vanlande *et al.*, 2008). Generally, BIM sees a project through its life-cycle spanning from feasibility studies to demolishing of the project (Kiviniemi, 2013; Love *et al.*, 2013; Bloombergs *et al.*, 2012; Azhar *et al.*, 2008).

Knowledge of BIM is gradually spreading and many big projects have been procured using BIM (Jongeling, 2008). Notwithstanding the improvement of BIM, the construction industry is yet to grasp it with its merit due to lack of clear cut vision of what is required for the operation of this technology (Azhar *et al.*, 2008).

2.2. Relevance and Challenges of BIM to Construction Firm

The importance of BIM remains very eminent particularly at the construction stage of projects. It provides higher efficiency during construction and reduces variation in design and request for information (RFI) at all project delivery stages (Aranda-Mena *et al.*, 2008).BIM is best for off-site pre-fabrication of structural elements, because it easily co-ordinates and assimilates all structural element with colour-coded format to enhance model development (Eastman *et al.*, 2011). Cummulatively, BIM provides ease of project documentation with better precision, up to a minute conception of models and quality management of work during the entire project life (Aranda-Mena *et al.*, 2008; Eastman 2008).

BIM saves a lot of time. This is because of the possible absence and reduction of repetitive work, drawing mistakes and oversights (Eastman, 2008). Also, it automatically updates any design variation in the building model; most argument at the design stage are resolved easily with BIM to give way for effective project planning (McGraw-Hill, 2009; Popov *et al.,* 2008). It also identifies clashes in programming before construction begins. More so, the likelihood of rework in conventional methods is curtailed with BIM implementation.

Furthermore, early cost estimation of project is possible due to the fact that BIM is able to enumerate quantities of materials. This helps in quantitatively and qualitatively checking design inputs early enough in the planning process (Eastman, 2008; Ahzar *et al.,* 2012) and to alert project owners on the possible cost consequences of the design for informed decisions to be made (Bloomberg *et al.,* 2012; Eastman, 2008). A lot of research recount financial benefits in the use of BIM (Jardim-Goncalves & Grilo, 2010; McGraw Hill, 2009) and has proven that it unifies all technical construction professional as well as perfecting bids and project pricing (Philip, 2012).

Notwithstanding the countless benefit and contribution of BIM to the built environment, it has challenges because it is yet evolving. BIM also has some pertinent problems which needs resolution (Xu *et al.,* 2014) to promote its adoption. Gu *et al.,* (2008) identified challenges to BIM and classified them in various groups as product, process and people and a combination of several issues (Kivineimi, 2013).

There are significantly high cost associated with adopting BIM as against the conventional methods on major areas including hardware, software and human factor. The high investment cost of BIM know-how (start-up budget, software, personnel training and hardware budget), have continually remained a barricade to BIM acceptance. Also, most small-medium enterprises (SMEs) have challenges with funding and hence difficult for SME contractors to adopt the technology due to the massive capital investment needed. The construction industry have doubt of investing into it due to the high initial budget, inadequate evidence of financial benefits and the time to develop human expertise coupled with absence of seeing BIM as a business point of view (Wix, 1997).

Researches have shown that, there is little knowledge about BIM to stakeholders. Again Thurairajah & Goucher (2013) confirms that SME's had no basic knowledge about BIM and lack the required IT skill principally about BIM. According to CREAM (2014) staff development and stakeholders' conservative nature to change also pose a great challenge to firms.

There are also legal issues with BIM technology. These issues are in relation to ownership, responsibility to maintain and add on data to the set up (Boon, 2009). Therefore, to achieve the collective purpose of BIM, stakeholders must work in a collaborative manner (Kelin, 2012). They must resolve all ownership issues by collectively seconding to a no requisition to guard BIM with a patent law and other legislative matters (Thomson & Miner, 2006) for effective utilization. Legislative matters can also be managed by including responsibilities of stakeholders during the development of the model in the contractual document for easy enforcement (Azhar *et al.*, 2008). According to Porwal & Hewage (2013), these unsettled legal issues continue to put fear in most stakeholders on BIM while Eastman *et al.*, (2008) considers it as a barrier to its implementation.

2.3. Global Development Pace of BIM

In the pursuit to tap into it prospects to national and economic development, many developed nations have adopted and implemented BIM in most sectorial infrastructural development (Agele, 2012). This position confirms that the adoption of BIM is gaining grounds worldwide.

The radical changes taking place in construction procurement systems in the UK have made it imperative for contractors to adopt BIM practices to enable them qualify to bid for any public work by the year 2016 (Construction Industry Council, 2013; British Standards Institute, 2012). This is in consonance with Government to lead in BIM adoption in construction works to promote efficiency and immense benefit to allow firms practicing BIM to legally bid for public works (National BIM Report, 2012; BIM Industry Working Group, 2011).

In spite of the challenges to BIM adoption, it has been successfully used in large scale projects in the UK such as London 2012 Olympic 6000 Velodrome cycle track, the leaden Hall structure with 48 floor and the cheese 8 grater and also used on small scale projects (Buildoffsite, 2011).

In a survey conducted by Kiviniemi (2007) 33% of BIM usage was found in Finland. All state infrastructures are now procured with BIM (COBIM, 2012). It is also established that 93% and 60% of architectural and engineering firms respectively are into BIM application (Kiviniemi, 2007). The McGraw-Hill Construction report (2009) confirms that the US construction industry has made massive progress towards BIM implement since 2003. Since 2008, the General Service Administration (GSA) made BIM a compulsory tool to execute state project (Construction Industry Council, 2013) and have led to about 39% of US current major projects been procured with BIM (McGraw-Hill Report, 2009).

Furthermore, most developed countries have put in measures to embrace and implement BIM in the building industry. Denmark, China, Malaysia, France, Germany etc. have specific legislation that has made it possible for the successful implementation of the technology.

2.4 BIM Software Packages

The propagation of BIM has led to great modifications in ICT by the construction industry. Agele (2012) outlined a number of BIM software packages which includes autodesk architectural desktop, autodesk revit, bently systems, graphisoft, archiCAD and nemetschek. Also Gu & London (2010) acknowledge the practice of the current BIM technology. Table 2.1 below itemizes the various software used in the built industry.

Table 2.1: Software Uses for BIM.

Modeling Software	Scheduling Software	Estimating	Audit and Analysis
Autodesk Revit Building Suit	Autodesk Navisworks	Back Dprofiler	Autodesk Navisworks
Graphisoft ArchiCAD	Synchro Ltd	Quantity Take-Off	Solibri Model Checker
Beck Dprofiler	Vico Control	Innovaya	Ecotect
Bently Building Suite			

Source: Ashurst (2014)

2.5 Overview and Structures of the Ghanaian Construction Firms to BIM adoption

The Construction Industry of Ghana (CIG), like its counter parts around the world, is enormous and a vital sector to economic growth. According to Anaman *et al.*, (2007) adopted from Lange & Mills (1979), described construction industry as a cluster of companies with closely connected events involving real estate, building, private and public infrastructure.

Egmond *et al.*, (2007) grouped Ghanaian Construction Industry into large, medium and small scale firms. They recounted that large and medium firms constitute around 10 percent of the total number of firms registered with the Ministry of Water Resources, Works and Housing. According to Egmond *et al.*, (2007) these firms do not have the appropriate technical competences, plant and equipment as well as strategic workforce to execute projects awarded. This fact has been strengthened by Amoah *et al.*, (2011) who are of the view that developing economies such as Ghana's is dominated by SMEs and is subjugated by 95% of small-scale contractors, implying that only 5% are large scale construction firms. The evidence is the fact that foremost construction works and activities in the country are awarded to few large foreign contractors in the country. Research by Lopes (2012) shows that construction activities contributes between 5-10 percent of Gross Domestic Product (GDP) in all countries and employs about 10 percent of the working populace and is accountable for roughly half of the Gross Fixed Capital Formation (GFCF). According to Field and Ofori, (1988) the industry creates a conspicuous contribution to the economic production of a country. Thus it creates employment and revenue for individuals. The construction industry is viewed as an indispensable and extremely noticeable provider of economic growth of a nation (Field & Ofori, 1988). ISSER (2012) reports that, the construction industry contributed about 10.5and 11.2 percent to GDP and economic growth of Ghana respectively in 2012. Again UNESCO (2010) affirms the fact that activities of construction industry contributes to growth by way of employing skilled and unskilled labour from the AEC industry.

In terms of categorization, contractors are put into four key financial classes in Ghana by the Ministry of Water Resources Works and Housing (MWrWH). This categorization is based on the scope of individual projects they are allowed to tender or bid for and the supreme threshold values they are allowed at all times (Dansoh, 2005). Building contractors in Ghana possess combined D and K groupings. This allows contractor's to embark on building and civil works. According to GhIS (2006), D1K1 falls under financial class of projects without any financial limit, D2K2 and D3K3 fall under financial class two and three with financial limits of projects of 500,000 and 20,000 US Dollars respectively. Also, D4K4 is the least class with projects of financial limits of 75,000 US Dollars.

In developing countries like Ghana corruption has seriously characterized the construction industry (Laryea, 2010). Projects are usually won by firms that are willing to corrupt government officials. For instance in 2000, Aon Ltd. was reprimanded and punished US $435,000 through Lloyd's Disciplinary Board in connection with certain payments that were illegally made in the 1990's to officials of government in Ghana, Nigeria and the Philippines (Laryea, 2010). The rampant cases of corruption have also resulted in an unwillingness by government agencies to enforce standards related to the environment, labour, health and safety (Wooldridge, 2010 cited in Laryea, 2010). A further consequence of corruption is poor performance in wide-ranging cost, budgeting, construction time overruns and poor quality of construction works (Agele, 2012). Eventually, there is a great concern for execution of project leading to adversarial dealings amongst contractors and their clienteles (Anvuur *et al.*, 2006; Laryea, 2010).

The Ghanaian Building Industry (GBI) finds itself in this gloomy environment. Bad institutional structures, poor enactment of law, absence of proper regulation, sole proprietorship businesses in construction, government interference, poor technological edge, poor harmonization of interested parties, unethical occupational practices, insufficient and ill articulated designs, scarcity of building professionals, inadequacy of training and constant professional advancement, and proficiency (Laryea, 2010). The GCI is classified as a highly threatening business by banking institutions resulting in no or little financial support. Nonetheless, Laryea (2010) predicts a change in this situation due to expected high economic growth following the recent discovery and production of oil in saleable quantities in Ghana. The construction industry is predicted to play a major role as a result of the demand for construction works and services likely to come from the oil production.

Apart from corruption, the contruction industry also faces other challenges. These challenges according to Ahadzie & Amoa-Mensah (2010) and Laryea (2010) include inadequacy of finance and credit services for contractors, design constraints and variation of works, poor preparation and supervision as well as low computerization. Besides these challenges, Migilinlskas *et al.,* (2013) and Amoah *et al* (2011) also emphasize poorly resourced contractors, who most of the times also lack professional training and managerial skills to execute sizable projects (Eyiah & Cook (2003). Smaller firms most of whom are one-man businesses do not have financial or capital backing to execute bigger contracts (Amoah *et al.,* 2011; World Bank, 2003). A further challenge of construction management is the poor estimation of project cost (Agele, 2012).

The World Bank estimates that developing economies are growing faster than their advanced counterparts, and this growth is driving a bulk of the construction market (Anvuur *et al.,* 2006). There is slight hesitation that the building industry plays a significant role in these developing economies. However, to circumvent the inherent bottlenecks identified in the industry there is the need to embrace a new technology such as BIM. It has been identified as having great relevance for the construction industry. This relevance becomes much more evident when discussing issues of cost management, efficiency in production, reduction of disputes, poor estimation and saving of costs which differ within the industry (Agele, 2012). BIM adoption will significantly enrich transparency, allowing diverse stakeholders to have an improved idea of accurate costs of project and the funding implications of variations (Agele, 2012). Potentially it can also improve a lot of worth to customer deliverables (Smith, 2012). Though BIM cannot be used to address all the challenges the construction industry identified by the various authors above, it will go a long way to address other challenges as poor design decisions, construction management, and poor estimation through the collection and use of information across projects (Smith, 2012). The Ghanaian construction industry requires a seriouse restructuring and improvement.

2.6 Stages / Levels of BIM

There are different levels of BIM and they can be applied at any stage of the project life cycle (Porwal & Hewage, 2013). Similarly there are several adoption stages. The stages of maturity starts from stage zero (0) where construction projects have not accepted and adopted whichever BIM values and philosophies (Georgios & Olafur, 2013). These stages, from one (1) to three (3) are considered maturity levels of BIM. According to Khosrowshahi & Arayici (2012) and Succar (2009) these levels provide an organized charter for the categorization of BIM implementation which serves as standard gears for evaluation of information and levels reached at in BIM implementation.

- Unmanaged CAD project ordinarily two-dimensional is categorized level zero and generally recognized as status for pre-BIM.

- Level one deals with CAD in two-dimension or three-dimension, an object-based modeling which comprise of documents and uses concerted software to distribute and use information in a structured and formatted manner.
- Level two manages three-dimension settings and holds a distinct BIM model with devoted data. Also it is a stage where Information exchange occurs amongst stakeholders on the BIM platform. At this stage the digital model is supported to perform four-dimensional tasks which assign processes with detailed schedule and five-dimensional task linking processes with budget approximation ability.
- Finally Ashurst (2014); Porwal & Hewage (2013); Khosrowshahi & Arayici (2012) and Succar (2009) have argued that level three is the eventual level; professionals are made to work in an integrated manner imitating the actual fundamental viewpoint of BIM. Stakeholders inter-relate timely to produce actual values and that there is complete organizational revolution regarding practices, strategies, awareness, infrastructure and culture of the implementing organization. Figure 2.1 depicts the maturity levels of BIM adoption.

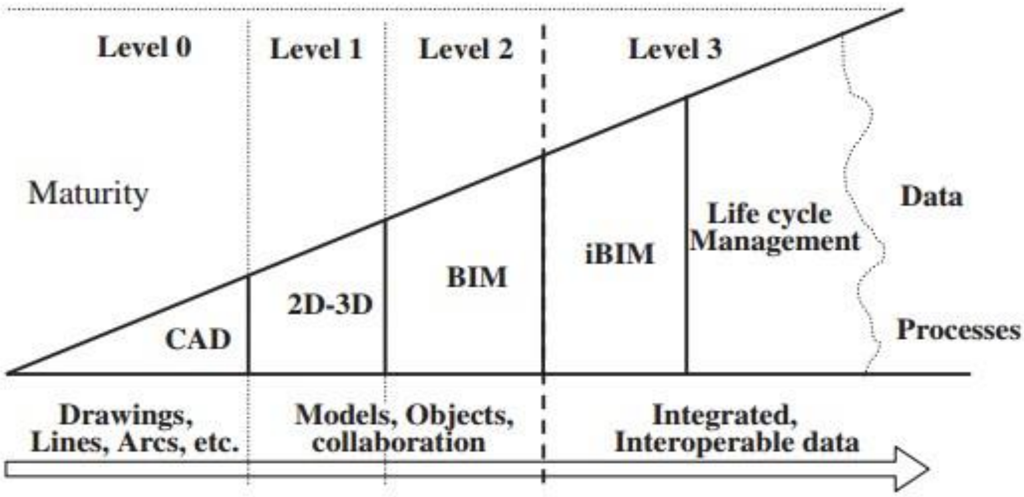

Figure 2. 1: BIM Maturity Levels U.K Adapted from Business Innovation and Skills (BIS, 2011)

According to Business Innovation and Skills (2011) as recounted by Thurairajah & Goucher (2013), UK has made it clear that public projects must be consrtucted and delivered to a BIM maturity stage two (2) requiring by 2016. This means that stakeholders are compelled to work in a collaborative manner with three-dimensional BIM. Therefore this shows that BIM adoption is in stages based on the firm capability in the area of expertise, knowledge, proficiency, technology, collaboration, and data ultilisation during project delivery.

2.7 Capacity Development Theoretical Frame Work on BIM Adoption

A number of research works have proposed various conceptual framework and models for BIM adoption, implementation and development. Among these models are from Succar (2009); Chuttur (2009); Bew & Richards (2008) and Davis (1986) which are BIM maturity models, BIM maturity stages in linear view and Conceptual model for technology acceptance respectively. This study considers Enegbuma & Ali (2012)'s model as shown in figure 2.2 as the best to achieve the objectives in the Ghanaian construction industry (GCI).

The adoption of this model was influenced by it being latest among others. Also it addresses BIM perception in relation to people, process and technology as compared to others. The model also addresses strategic IT in computer in relation to Business process re-engineering and computer integrated construction in a collaborative process which is needed for BIM adoption. Finally, since BIM is a collaborative technology the hypothesis of the model as shown in Figure 2.2 depicts the collaborative nature of the technology leading to BIM adoption for the study.

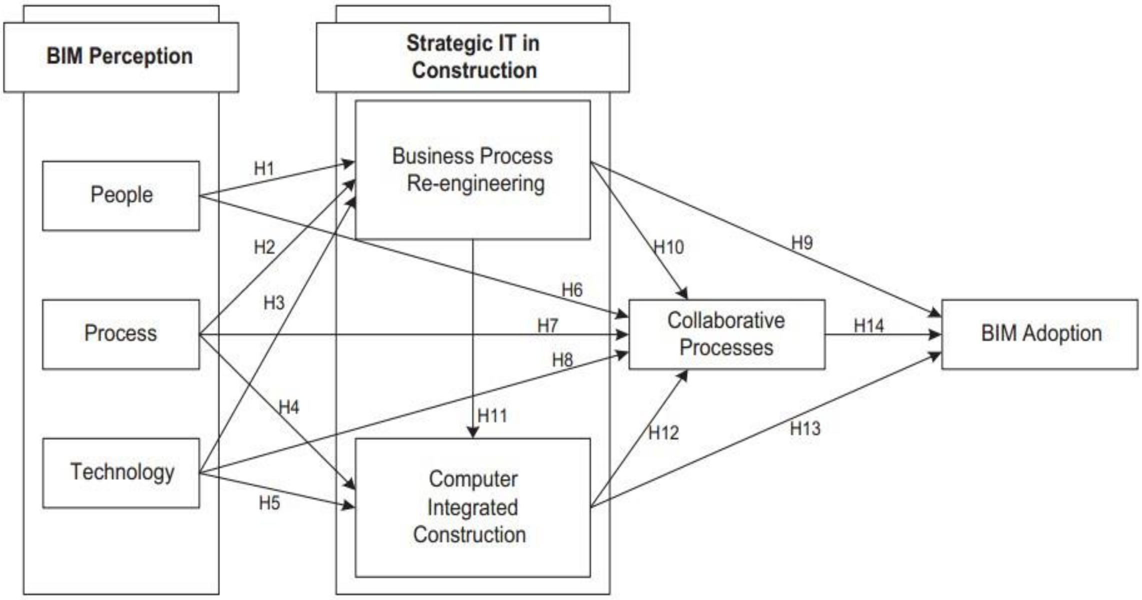

Figure 2.2: A Visual Representation of Research model and hypothesis (Source: Enegbuma and Ali (2012).

According to Enegbuma and Ali (2012), BIM adoption starts with perception. This perception is in relation to people, process and technology. This perception must be linked to strategic informatin technology in construction which involves business process re-engineering and computer integrated construction. All these must be enbodied in a collaborative process to achieve BIM adoption. This will enhance the ability to identify the perception of GCI towards BIM adoption.

2.7.1 People in relation to BIM Perception

The new technological processes to improve the construction automated design and construction expert must recognize the distinct danger connected to such a new technology. With BIM model, working boundaries of professional obligations are not clearly well-defined leading to uncertainty for liability. For the fact that the technology is emerging, older professionals are lagging behind in its usage while fresher professionals have deficient knowledge in legal issues. Researchers such as Jordani

(2008); Rosenberg (2006) and Salmon (2009) opine the need for flexible legal form of contract among construction experts to meet the swift development. In order to enhance the construction process, construction experts must take note of the individual risks associated with such a new technology as BIM. According to Lega (2008), conversation on BIM concepts, software application and evidence on accomplishments have caused an adaptive response by people even though others (Edgar, 2008; Henderson & Jordan, 2009) have argued for lack of awareness about BIM success and that to avert this situation there must be an expansion and modification of current training in education of building experts.

2.7.2 Process in relation to BIM Perception

Process is described as a series of activities taken towards attaining a particular goal. BIM process is imbibed in information technology but Latham (1994) British Property Federation (1983) Banwell (1964) and Simon (1944) have jointly argued that, the building industries have played down the importance of IT as a vivacious process in construction. However, Aouad *et al.,* (2010) is of the view that technology innovation only place less consideration to organizational and human matters. Furthermore Thwala *et al.,* (2012); Liu (2010); Yan & Damain (2008); Rezgui & Zarli (2006) argue that there is inadequate staff and training within the construction industry to work on BIM model. Hence the need to have long-term goals by
construction firms to address the problem of inadequate staff and training.

In the past the migration from manual drawings to Computer Aided Design (CAD) was fraught with a lot of hitches. Likewise BIM technology today is faced with gigantic problem of bureaucracy by upper executives because of faceless hazard, obligation, and hesitations leading to abandonments during the sharing of BIM model

(Jordani, 2008; Smith, 2007). To achieve BIM success, the culture of stakeholders (people) and top management struggle to new technological approach must change to enhance workflow modifications, high-tech novelty and advancement.

2.7.3 Technology in relation to BIM Perception

Technology is the use of technical knowledge for real-world purposes. Jordani (2008) has stressed that client's need to push for faster invention and technology delivery that would enhance construction, in offensive building environment, lower cost of construction, and lean implementation to espouse technology such as BIM. This according to Ibrahim *et al.*, (2010) has been achieved by Malaysia's construction industry and American Institute of Architects. These countries have advanced in information technology and project administration practices which become a vital component of capital intensive construction and high- technology. For BIM to endeavor and solve future problems within the construction industry there must be readily available model objects that would allow smooth information extraction.

Though product library has been established to epitomize the requirement of building product manufacturers (BPMs), the knowledge of software and inadequate situation of material are in-built deficits in BIM deliverables and know-how. To provide such evidence, according to (East, 2009; Jones & Lien, 2008; Onuma, 2008) have argued that during hyperactive collaborative platforms like BIM Storm, stakeholders had to revert to allow manual practices.

2.7.4 Strategic IT planning of BIM

Even though Information Technology (IT) adoption and usage has been fraught by great hesitation by building industry stakeholders, it is presently changing because researchers (Alshawi, 2007; Kangas, 1999; Moingeon *et al.*, 1998) have argued for dependence on IT to create conducive environment for the purposes of sustainability and competitiveness among stakeholders. It is therefore important to note that Business Process Re-engineering (BPR) require firms to modify their professional pathways, working out strategies to embrace information technology (Liang & Cohen, 1994; Porter & Millar, 1985; Anthony, 1965). This is further confirmed by Kohar *et al.*, (2012), that factors such as institutional training, reward, communication, research and development are to be considered in order to achieve business process reengineering.

2.7.5 Collaborative processes of BIM

Collaborations in the construction industry have been underlined by Jayasena & Weddikkara (2012) for measuring BIM maturity levels. They describe collaboration in construction as an agreement or working together in a unified manner among construction professionals such as architects, quantity surveyors, planners, engineers, contractors and sub-contractors to share their technical know-how in a definitive manner, for the purpose of attaining the set up objectives of the project as defined by the client.

Anumba & Newnham (2000) and Hobbs (1996) assert that collaboration becomes more effective during the project inception stage. According to (Yeomans, 2006; Kalay, 2001; Sun & Aouad, 2000) the building industry requires an exceptional method to collaboration and once this collaboration comes on board unsuccessfully, it creates a landmass of automation. The independent activities and decision making of stakeholders in construction industry creates major challenges to effective collaboration (Yeomans, 2006; Anumba *et al.*, 2002; 2001; 1997). Again Lang *et al.*, (2002) have highlighted different educational upbringing, languages and contractual arrangement as barriers to collaboration. Therefore there is an urgent need to enhance collaboration among construction stakeholders.

2.7.6 Business Process re-engineering

Business Process re-engineering (BPR) is a thorough rethinking of all business processes job definition, management systems, organizational structure, work flow and underlying assumptions and beliefs. BPR is aimed at breaking away from older ways of working and radical redesign processes to achieve dramatic improvement in critical areas such as cost, quality, service and response time through the in-depth use of information technology. The model shown in Figure 2.2 builds on BIM perception incorporating strategic IT implementation (Bett, 1999) technology acceptance model (Davis1985; Chutttur 2009), bussines process re-engineering (Anthony 19655; Porter & Millar 1985; Liang & Cohen 1994)

2.7.7 BIM adoption as a new technology

Adoption requires diffusion of the technology. Rogers (2003) defines diffusion as the receiving and usage of novel technology while invention connotes a new product or process of technological procedure and management. This study gives attention to the adoption of BIM in Ghana by contractors to foster swift, and improve grey sections within the construction industry.

2.8 Adoption of Theoretical Frameworks

This study and literature affords not at all an easy formulation for the building of an organizations capacity. Light (2000) affirms that developing an institutional capacity building framework has no established clear-cut process. The reason is that no single individual has recognized what features accurately make an organization more effective. As an alternative, the framework shown in figure 2.4 below provides a guide to develop an organizations capacity building as an intervention tactic of this research.

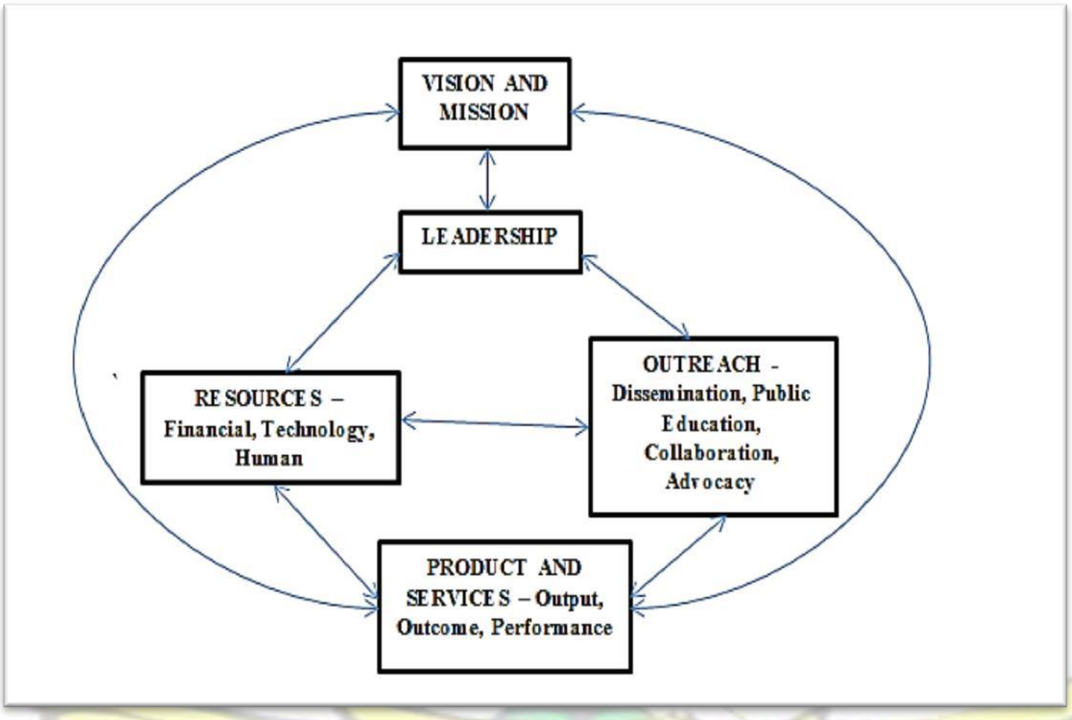

Figure 2.4 Visual Representation of theoretical framework model for Capacity building (Source: De Vit, et al., 2002).

Figure 2.4 exemplifies a mutual background for scrutinizing and assessment of possible conduits for resolving the capability requirements of a non-profit sector. This capacity building guideline has been taken on for this research. The framework establishes five components frequently found in all organizational arrangements. These are vision and mission, leadership, resources, outreach, then products and services. Presented in fig. 2.4 and indicated by the arrows, they are interconnected and reciprocally reliant on each other. They strengthen and support one another in the model; a well fusion of these five components is essential for the survival of an organization. The entire five factors are deliberated fully below, and can be seen as a probable intermediation for improving the capacity the organization capacity.

2.8.1 Vision and Mission

According to De Vit *et al.,* (2002), the vision and mission of an organization afford a worthy introductory level for considering its capability development needs. The vision and mission of an organization does not lone reveal the kinds of activities and services presented. Nonetheless it affects the other four (leadership, resources, outreach, then products and services) elements of the capacity development model. There is no doubt that the vision and mission of an institution will accordingly impact and affect its capability to entice and retain leaders who have common goals, and will in turn influence the organizational setting and maintenance, or refocusing the mission of the organization.

As an organization put in efforts to seek resources either employing staff or looking for funds, its vision and mission cannot be overlooked and that prospective workers must discover a match amongst personal desires, values besides that of the institutions vision and mission (De Vit *et al.,* 2002). Again, the vision and mission proclamation of an organization will outline the outreach events of that organization. Furthermore the vision and mission of an institution will provide an imperative background for assessing the competence of its work force. For the sack of communal responsibility in this era, organizations are urged to prove their accomplishments in a visible manner. The insights of efficiency can be predisposed through the capability of the organization to establish clear and measurable consequences of their products and services.

Granting that vision and mission proclamations are expected to ensure or have lasting abilities, will call for revision from time to time making reassessment and recommitment of vision and mission of the organization is an important foremost steps in answering the question, why we need to or must build capacity?.

2.8.2 Leadership

Robust and effective leadership is the fulcrum of every organization. An organization that succeeds is one that is proficient in enrolling, evolving, and holding capable staff and technical resources. Leadership is the course of persuading an individual or group of people to chart a set of intentions of that leader. Organizations leadership may come from several sources, including qualified staffing, chief executive directors and board members.

Whereas leadership is of an essence to any organization including GCI, it is problematic to describe and capture. Leadership always motivates others by creating activities. Leaders forecast and eloquently express the goals and establish systems and mechanisms to achieve those goals of the organization. Leadership is always and closely knotted to vision and mission of any institution. Leadership have always own vision and can explain those principles which is in line with the mission of the organization. And have an obligation to the mission and a willingness to work toward accomplishing it.

Fundamentally, construction firms need strong leadership because decision making occur at all levels of construction process. This encourages problem resolution and decision making within an institution and releases itself from the constraints of a top to downcast supervision style. Organizational leadership concerns itself with growth and will always drive all the various sub systems to ensure proper supervision at all levels to make the guidelines work by providing human decisions. According to

Gardner (1988a, 1987) leadership has always been individual personnel's who have the influence to make choices and to experience the penalties or significance of those choices.

De Vit *et al.,* (2002) are of the view that Leadership enables the attainment and improvement of resources that can improve the organization's outreach or advocacy activities. In short, the leadership of an organization offers ways in choosing amongst the constraints and alternatives pretended by both inner and outer surroundings. Precisely, leadership always sets the tone for in-house administrative choices and offers an institutional façade to the outside world. Good leaders improves organization's image, prestige, and reputation within the community and are prominent in creating partnerships, teamwork, and other working relationships that progress the goals of the institution.

Resilient headship does create the variance amid accomplishment and catastrophe in executing products and services. It has resilient intellect of proprietorship in their company's activities and set principles for managerial performance (De Vit *et al.,* 2002). Bernstein (1997) is of the view that good leadership insists on brilliance within an organization's performance, and discards gratification and firmness. Amherst H. Wilder Foundation (2000) held that, for capacity developments to actually accomplish its prospects, concerns must be given to the system affecting all individuals, institutions, and groups.

With BIM as a new technology within the construction industry, it will require strong leadership, to take care of space, software, hardware and training. All these have cost implications and require resources to fully implement.

2.8.3 Resources

These are asserts that can be drawn on when needed and are in the form finance resources, technical resources, and human resources. These resources are always in short supply and demand. For this reason every organization will need development plan to manage its resource and this must be aligned to the organizations mission, goals, and tactical trend.

It takes sufficient resources for organizations to fully implement their vision and mission. According to Connoll & Lukas (2002) there is the need for every organization to successfully secure help from a diversity of sources to guarantee that the establishment's incomes are varied, and adequate to enhance the mission plus goals. The development plan on resource is ranged through the mission, and longterm aspiration. De Vit *et al.,* (2002) maintain that every resource in the form of personnel, funding and technology are an indispensable and serious constituent of every organization. They influences the establishment's ability to ensure and maintain its mission, entice experienced and capable leadership, even though resources in itself do not inevitably have to be widespread, they must be managed well. Getting institutional capacity up to date to deliver construction activities and programs has been a continual difficulty of most private sectors, including the construction industry (De Vit *et al.*, 2002)

Resources originate from different sources at all times. Economic resources remain perhaps the greatest dominant facet of the organization's pool of resource since they influence the enlistment of human resources and the procurement of technical resources such as constructing space, software then equipment. According to De Vit *et al.,* (2002) in today's world, technical resources progressively comprise of admittance to computer-based know-hows, such as databases, trailing systems, and, Websites. Computer know-hows and persons with the ability to practice these systems efficiently can expose up fresh prospects, nevertheless these resources are habitually in short supply in most cases.

How and when resources are used is also a critical issue. Training staff periodically is an intelligent use of resource. In a fast moving world, improvement of abilities and overhauling well-known measures can assist and expand limited resources. The improvement of technology has also allowed institutions to use resources in novel and more effective techniques. To Gronbjerg (1993); Smith & Lipsky (1993), the nature of resource use in an organization is dependent on the organization's mission as well as the extent of funding streams available to it.

2.8.4 Outreach

Outreach is described as mechanism for building a fundamental support for an organization or its product. It is important for an organization to engage in publicity to publicize what programs and services to be under take. Vigorous interaction and publicity by an organization will increase access to more people and critical clients. The more people are aware of an institution and its activities, the more prospect there is to entice clients to the institution (De Vit, *et al.*, 2002). The organization's effectiveness in its outreach and networking struggles will certainly have short and long term effects. Outreach will certainly bring about increase in resources available to any institution; however this is not a substitute for an effective tactic to secure fresh and extra resources. According to Galaskiewicz & Bielefeld (1998), organizations without outreach are the ones most expected to tussle then eventually nose-dive in achieving their organizational mission and goals.

2.8.5 Products and Services as a Requirement

Theoretically, the output of an institution and its consequences is the creation of the manifold and increasing collaborations inclusive of the vision and mission, management, resources, advocacy and outreach. The elements of collaborations will together works with the aim to generate an operational productivities and products. Thus promoting and assisting the model to outline the qualities of the finished product. The productivities and products, nevertheless, offer a response circle towards features within the model then does improve or weaken their readiness and aptitude.

Badly conveyed produce and services, for instance, might bring about less resource including human, financial and technical made to the organization. On the other hand, high-grade products and services does upsurge access to resources, build better systems, give adequate perceptibility to the institution, and fortify management (De Vit *et al.*, 2002).

2.9 Capacity Building for BIM Adoption and Implementation Approaches

Successful adoption of BIM within the building industry is reliant on BIM data, and the working practices. CURT, (2010) have the view that each project and client is not the same; therefore there is no fully developed capacity building formats solution for BIM adoption and implementation. The situation calls for a practical guide to help construction firms to adopt and implement BIM technology. BIM adoption can basically operates within an office then require certain software, the need to address information technology matters, training as well as execution the model. Furthermore, BIM implementation can also occur across the design team which also require selecting of software, addressing information technology issues as well as consideration of Legal and contractual matters. Finally, implementation of BIM can also take place across the project delivery team and in this case it requires procedural scope, legal as well as contractual matters (Ahmad *et al*., 2012).

On BIM adoption, researchers such as Construction Industry Council, (2013);

Building & Construction Authority (2013); Bloomberg *et al*., (2012) and Auto-desk, (2010) have put forward diverse tactics for adoption and implementation (Construction Industry Council, 2013; Building and Construction Authority, 2013; Bloomberg *et al*., 2012; Auto-desk, 2010). Among these tactics are inclusive of assessment and collaboration, funding of project, legislative implications and insurance, execution plan of BIM, collaboration of Data, monitor matrix and finalization of execution plan.

2.9.1 Assessment and Collaboration

The requirements of projects and proprietors are uniquely different in methodology of BIM. Knowing and understanding the exact consequences required of BIM always affect the course and methodology. This necessitates a cautious valuation of the organizations' leadership, administrative role and obligation to BIM adoption.

According to Building and Construction Authority (2013) management is a vital tool that drives the execution of BIM within the building industry and it is needed throughout the lifecycle of every project (Gu & London, 2010). Effective managerial team will required designated roles and is a requirement for organizations if they want to adopt and implement BIM. For this reason firms must consider the skillfulness and technical proficiency of their personnel's in software knowledge, experience, and training of personnel (Messner *et al.*, 2012). Again BIM technological awareness and training programmes must be provided with the view to generating awareness of BIM technology (Gu & London, 2010). Furthermore high-ranking technical officers, managers and executives of organizations must invest in the BIM technology resulting in the development of human resources who are able to bid for projects that require BIM; there by providing organizations with strategic direction for BIM adoption.

For easy implementation of BIM, firms must have the required logistics and must establish workflow beginning from evaluation, setting up and creating accessible resources meant for initialization of BIM project with software application. Gu & London (2010) acclaim the difussion of technology to positively impact the knowledge of users with the view to modifying this technology to fit individual organisational needs in order to efficaciously improve construction delivery of projects.

Construction Industry Council (2013) urges for localised collaboration among industries so as to improve and hasten the indispensable standards, etiquettes, practices, legislative outlines and educational programmes in harmony with satisfactory implementation plans, targets and scale. Considering all these it is obvious that human resources can considerably become a hindrance to smooth adoption of BIM.

2.9.2 Project Funding

Project funding and cash flow has been identified as an area which needs considerations during BIM adoption. It is essential to create project milestone forecast, to appreciate when cost will be incurred and in what way to fund the project. This approach varies from the traditional delivery technique in that additional resource and efforts are spent in the earlier method to confirm better proficiency in the cause of construction (CURT, 2010). Presently, trends have shown extraordinary budget of software application and hardware in the area of exceptional computers tied to the high cost of specialized training and preparation to allow smooth adoption of this new technology (McNell *et al.,* 2011; Xu *et al.,* 2014).

BIM projects are known to have lesser completion cost but have great cost for effecting a spatial organization and production fitting drawing after bidding as compared to conventional techniques. It has been established by (CURT, 2010) that modest pricing for gears, resources and joint technique selection is a major key element specially provided to enhance value stream of project. In addition to this the question that model owners continuous to contend with is who is to fund BIM project

(Gu & London, 2010). According to Both & Kindsvater (2012) firms yet to accept BIM contend that funding resources for BIM in the area investment remains malignant to adoption of BIM

The budget of using BIM has always included buying software, getting supporting personnel's, modernizations of hardware, network configuration and initial high cost of training professionals. All these costs must always be considered (Xu *et al.*, 2014).

2.9.3 Legislative Implications and Insurance

BIM agreements are design vary from conventional contracting techniques known in the construction industry and might necessitate review of legislation and indemnity insurance arrangements to safeguard compliance with corporate environment. The issues of collaboration and distribution of information, the problem of accountability between stakeholders, require legislative solutions (CURT, 2010). For this reason contract forms, agreement, and procurement system ought to be reviewed such as what the US and UK have done. This means that traditional technique of measurement, BIM information or data insertion in agreement; suitable sections and clauses must be integrated in BIM contract. Also payment practices to facilitate BIM process are easy means to BIM adoption among different stakeholders (Construction Industry Council, 2013; Porwal & Hewage, 2013; Smith, 2012).

BIM technology is very significant but is not devoid of dangers including ineffective and expensive insurance policies. The present difficulties and concerns of BIM project has been proprietorship and content control since it permits all stakeholders to have access to work of the other member's intellectual property (Mycock, 2012; McNell *et al.,* 2011). The situation bring about errors in the model and it might be problematic to know who and under what condition the error happened. McNell *et al.,* (2011) observe that there have been some court cases presenting an insight into BIM legislation, risk and accountability for future use. Yet, the legislative regulation of the building industry on this new know-how is in evolution and developing.

Large research such as Construction Industry Council (2013); COBIM (2012); National BIM Report (2012); Mycock (2012); Det (2007) and Khemlani (2005) have it that some governments in developed countries have promulgated laws to enforce the adoption of BIM. They have made BIM a key requirement in the delivery of projects and have instituted targets to phase out conventional practices. Implying that, BIM adoption and accomplishment in any nation is dependent on the legislations of that country. For instance the Ghanaian construction industry will greatly and best appreciate the technology when supported by the legislations of the country.

Furthermore, Xu *et al.,* (2014) advocate for indemnity on the know-how since financing an unaccustomed technology is risky and attract higher cost of insurance. Nonetheless, complete adoption of BIM know-how will moderate faults and
oversights (McNell *et al.,* 2011).

Porwal & Hewage, (2013) affirms that BIM project advances imperative contractual matters in relation toward duties, danger, contractual protections, patents and usage of documents not inconsonance with normal industrial contract form. Intellectual Property

(IP) and patent matters can be relieved through more consciousness and legislative actions. BIM Intellectual Property is legislative matters, which no longer different from IP issues prevailing in current practice (Gu & London., 2012).

Organizational and legislative BIM framework varies from country to country (Volk, *et al.*, 2014). Current contractual arrangements cause disagreements and inadequacies since it inspires stakeholders to worry themselves with its individual benefits (Ghasseni Becerik-Gerber, 2011). It is thus significant to resource the inner legitimate personnel's and train more legal personnel to address the apprehensions and seek explanation that will essentially enhance BIM process to attain its benefits (CURT, 2010). Several construction firms have limits or legislative limitations that prohibit a unified form of contract, however a collaborative development can take place under any kind of contract and this must be considered.

2.9.4 BIM Execution Plan

This is a tactical tool that aid in planning an effective communication of the BIM team from the early planning stage, to the design and construction period. It is an important tool that assists with post-construction information which defines the project various inputs and uses (National BIM Standard, 2012). Also, it summarizes how a project is to be organized, executed and administered with BIM processes; and further provides data for management and the planning team (Bloomberg *et al.*, 2012).

Roles and duties of stakeholders and a precise contract plan for an organization is important. This is confirmed by Bloomberg *et al.*, (2012) explaining that execution plan offers in details the responsibilities and roles of all stakeholders to enhance growth in BIM development, hence improvement in construction delivery. It contains a complete project brief from the client, which is further developed through the collaboration of all construction stakeholders (Bloomberg *et al.,* 2012). During the execution planning process, stakeholders on construction project must always get involved (Messner *et al.,* 2012) in order to guarantee model accuracy (BIM execution planning guide, 2012). A thoughtful style to BIM execution plan ought to set a strong and clear expectation amongst team players (McNell *et al.*, 2012).

The execution plan is put into four platforms and is anticipated to guide successfully the client, and project stakeholder by providing complete and reliable project plans (Messner *et al*., 2012) as shown in Fig 2.4 below.

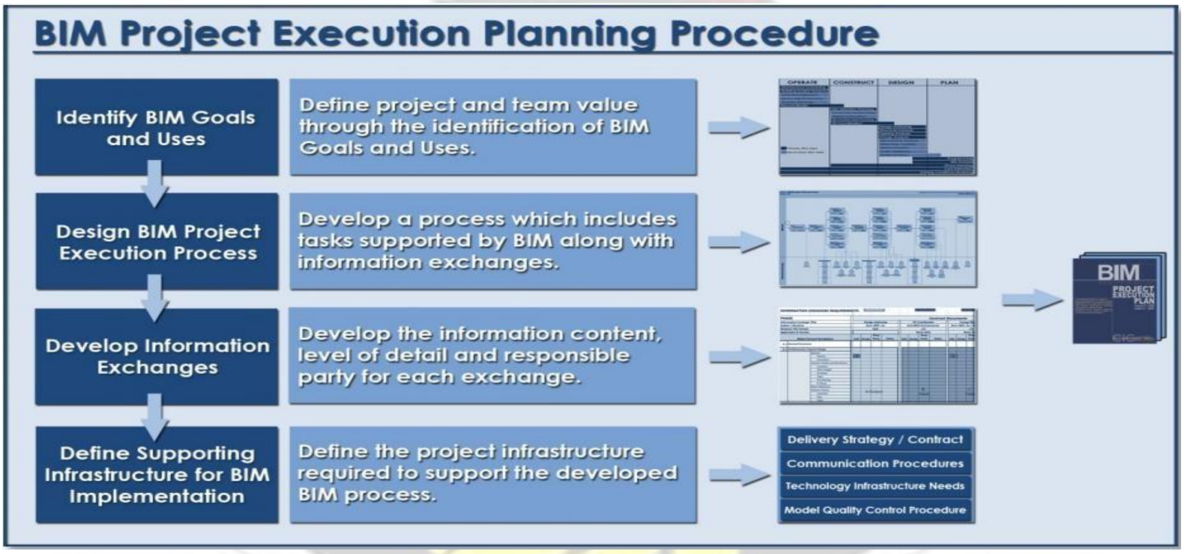

Figure 2.4 BIM Project Execution Planning Procedure (National BIM Standard 2012)

a. Identify high value goals and uses for a BIM project

The first point in the planning stage of every project is to identify the appropriate technical personnel of BIM users, with the project demands, goals and the possible risk allocation into consideration. This aid in specifying an implementation plan and goal for BIM which are linked to the performance of the project inclusive increase efficiency and productivity of the processes, eliminating delays, enhancing excellent produce and services, and budget impact reduction of projects for effective control of the facility (Messner *et al.*, 2012; National BIM Standard, 2012).

b. Designing the Project Execution Process of BIM

Messner, *et al.*, (2012) and the National BIM Standard (2012) maintain that the design plan for BIM implementation is important. It outlines the processes and inputs that must exist among the basic BIM users in project delivery. This enhances an appropriate meaning to the implementation of BIM and effective tasks performance within the team.

c. Develop Information Exchange Requirements and Deliverables

As soon as the precise process plans are developed, the information deliverables and exchange requirements ought to be clearly acknowledged. Information deliverables and interactions within the processes of project are lethal to a successful BIM implementation. This is vital to project stakeholders in order to understand the information content for each information exchange contract. In addition, an understanding of the information flow to the team is crucial to users of BIM. There is the need for an information exchange questionnaire to solicit information to be used to finalize and design for this purpose at the early stage of the project (Messner *et al.*, 2012; National BIM Standard, 2012). Hence, it is important to specify the right information in time to promote BIM processes (National BIM Standard, 2012; Hopper & Ekholm, 2011; BuildingSMART, 2011).

d. Define BIM implementation supporting infrastructure

Project stakeholders are responsible to acquire the required systems and structure towards the support of BIM process. Besides there is the need to outline the implementation structure, agreements, contractual linguistic, communiqué processes, and technological groundwork (Messner *et al.*, 2012; National BIM Standard, 2012). They argue that achieving high quality information models will require quality control identification procedures.

e. Pre-Planning of Project

Pre-planning of project is the hallmark for active project execution. This is essentially vital for an effective implementation of BIM on a project. Pre-planning requires gathering the right technical team especially on projects using BIM (McGraw Hill, 2009) as well as setting the right standards and ethics. Standardization is an important supporting element meant to simplify and secure contracting in case of model change for easy extraction of data (Both &Kindsvater, 2012). This view is supported by Isikdag *et al.,* (2007) asserting that BIM is heavily reliant on standards thereby making standards a fundamental enabler and facilitator of BIM model and that it must be taken into consideration during pre-planning period. Hence the power of BIM is in its ability to communicate to stakeholders through the entire project lifecycle (Construction Industry Council, 2013).

f. Project Team

Gathering the right technical personnel is essential in project pre-planning (McGraw Hill, 2009). The technical maturity, qualification and knowledge of these personnel on BIM projects are critical factor worth considering finding a good BIM project team.

Early inclusion of contractors/consultants will lead to an effective project delivery (CURT, 2009). This knowledge thus influences the information entered into or produced from the model. For desired implementation strategies and goals, BIM experts who are required should be available in your locality.

It is important that the stakeholders of BIM must possess good attitude which is aligned to the firms' goals and objectives towards BIM adoption. All these together ensure a successful BIM whereas, averse stakeholders believe BIM does not exist and will not work.

2.9.5 Assignment of Roles and Responsibilities

Gu & London (2010) contends that to adopt BIM requires a complete change of work practice. Mostly roles and responsibilities of the stakeholders in the BIM development do not vary from that of conventional delivery procedures. However, variation in personal contribution to the model is highly significant as compared to any traditional practices (National BIM Standard, 2010).

In assigning for an Information manager, Gu & London (2010) recommended some basic qualities in communication and leadership to be able to inform BIM team on their roles and responsibilities in this ever changing world.

2.9.6 Data Collaboration

Stakeholders in the construction industry collaboratively contribute to generate, modernize, analyze, collaborate then integrate BIM models Gu & London (2010). Research confirms the creation of a repository library by stakeholders to enhance an effective collation of data, management and sharing to promote and reconcile design to construction, operation to maintenance in a unit portal (Construction Industry Council, 2013; Aakanksha 2010).

BIM is rich in data, object-oriented, intellectual and parametric arithmetical depiction of the facility. Information in its repository can be extracted and scrutinized to generate desire information required by users to make resolutions then to advance the process of project delivering (Construction Industry Council, 2013). BIM has a multiple integrative tools and varying levels of integration which creates data for multiple uses (COBIM, 2012). Individual data contribution to the model should be checked, approved and given-off to the library for collaborative use (Construction Industry Council, 2013).

This collaboration requires a sole repository library which uses a common server from which all information are drawn by BIM stakeholders. BIM data should be stored well, sharing and access permission to its usage and updating should be considered in detail; provision guideline for stakeholders to manage, maintain data to retain accurate up-to-date should be well-thought through (Construction Industry Council, 2013).

It is necessary for the construction industry to re-orient themselves' towards BIM technology as mode of project execution is changing per advancement in technology in reducing manufacturing process, adding value and information sharing and collaboration throughout the project lifecycle is becoming more popular (Isikdag *et al.*, 2007). Accordingly, the establishment of common info environment and work culture in the construction industry is essential to BIM info exchange.

2.9.7 Monitoring Matrix

There is the need to establish metrics to ensure and track the success of project at the project pre-planning stage and also regularly monitor against project goals and project delivery methods. This metrics must embrace milestone durations, enhanced security, performance goals, sustainable outcomes, request for information, change remits, value, program, budget, and procedures considered important to the project stakeholders (CURT, 2013)

2.9.8 Finalization of Execution Plan

Georgios & Olafur (2013) opines that it is critical to appreciate the documentation of the overall administrative structure and processes so as to improve them. Additionally checkpoints and metrics for regular measurement and valuation are to be undertaken to ensure compliance with budgetary development, schedule, quality control and assurance procedures need to be established. Furthermore according to Autodesk (2010) there is the need to put in place and monitor project milestone periods for design choices, by determining how frequently to apprise the BIM technology; during project construction, after construction and throughout project lifespan.

Stakeholders need to decide in advance regarding how to handle field changes and how to incorporate the BIM processes before project completion and project turnover package.

In making such decision, the process needs to be opened, timeously, collaborative and also define how to measure success in their operations (Autodesk, 2010).

Stakeholders including contractors ought to be encouraged to remove redundant work procedures through close teamwork. Autodesk (2010) contends that BIM tools ought to certify the standards then execute the functions to achieve the set goals and objectives.

Porwal & Hewage (2013) contend that, unique definite technique to expedite BIM adoption well be to make BIM technology mandatory for every public sector project; hence a calls for a legislative mechanism to be enforced by government of Ghana for BIM adoption.

2.9.9 Implementation Strategy of BIM

For a successful BIM adoption, it will require implementation tactic. Arayici, *et al.,* (2011) put forward seven (7) mainstays of a BIM implementation. These tactic include elimination of excess, intensification of response, postpone resolutions to realize unanimity, speedy delivery, ensure reliability, provide resources to the stakeholders, and then provide strict management. The realization of this ensured that managers of project and their firms are bound to have better productions of project and the products.

To promote BIM, managers of project and their firms are best qualified to do so since they ensure great control on resources and project stakeholders (Gu & London, 2010). In considering BIM significance and the challenges to be overcome, there is the need for effective multi-disciplinary collaboration among stakeholders, which is supported by extreme usage of BIM (Sebastian, 2011). The disjointed nature of the building industry is to be considered at all time in order to promote BIM adoption.

2.10 Existing BIM Research Strategy, Design, Process Sampling, Technique and Sample Size Determination

It is important to consider the existing BIM research design in the conduct of this study. This is to enable the identification of existing gaps as far as the BIM research is concern in order to address them. For instance, Stanley & Thurnell, (2014) in their work on "the benefits and barriers of 5D BIM implementation for quantity surveying in New

Zealand" adopted structured interview with purposive sampling to select a sample size of 8. Considering the popularity, usage, adaptability and adoptability that BIM is gaining, it is appropriate to conduct studies that involve appreciable level or number of participants. This study addressed this gap by adopting survey process with larger sample size to gather information from a broader spectrum of contractors who use BIM. The purposive and non-probability sample adopted by Stanley and Thurnell (2014) could be appreciated because BIM technology has not caught up with most contractors, it would be right to adopt purposive and non-probability sampling method, in order to have the right respondents (Contractors personnel) with knowledge and resources to adopt BIM.

Also, structured interviews are best for smaller sample size as in Stanley and Thurnell (2014). However, because of the large population size of Ghanaian contractors, survey questionnaire was used to aid in the gathering of data from appreciable number of respondents. In this study of purposive sample technique was employed; a practice that encompasses the choice of individuals who sufficiently represent the preferred populace for the resolution of this study.

In a similar manner, Won *et al.*, (2013) in their research ''Where to focus for successful adoption of building information modeling within organization" used interviews and survey questionnaires. Also Purposive, non-probability sampling technique was used to choose 6 interviewees and 206 study questionnaire with only 52 respondent in a study conducted on four continents. A study being conducted on four continents ought to have larger sample size to reflect more binding and consistent data collection. To address this gap in BIM research design, this study focused on selecting appreciable number of respondents to improve on the existing research design for BIM.

Wei and Raja (2013) in their study "Impacts of BIM on talent acquisition in the construction industry" adopted online survey questionnaire with purposive and non-probability sampling method. The sample size used was 840 survey questionnaires. Data analysis was descriptive statistics with only 99 respondents out of 840 survey questionnaire administered; it is possible the online survey was not effective as a result of the lack of possible face to face contact. For effective data collection with high respondent rate this study will not use online survey questionnaire but rather face to face administration of questionnaire to create good relationships between the researcher and the respondents.

Peterson *et al.,* (2010) adopted case study method for their research- "teaching construction project management with BIM support: Experience and lessons learned". Purposive sample sizes of two Universities using qualitative analysis were used. The shortfall in the research was that data was collected on ad-hoc bases often irregular and unsystematic. However, this study is improves on the existing research design by collecting data in a systematic manner within a specific period of time. Even though qualitative analysis was used it was as a result of the case study method adopted.
However, quantitative analysis was appropriate considering the survey questionnaire used in the conduct of this study. This is supported by Dainty (2008) who has established that quantitative approaches dominate research works in the construction industry. This is followed by a mixture of both quantitative and qualitative procedures and that the use of only qualitative procedures is the slightest popular among research procedures adopted in construction and building related study.

A quantitative approach implies the search for measurable knowledge; it describes, and offer explanations to occurrences of realism. Often it is formal and wellstructured in character. To Malhotra (2007) quantitative research quantifies and, statistically analyses the data. It is also a numerical data collection that describes, clarifies, forecast and regulates occurrences of importance. Finally quantitative approaches offer additional valid information taking into consideration the research

Table 2.2 Summary of BIM Related Research Design

Reference	*Method*	*Sampling Techniques*	*Data Analysis*	*Lag*
Stanley & Thurnell (2014) 'The benefits of, and barriers to, implementation of 5D BIM for quantity surveying in New Zealand', Australasian Journal of Construction Economics and Building, 14 (1) pp. 105-117	*Structured Interview*	*Purposive, non-probabilistic sampling Sample size 8*	*Thematic Analysis and*	
Won et al., (2013) "Where to focus for successful adoption of building information modeling within organization." Journal of Construction Engineering and Management 139.11.	*Interviews and Questionnaires*	*Purposive non-probability sampling, (Sample 6 interviews, 206 survey questionnaires*	*quantitative data analysis*	*Only 4 continents responded with 52 response*
Peterson et al., (2010) Teaching construction project management with BIM support: Experience and lessons learned. Automation in Construction. 20(2), pp. 115-125.	*Case Study*	*Purposive Sampling (Sample size 2 University)*	*qualitatively analyze (Descriptive Analysis*	*Data was collected on ad hoc basic, often irregular and unsystematic*
Yusuf, A., Egbu, C. & Coates , P., 2012. Building Information Modeling (BIM) Implementation and Remote Construction Projects: Issues, Challenges, and Critiques. Journal of Information Technology in Construction, Volume 17, pp. 75-92.	*Case Study (qualitative and quantitative approach)*	*Non Probability Sample (Sample 2 institutions*		
Khosrowshahi & Arayici (2012). Roadmap for implementation of BIM in the UK construction industry. Engineering, Construction and Architectural Management, 19(6), pp. 610-635.	*interviews and questionnaires*	*Sample size 8 organisations*	*quantitative data analysis*	
Wei Wu and Raja R.A. (2013) Impacts of BIM on talent acquisition in the construction industry In: Smith, S.D and Ahiaga-Dagbui, D.D (Eds) Procs 29 th Annual ARCOM Conference, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, pp. 35-45.	*Online Survey Questionnaire*	*Purposive and non-probability sampling, (Sample size 840 survey questionnaires*	*Descriptive statistics*	*Only 99 responded*
Eadie et al., (2013) BIM implementation throughout the UK construction project lifecycle: An analysis Automation in Construction 36. Pp.145–151.	*A Pilot Survey and three semi structured interviews*	*Purposive and A random sample (Population 6958 sample size 148)*	*relative importance index (RII)*	

. scope. Nevertheless, Ghauri & Gronhaug (2002) are of the opinion that qualitative approaches are flexible and might be adopted to exploit detailed research question. It is important to note that survey questionnaire is an organized questionnaire given to a population sample intended purposely to obtain precise and detail evidence from respondents (Malhotra & Peterson, 2006). It is a well-known approach adopted in professional study which permits the gathering of a large quantity of data from a considerable populace in a greatly efficient technique such as this research. Summary of these related research are shown in Table 2.2 above.

2.11 Chapter Summary

BIM unifies all the technical stakeholders and manages construction project throughout its life-cycle. Obviously, BIM technology is a new development, yet evolving and beneficial to the construction firm. BIM software packages includes
Autodesk Architectural Desktop, Autodesk Revit, ArchiCAD, Bentley Systems, Graphisoft and Nemetschek. Lawful matters like proprietorship of BIM models, the right to the information confined in the BIM models have been problematic to stakeholders during implementation.

Though BIM is widely accepted in the building industry, the absence of persons with BIM abilities and knowledge is a significant problem hampering its effective utilization.

BIM adoption and implementation requires capacity building in the area of assessment and collaboration, project funding, legislative consequences and insurance. Also, BIM execution plan which include; identification of high value BIM goals and usages for a project, designing the BIM project execution procedure, developing information deliverables and Exchange Requirements, and defining supporting infrastructure for

BIM implementation. Capacity building of Project team members, issues of data collaboration, monitoring matrix and finalizing execution plan are essential.

Implementation Strategy of BIM will be to remove excess, increase response, postponement of resolutions to realize compromise, ensure integrity, resource project stakeholders, and then provide management. When these are observed managers of project and their firms will have improved project productions along with products. A successful adoption and implementation of BIM is heavily reliant on BIM data model, working procedures, logistics and capacity for easy implementation of BIM.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter considers the background and reasons for choosing a particular research methodology and various steps taken by the researcher to arrive at the objectives of this study. Also, the chapter considers proposed research method; research ethics, research design, research procedure, population size, target group and sample determination that would help to achieve the aim of developing a guideline that will support contractor's capacity building to enable the adaption and implementation of BIM in Ghana. These gives meaning to the research work having in mind the research problem and research questions. Furthermore the chapter discusses methods and techniques used in gathering data, development of questionnaires, sources of data and data analytical tool to be used for the research.

The conclusion of every research is openly connected to the methodology adopted and subsequently the achievement and soundness of the research depend critically on the suitable selection and application of the research technique (Naoum, 1998; Fellows & Liu, 2003). To Naoum (1998) when the purpose of a research is arrived at and an indepth study review has been finalized, it is required to detail the research design.

The method offers appreciation of the way the research was organized then conducted in order to get the needed information. This procedure adopts survey questionnaires on contractors in Accra in the Greater Accra region of Ghana. Also, information obtained from the various firms and their personnel was processed and analyzed.

3.2 Philosophical Stand Point of the Research

A large body research including Koetting (1996) and Christou *et al.*, (2008) share the view that theoretical probes of life of knowledge, and worth, need momentous effects on the design of the research. Guba (1990) has observe that research paradigm that is positivism; precarious theory and constructivism remain the fundamental guiding principles that monitor an act.

This research considers the positivists approach to knowledge by verifying facts; and establishing scientific knowledge (Bryman, 1992 *c.f* Osei-Hwedie, 2010), thus considering the identification and analysis of BIM practices within construction firms in Ghana. Also, because of the adoption of BIM by contractors in Ghana, there exist peripheral evidences outside the scope and impact of the researcher objectivism, and ontological position was considered.

3.3 Research Procedure

The research procedure adopted for this study was the method of sampling, instruments for data collection, and procedures involving review of literature, data collection and data analysis.

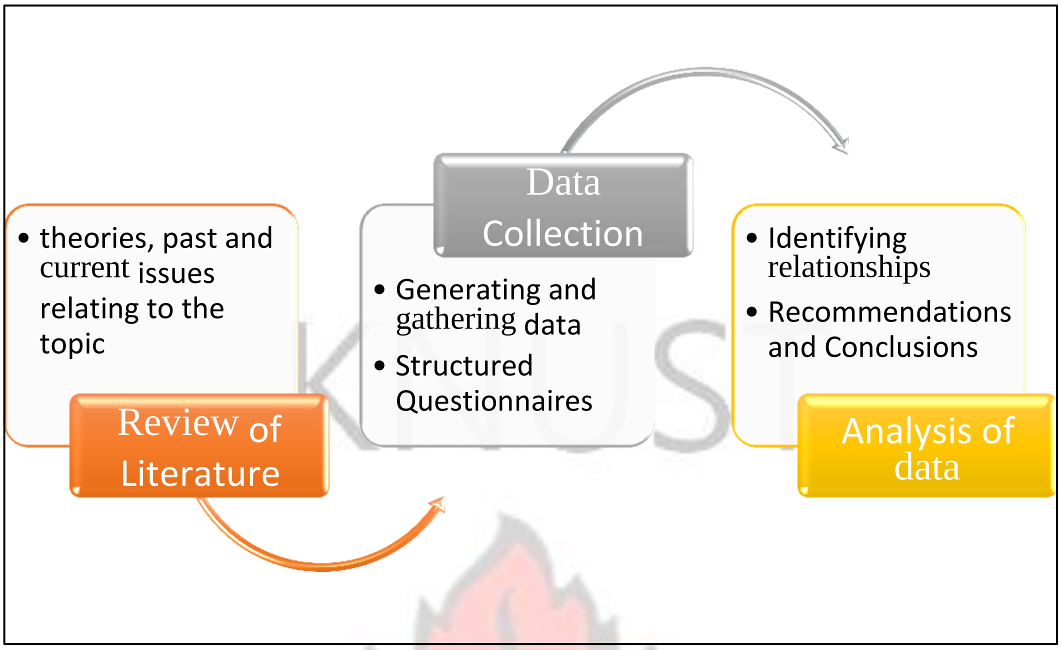

Figure 3.1: Flow process chart of research procedure

3.4 Population Size, Target Group and Sample Determination

BIM is an emerging technology to construction firms. Its adoption and implementation implies significant cost impact on three major areas including hardware, software and workforce. A major barrier to BIM adoption and implementation has been the high investment budget of the know-how which includes setting up cost, cost of training cost of hardware and software. This is confirmed by Thurairajah & Goucher (2013) and McGraw-Hill Constructionreport (2012) that small-medium enterprises (SMEs) are faced with funding difficulty in acquiring software applications and hardware upgrading while high class construction firms (contructors) are capable of meeting the demands. These influence the kind of selection for the study D1K1 contractors registered with Ministry of Water Resources, Works and Housing were considered. It further focused on Accra, the regional capital of Ghana because major multi-national construction activities on large-scale is always present. Also research confirms that construction is massively skewed to Accra the capital of Ghana in the Greater Accra than other regions (Amoah, *et al*., 2011).

Polit & Hungler (1999) describes the technique of purposive sampling as a nonprobability sampling technique involving considerable choice of certain issues to be incorporated a study. This technique was used to identify main respondents in construction firms in Ghana. It usage is suitable in circumstances where the number of components within the populace is either unknown or cannot be identified individually (Kumar, 1999). The reason is that the researcher required some groupings of respondents who had been involved in some level of construction projects and consequently had some experience with the use of BIM in construction and management programmes adopting industry perceptions, to answer the questionnaires.

A list of the registered D1K1 contractors was obtained. Snowballing was used to identify those who were in active business with ongoing projects. Based on the snowballing used, a sample of 35 contractors was obtained from the study area- Accra metropolis. Furthermore, firms were selected on the bases of their experience and the type of project being executed and are being undertaken in terms of the complexity and the use of computer software technology. Data collection adopted the purposive and snowball sampling method. Questionnaires were administered to all firms identified in the sample. These were professionals (Quantity Surveying, Civil Engineering, Geodetic Engineering, Mechanical/Electrical/Plumbing, Architectural, and Project Management) who are members of the respective professional bodies such as Ghana Institute of Architect, Ghana Institution of Surveyors, Ghana Institute of Engineers, Ghana Institution of Construction and others within the sampled firms.

These provided the provided answers required to the questionnaires.

3.5 Sources of Data

To ensure the reliability of the 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, evolution, and development; significance of BIM to construction firms; challenges to successful implementation of BIM; global development of BIM; BIM software packages; the structure of the Ghanaian construction firm to BIM implementation; Stages or Levels of BIM; Guidelines for Capacity development for BIM adoption and implementation and finally implementation strategies of BIM. The review on these precarious topical areas and the variables identified during the literature review were used as source of information for the development of the questionnaire. This provided comprehensive fundamental basis for the design of reliable questionnaire to be administered to respondents during the field survey. Thus secondary source of data were used.

3.6 Questionnaires Development

Rattray et al., (2004) opined that the use of questionnaires as a tool for collecting data in recent times for research is recognized internationally by questionnaires promote the gathering of information in a standardized way which, when collected from a representative sample of a distinct population, will allow the inference of consequences to the broader population (Rattray & Jones, 2005). The responses from questionnaires are then converted to numerical form and are statistically analyzed. This becomes the crucial operational concepts within which specific research questions, aim and objectives become important and satisfactory to the target group

(Brace, 2004). The questionnaire was structured into five (5) sections. These are; **Section A:** Demography

Section B: Challenges of BIM to the Ghanaian construction firms

Section C: Significance of BIM in Ghanaian construction industry

Section D: Software usage in BIM

Section E: Guidelines for Capacity building for BIM adoption and implementation approaches

The questionnaire started with an overview, outlining the study theme; research aims and objectives. It also considered the management and what the information gathered from respondent are to be used for. This is to convince respondents of their confidentiality and discretion. Adequate guidelines were given in simple English wording to guide respondents in providing answers to the questions asked in the questionnaires. The questions asked in the questionnaire were closed-ended questions on A4 sheets and allow respondents to tick the appropriate answers on a likert scale.

Section- A establishes the demographic features of the respondents. This is to ensure that respondents fall within the scope of the study i.e. construction firms with D1K1 certification in Accra the capital city of Ghana. The questions solicited the qualification and background educational of respondents to establish the skills and competence, attained in the past years within the construction firms.

Section- B, C, D and E were questions developed with the help of the information resulting from literature review in order to ask questions that are relevant to the investigation. The style and ease of reading and appearance were the guiding principles for the design of the questionnaire so that the respondents will enjoy answering the questions during the data gathering process. It captured the BIM concept, evolution, and development; Significance of BIM to construction firms; Challenges to successful implementation of BIM; BIM software packages; Stages or Levels of BIM; Guidelines for Capacity development for BIM adoption and implementation and implementation strategies of BIM. The likert-type scale used fixed choice answer layouts and were intended to measure attitudes or opinions (Bowling, 1997) as well as the reactions of respondents from one (1) to five (5) in ascending order, significance efficacy, and severity depending on the nature of the questions asked.

3.7 Distribution of Questionnaires

The survey questionnaires were distributed personally to ensure the proposed respondents answered the questionnaires in full and are retrieved with little effort so as to enhance the response rate of the study.

3.8 Data Analysis Tool

The data received were imputed into Statistical Package for Social Science (SPSS) version 20, accumulated and later conveyed into the Microsoft Excel 2010 for analysis using descriptive statistical tools and measures namely tables; mean and standard deviation; Relative Importance Index (RII), and factor analysis.

The ultimate notion underpinning factor analysis is its capability to statistically influence the empirical interactions amongst numerous variables to help in enlightening speculative concepts of relationships (Kreuger & Neuman, 2003). It addresses some relevant matters relating to the right sample size for accepting and creating the reliability of factor analysis (Field, 2005a, b). Thus analysis factor is valuable for decreasing a mass of information of an economical explanation. The administration, analysis, and appreciation of such statistics are facilitated through reduction of mutual factor patterns. These factors pay attention and index the dispersed information in the original statistics and can consequently substitute the mass data features without great loss of information. The variables used to measure BIM guidelines of capacity developments of Construction Firm were excessively huge and hence factor analysis was conducted to reduce the information into an economic description. Relative Importance index (RII) was applied to factors generated from factor analysis for further analysis. Before conducting principal component analysis, two tests were done to screen the presence of correlation among the items and then appropriateness and correctness of factor analysis. The two tests considered are Kaiser-Meyer-Olkin (KMO) and Bartlett's tests. KMO enumerates the grade of inter-correlation between variables and the relevance of factor analysis (Field, 2005). KMO measure is performed to check the degree of inter-correlation between the items and the appropriateness of factor analysis. Kim and Mueller (1978) suggested that KMOs in the range of 0.5-0.6 are considered poor, those in the range of 0.6-0.7 are average, those in the range of 0.7-0.8 are considered good, 0.8-0.9 are great and values bigger than 0.9 are considered excellent.

However, KMO and Bartelette Spherity were not able to generate data due to nonpositive definite (NPD), thus, some of the eigenvalues of the correlation matrix are not positive numbers. Due to this case, there was a footnote to the correlation matrix.

With the exception of the demographic information, relative importance index was used to rank each section to determine the significant factors because, according to Enshassi *et al.*, (2007) analysis of data on Likert scale 1-5, the request of Importance Index is also appropriate. Variables with high significant effect could be observed through this method because unlike the mean that could be influence by extreme values (outliers), relative index weigh each variable in relation to other variables.

Furthermore mean scores with their standard deviation were used to measure the average ranking of each variable.

3.9 Chapter Summary

The chapter deals with the research methodology and procedures of this research, explaining the selection of sample, description of the technique used in designing the instrument and collecting the data. It also offers justification for the statistical measures used to analyse the information. Finally, chapter is dedicated to the analysis and conversation of the survey outcomes

CHAPTER FOUR

DATA ANALYSIS AND RESULT DISCUSSIONS

4.1 Introduction

After gathering the required data through the survey questionnaire, as discussed in the preceding chapter, the analysis and discussion of results from the study were exhaustively presented in this chapter. Due to the large volume of variables that was generated from the survey, it was imperative to separate the variables according to the specific research objective or question it seeks to answer.

4.2 Demographic and Characteristics of Respondents

The presentation of the outcomes from the survey data on the demographic of respondent was scrutinized using descriptive analytical method. Table 4.1 below represents the results of various variables.

The professional background of the respondents demonstrated that 27% were Structural Engineer and Project Managers, 23% were Structural Engineers, 13% percent were Quantity Surveyors, Architects and Project Managers each. The other professions were Architect and Project Manager and M. E & P representing 7% and 3% respectively. The results showed that some of the respondents had multiple professions; Civil or Structural engineers and Project Managers and Architects and Project Managers. Profession of the respondents exhibited normal distribution. The number of years respondents have been practicing their profession was also important as far as the quantum of information they have gathered over the years is concerned. It was observed that majority of the respondents have practiced their profession between

5-10 years, representing 70%. A considerable number of the respondents have practiced their profession between 11-15 years and 20% have practiced the profession for less than 5 years.

Table 4.1: Characteristics of Respondents

	Categories	***Frequency***	***Percent***
	Quantity surveyor	*4*	*13*
	Civil or Structural engineer	*7*	*23*
	Architect	*4*	*13*
	Project Manager	*4*	*13*
Professional background	*M, E& P*	*1*	*3*
	Civil or Structural engineer and Project Manager	*8*	*27*
	Architect and Project Manager	*2*	*7*
	Total	***30***	***100***
	Under 5 years	*6*	*20*
	5-10 years	*21*	*70*
professional experience	*11 – 15 years*	*3*	*10*
	Total	***30***	***100***
	Small Renovation Contractors	*1*	*3*
	General Contractors	*27*	*90*
Type of organization	*Real Estate Developers*	*2*	*7*
	Total	***30***	***100***
	Post Graduate First	*26 4*	*87*
Education level	*Degree*		*13*
	Total	***30***	***100***
	Ghana Institute of Architect	*6*	*27 9*
Membership of professional bodies	*Ghana Institution of Surveyors*	*2*	*64*
	Ghana Institute of Engineers	*14*	
	Total	***22***	***100***
	Yes	*28 2*	*93*
Knowledge of Building Information Modeling	*No*	***30***	*7*
	Total		***100***
	Yes No	*6*	*21*
Firm practicing BIM		*23*	*79*
	Total	***29***	***100***
Firm willing to adopt and implement BIM in the future	*Yes*	*29*	*100*

The study revealed that 93% of GCI have knowledge about the prospects of BIM, but surprisingly, 79% of the surveyed firms do not practice BIM even though 21% of the firms practice it on a small scale. This is confirmed by, Bentein & Pittman (2004) that the adoption of BIM is always in a slow pace, whereas the rate of adoption differ per country (McGraw-Hill, 2009; 2007). Undoubtedly, the knowledge of BIM is spreading in Ghana as purported by Jongeling (2008), so is the gradual acceptance and eventually fully adopting it. It was clearly shown that the respondents including those whom their firms were not practicing BIM said their firms will adopt and implement BIM in the future.

Table 4.2 showed the level of understanding the respondents have in BIM in their organization. All the respondents indicated that they have some knowledge of BIM as a concept, 97% percent said they have the understanding of BIM software application skills and 17% understand BIM standard. It was observed from the results that, respondents' level of understanding on the knowledge of BIM concept and BIM software application skills was very high. Understanding of BIM standards was observed to be very low.

Table 4.2: Level of understanding do you have in BIM in your organization

	Yes		*No*	
	Frequency	*Percent*	*Frequency*	*Percent*
BIM Software application skill	*29*	*97*	*1*	*3*
Knowledge of BIM concept	*30*	*100*	*0*	*0*
Understanding BIM standards	*5*	*17*	*25*	*83*

It was observed from Table 4.3 that at least six departments were found in each firm. The departments that were not in all the firms were Geodetic/Geomatic Engineering, Mechanical/Electrical/Plumbing and few of them do not have Architecture and Design.

Table 4.3: Number of Departments in the Firm

	Yes		*No*	
	Frequency	*Percent*	*Frequency*	*Percent*
Quantity Surveying	*26*	*87*	*4*	*13*
Structural/Civil Engineering	*28*	*93*	*2*	*7*
Geodetic/ Geomatic Engineering	*2*	*7*	*28*	*93*
Mechanical/Electrical/Plumbing	*8*	*27*	*22*	*73*
Architectural	*21*	*70*	*9*	*30*
Project Management	*29*	*97*	*1*	*3*
Procurement	*29*	*97*	*1*	*3*
Logistics and Store/Supply	*28*	*93*	*2*	*7*

4.3 Discussion of Results

4.3.1 Discussion of Results on Challenges of BIM Adoption by contractors in Ghana.

A number of empirical studies have been conducted to investigate the challenges evolving around the implementation of BIM. The following challenges were extracted from literature. This study had an interest in investigating the challenges and barriers to the implementation of BIM by construction firms Ghana.

Table 4.4: Challenges of BIM Adoption by contractors in Ghana.

	N	*Sum*	*Mean*	*Std. Deviation*	*RII*	*Ranking*

Contract Provision with BIM	*28*	*107*	*3.82*	*0.86*	***76***	*1*
Procurement Systems	*30*	*104*	*3.47*	*1.14*	***69***	*2*
Standardization of Practice	*30*	*104*	*3.47*	*1.01*	***69***	*3*
Lack of Professional with BIM knowledge	*29*	*85*	*2.93*	*0.84*	***59***	*4*
Technical Inefficiencies	*30*	*85*	*2.83*	*0.79*	***57***	*5*
Shortage of Professionals	*30*	*85*	*2.83*	*0.83*	***57***	*6*
Poor Technological Edge	*30*	*83*	*2.77*	*0.86*	*55*	*7*
High Initial Cost	*29*	*80*	*2.76*	*0.95*	*55*	*8*
Laws of the Land	*30*	*82*	*2.73*	*0.58*	*55*	*9*
Information Security and Accuracy	*30*	*78*	*2.60*	*0.86*	*52*	*10*
Lack of Information Management Standard practice	*30*	*75*	*2.50*	*0.97*	*50*	*11*
Education/CPD	*30*	*74*	*2.47*	*0.86*	*49*	*12*
Information Timeline	*30*	*73*	*2.43*	*0.82*	*49*	*13*
Lack of External and Internal Communication	*30*	*71*	*2.37*	*0.72*	*47*	*14*
Innovation	*30*	*63*	*2.10*	*0.61*	*42*	*15*
Lack of Financial Resources	*30*	*61*	*2.03*	*1.10*	*41*	*16*
Lack of Managerial Capacity	*30*	*56*	*1.87*	*0.94*	*37*	*17*
Investment in BIM Technology	*30*	*55*	*1.83*	*0.59*	*37*	*18*
Logistics	*30*	*52*	*1.73*	*0.64*	*35*	*19*
Adjustment of Current Practices	*29*	*42*	*1.45*	*0.69*	*29*	*20*

In measuring the challenges and barriers to implementation of BIM by Ghanaian contractors, Relative Importance Index of the challenges and barriers to implementation of BIM by Ghanaian contractors were used. This measure revealed the weight of each challenge in relation to the other challenges. The indexes were presented in percentages and ranked from the variables considered to be the most prominent challenge to BIM implementation. The indexes have been ranked from the highest to the least. The highest indicates the most challenged of all the factors, and it follows to the lowest rated. In value when an index is more than 70% then it is highly significant.

The study observed that Contract Provision with BIM, Procurement Systems and

Standardization of Practice were highly significant challenges that firms would face in BIM implementation. These challenges have mean scores between 3.47-3.82; Contract Provision with BIM with mean score of 3.82, Procurement Systems had mean score of 3.47 and Standardization of Practice had mean score of 3.47. The mean score and the standard deviation of provision with BIM demonstrated it to be critical challenge. The other two were observed to be neutral challenge but very significant challenges in terms of the other challenges with index of 69% each. The fourth ranking of the challenges was lack of Professional with BIM knowledge which had index of 59%, mean score of 2.93 and standard deviation of 0.84. Technical
Inefficiencies and Shortage of Professionals were ranked fifth and sixth with index of 57% each, mean scores of 2.83 each but different standard deviation of 0.79 and 0.83 respectively.

From the seventh ranked challenge to the eleventh ranked challenge do not show enough significant challenge of BIM adoption. They had mean scores ranging from minimum of 2.50 to 2.77 and standard deviation from 0.97 to 0.86 and indexes from 50% to 55%. They showed neutral challenges of BIM adoption. The ranked from 12th to 16th showed that these variables had no challenge to BIM adoption. Their mean scores ranged from 2.03 to 2.47 and indexes from 41 percent to 49% as shown in the table. The mean scores and the indexes of the last four variables showed no challenge at all to BIM adoption.

From the discussion above, it could be concluded that the principal challenges of BIM adoption to the Ghanaian construction firms were contract provision with BIM, procurement systems, standardization of practice, lack of professional with BIM knowledge, technical inefficiencies and shortage of professionals

4.3.2 Discussions of Result on Relevance of BIM to contractors in Ghana.

To identify the significance of BIM implementation to contractors in Ghana, questionnaire survey and descriptive analysis were used. Table 4.5 presents the relevance of BIM to contractor in Ghana.

In table 4.5, the sixteen significant variables of BIM in Ghanaian construction industry items that were identified through literature were analyzed using descriptive and relative index and ranked according to their relative significance. From the table, it clearly shown that overall cost reduction was ranked first with index of 96%. This variable was observed to be highly significant. It was scaled as very important significant factor of BIM in Ghanaian construction industry.

The second ranked significant is ease of construction documentation with index of 93 %. This is followed by reduction in rework, possible drawing errors and omissions with index of 92, quality control and assurance with an index of 91% percent and unifier of all technical construction experts with an index of 91%.

Table 4.5: Relevance of BIM to Construction firms in Ghana.

	N	*Sum*	*Mean*	*Std. Deviation*	*RII*	*Ranking*
Overall Cost Reduction	*30*	*144*	*4.80*	*0.407*	*96*	*1*
Ease Construction Documentation	*30*	*139*	*4.63*	*0.556*	*93*	*2*
Reduction in rework, possible drawing errors and omissions	*30*	*138*	*4.60*	*0.563*	*92*	*3*
Quality Control and Assurance	*30*	*137*	*4.57*	*0.504*	*91*	*4*
Unifier of all technical construction experts	*29*	*132*	*4.55*	*0.506*	*91*	*5*
High Productivity	*30*	*134*	*4.47*	*0.507*	*89*	*6*
Better Coordination of Stakeholders	*30*	*134*	*4.47*	*0.507*	*89*	*7*
Better Clarity and Time Management	*30*	*129*	*4.30*	*0.596*	*86*	*8*

Logical/Better Project Management	*30*	*126*	*4.20*	*0.484*	*84*	*9*
Premise and early cost estimation	*30*	*122*	*4.07*	*0.640*	*81*	*10*
High financial benefit	*30*	*121*	*4.03*	*0.414*	*81*	*11*
Safety	*29*	*116*	*4.00*	*0.535*	*80*	*12*
Accuracy of bids and project pricing	*30*	*120*	*4.00*	*0.455*	*80*	*13*
Clash Detection	*30*	*119*	*3.97*	*0.615*	*79*	*14*
On-Time Completion	*30*	*118*	*3.93*	*0.640*	*79*	*15*
Accurate Accounting and Price Modeling	*30*	*118*	*3.93*	*0.521*	*79*	*16*

The mean scores ranged from 4.55 to 4.8 with very low standard deviation ranging from 0.504 to 0.563 demonstrating that the means were representative. Hence they are important significance of BIM in construction industry.

The fifth to thirteenth ranked variables also shows significant of BIM with indexes ranging from 80 percent to 89 percent and mean scores from 4.00 to 4.47 with their standard deviation ranging from 0.414 to 0.640. The last three ranked variables also demonstrate average importance with indexes of 79 each and mean scores from 3.93 to 3.97 and their standard deviations from 0.521 to 0.615.

4.3.3 Discussions of Result on Software Usage in BIM

The result in Table 4.6 shows the four BIM tools or software identified; architectural modeling, modeling/scheduling, estimating and audit and analysis. They had mean scores of 2.84, 1.41, 1.58 and 1.47 respectively.

Table 4.6: Software Usage in BIM by Construction firms in Ghana.

BIM TOOLS/SOFTWARE	*N*	*Sum*	*Mean*	*Std. Deviation*	*RII*	*Ranking*
Architectural Modeling			***2.84***	***0.674***	**57**	**1**
AutoCAD	*30*	*129*	*4.30*	*0.466*	*86*	*1*
Autodesk Architectural Desktop	*30*	*122*	*4.07*	*0.450*	*81*	*2*
Autodesk Revit	*30*	*108*	*3.60*	*0.675*	*72*	*3*

ArchiCAD	*29*	*88*	*3.03*	*0.778*	*61*	*4*
Bentley Systems	*30*	*72*	*2.40*	*0.855*	*48*	*5*
Graphisoft	*30*	*69*	*2.30*	*0.651*	*46*	*6*
Nemetscherk	*30*	*49*	*1.63*	*0.890*	*33*	*7*
Beck Dprofiler	*29*	*41*	*1.41*	*0.628*	*28*	*8*
Modeling/Scheduling			***1.41***	***0.758***	***28***	***4***
Autodesk Navisworks	*29*	*44*	*1.52*	*0.986*	*30*	*1*
Synchron Ltd	*29*	*40*	*1.38*	*0.677*	*28*	*2*
Vico Control	*28*	*37*	*1.32*	*0.612*	*26*	*3*
Estimating			***1.58***	***0.735***	***31***	***2***
Quantity Take Off	*28*	*52*	*1.86*	*0.803*	*37*	*1*
Back Dprofiler	*28*	*45*	*1.61*	*0.956*	*32*	*2*
Innovaya	*27*	*34*	*1.26*	*0.447*	*25*	*3*
Audit and Analysis			***1.47***	***0.917***	***29***	***3***
AntodeskNavisworks	*29*	*44*	*1.52*	*1.022*	*30*	*1*
Ecotect	*29*	*43*	*1.48*	*0.949*	*30*	*2*
Solibri Model Checker	*29*	*41*	*1.41*	*0.780*	*28*	*3*

The first ranked BIM tool usage was architectural modeling with an average index of 57%, followed by estimating with index of 31%, then audit and analysis with an index of 29% and lastly Modeling/Scheduling with an index of 28%. As observed the first ranked modeling showed significant usage. Tools or Software usages under architectural modeling are mostly used by the firms than those in the others. The first ranked tools or software observed was AutoCAD with an index of 86% showing very high usage, followed by Autodesk Architectural Desktop with an index of 81% and mean score of 4.07 showing high usage. Autodesk Revit also showed significant usage in BIM which had index of 72% and mean score of 3.60and ArchiCAD with an index of 61% showed average usage.

The other tools or software exhibiting no usage in the Ghanaian construction firms have mean score and relative index below 3.00 and 40% percent respectively.

4.3.4 Discussions of Result on BIM Guidelines/ Capacity Developments of Construction Firm in Ghana.

Factor analysis has been used to group the variables into six component factors. The extracted factors explain nearly 86% of the variability in the original 25 variables obtained for the study. These variables are shown in Table 4.7 with their total variance explained shown in Table 4.8.

Table 4.7: Communalities

	Initial	*Extraction*
Software and Hardware training (Technological)	*1*	*0.879*
BIM Expertise or Technical Staff (skills and knowledge)	*1*	*0.789*
Institutional or Organizational Structure	*1*	*0.865*
Legal instrument and contractual agreement	*1*	*0.898*
BIM laws and regulations (Legal instruments or framework)	*1*	*0.914*
Local Data utilization and Collaboration across industries	*1*	*0.799*
BIM Contract provisions	*1*	*0.868*
BIM Protocol and standard practices	*1*	*0.921*
Project bidding	*1*	*0.942*
Leadership (effective managerial team)	*1*	*0.806*
BIM knowledge and training programmes (Outreach)	*1*	*0.725*
Work process of BIM (Strategic IT in Construction)	*1*	*0.855*
Network configuration (Strategic IT in Construction)	*1*	*0.871*
Data Collection	*1*	*0.75*
Repository Library (Single portal System)	*1*	*0.895*
Project pre planning	*1*	*0.846*
BIM execution plan	*1*	*0.843*
Internal professional training	*1*	*0.804*
BIM Procurement system	*1*	*0.908*
Ownership (Copyrights and Control content)	*1*	*0.875*
Project Funding	*1*	*0.823*
Monitoring matrix systems	*1*	*0.915*
Finalization of BIM execution plan (product and services)	*1*	*0.949*
Quality assurance and Control procedures (product and service)	*1*	*0.815*
Public Education and Advocacy	*1*	*0.915*
Extraction Method: Principal Component Analysis.		

Table 4.8: Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	12.145	48.581	48.581	12.145	48.581	48.581	5.885	23.54	23.54
2	3.221	12.882	61.463	3.221	12.882	61.463	4.514	18.057	41.597
3	2.302	9.206	70.669	2.302	9.206	70.669	4.374	17.495	59.092
4	1.44	5.762	76.431	1.44	5.762	76.431	2.697	10.787	69.879
5	1.287	5.149	81.58	1.287	5.149	81.58	2.69	10.76	80.638
6	1.075	4.299	85.879	1.075	4.299	85.879	1.31	5.241	85.879
7	0.783	3.13	89.009						
8	0.74	2.959	91.969						
9	0.571	2.285	94.254						
10	0.342	1.369	95.623						
11	0.277	1.11	96.733						
12	0.214	0.857	97.59						
13	0.182	0.728	98.318						
14	0.125	0.501	98.82						
15	0.101	0.403	99.223						
16	0.088	0.351	99.574						
17	0.052	0.207	99.781						
18	0.025	0.1	99.882						
19	0.018	0.074	99.956						
20	0.011	0.044	100						
21	4.05E-16	1.62E-15	100						
22	1.22E-16	4.88E-16 -	100						
23	-5.29E-17	2.12E-16	100						
24	-1.22E-16	-4.90E-16	100						
25	-2.04E-16	-8.17E-16	100						

Extraction Method: Principal Component Analysis.

From the scree plot shown in figure 4.1, it confirmed the number of components that can be extracted from the 25 variables obtained for the study and that six components have their eigenvalue being greater than 1. Therefore all the 25 variables can have their composite in these six components which are management, technology and training, planning and execution, quality assurance and control, regulations and legislations and data collaboration.

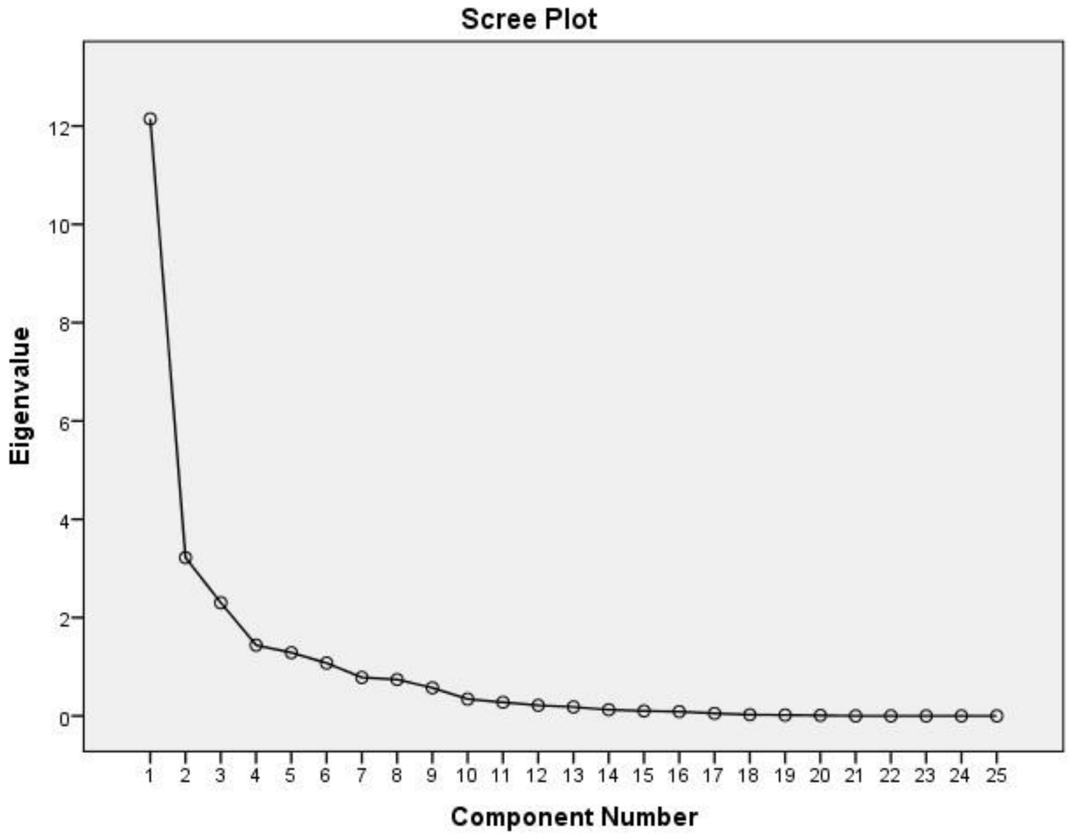

Figure 4.1: Scree Plot

From Table 4.9 it shows the Rotated Component Matrix[a] of the 25 variables obtained for the study in relation to the six components extracted.

Table 4.9: Rotated Component Matrix[a]

	Component					
	1	*2*	*3*	*4*	*5*	*6*
Software and Hardware training (Technological)	*0.209*	*0.342*	*0.667*	*0.171*	*0.492*	*-0.04*
BIM Expertise or Technical Staff (skills and knowledge)	*0.394*	*0.37*	*0.648*	*0.032*	*0.274*	*0.005*
Institutional or Organizational Structure	*0.572*	*0.065*	*0.504*	*0.267*	*0.45*	*-0.085*
Legal instrument and contractual agreement	*0.458*	*0.093*	*0.142*	*0.151*	*0.783*	*0.156*
BIM laws and regulations (Legal instruments or framework)	*0.295*	*0.042*	*0.089*	*0.156*	*0.883*	*-0.11*
Local Data utilization and Collaboration across industries	*-0.015*	*0.171*	*0.013*	*0.03*	*-0.01*	*0.877*
BIM Contract provisions	*0.319*	*0.257*	*0.799*	*-0.191*	*0.14*	*0.071*
BIM Protocol and standard practices	*0.653*	*0.271*	*0.502*	*-0.331*	*0.212*	*0.123*
Project bidding	*0.644*	*0.285*	*0.544*	*-0.311*	*0.179*	*0.147*
Leadership (effective managerial team)	*0.777*	*0.303*	*0.17*	*0.226*	*0.173*	*-0.037*
BIM knowledge and training programmes (Outreach)	*0.016*	*0.819*	*0.097*	*0.029*	*0.205*	*-0.032*
Work process of BIM (Strategic IT in Construction)	*0.078*	*0.811*	*0.334*	*0.151*	*-0.134*	*0.197*
Network configuration (Strategic IT in Construction)	*0.137*	*0.816*	*0.309*	*0.104*	*-0.114*	*0.257*
Data Collection	*0.782*	*0.072*	*0.114*	*0.116*	*0.225*	*0.238*
Repository Library (Single portal System)	*0.023*	*0.641*	*0.393*	*0.262*	*0.47*	*0.198*
Project pre planning	*0.044*	*0.488*	*0.709*	*0.142*	*0.086*	*0.274*
BIM execution plan	*0.115*	*0.125*	*0.763*	*0.396*	*-0.12*	*-0.247*
Internal professional training	*0.418*	*0.376*	*0.503*	*0.408*	*0.075*	*0.252*
BIM Procurement system	*0.567*	*0.596*	*0.426*	*0.015*	*0.186*	*-0.12*
Ownership (Copyrights and Control content)	*0.78*	*0.115*	*0.174*	*0.304*	*0.349*	*-0.088*
Project Funding	*0.863*	*0.011*	*0.117*	*0.228*	*0.093*	*-0.061*
Monitoring matrix systems	*0.188*	*0.087*	*0.058*	*0.899*	*0.246*	*0*
Finalization of BIM execution plan (product and services)	*0.228*	*0.204*	*0.082*	*0.912*	*0.116*	*0.067*
Quality assurance and Control procedures (product and service) 0.594	*0.616*		*0.192*	*0.066*	*0.195*	*-0.061*
Public Education and Advocacy 0.571	*0.739*		*0.132*	*0.078*	*0.038*	*-0.133*

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. a. Rotation converged in 8 iterations.

The Table 4.10 below showed the six groups of factors observed in the factor analysis. Relative index was run under each factor to observe the variable that was rated with the highest weight in relation to the others.

Table 4.10: Summary of t-test showing ranking results

	N	*Sum*	*Mean*	*Std. Deviation*	*RII*	*Ranking*
Factor 1: Management			***4.15***	***0.692***	***83***	***2***
Quality assurance and Control procedures (product and service)	*30*	*132*	*4.40*	*0.675*	*88*	*1*
Leadership (effective managerial team)	*30*	*130*	*4.33*	*0.844*	*87*	*2*
Public Education and Advocacy	*24*	*104*	*4.33*	*0.702*	*87*	*3*
Project bidding	*30*	*129*	*4.30*	*0.750*	*86*	*4*
BIM Protocol and standard practices	*30*	*126*	*4.20*	*0.761*	*84*	*5*
Project Funding	*30*	*121*	*4.03*	*0.556*	*81*	*6*
Data Collection	*30*	*119*	*3.97*	*0.556*	*79*	*7*
Ownership (Copyrights and Control content)	*30*	*118*	*3.93*	*0.640*	*79*	*8*
Institutional or Organizational Structure ***Factor***	*29*	*112*	*3.86*	*0.743*	*77*	*9*
2: Technology and training			***4.29***	***0.615***	***86***	***1***
Work process of BIM (Strategic IT in Construction)	*30*	*135*	*4.50*	*0.572*	*90*	*2*
BIM Procurement system	*30*	*132*	*4.40*	*0.814*	*88*	*3*
BIM knowledge and training programmes (Outreach)	*30*	*130*	*4.33*	*0.547*	*87*	*4*
Network configuration (Strategic IT in Construction)	*30*	*130*	*4.33*	*0.661*	*87*	*5*
Repository Library (Single portal System) ***Factor***	*30*	*117*	*3.90*	*0.481*	*78*	*6*
3: Planning and Execution			***4.09***	***0.716***	***82***	***3***
BIM execution plan	*30*	*131*	*4.37*	*0.964*	*87*	*1*
BIM Contract provisions	*30*	*124*	*4.13*	*0.681*	*83*	*2*
Internal professional training	*30*	*123*	*4.10*	*0.712*	*82*	*3*
Software and Hardware training (Technological)	*30*	*121*	*4.03*	*0.556*	*81*	*4*
BIM Expertise or Technical Staff (skills and knowledge)	*30*	*120*	*4.00*	*0.643*	*80*	*5*
	30	*118*	*3.93*	*0.740*	*79*	*6*

Project pre planning			***3.67***	***0.633***	***73***	***4***
Factor 4: Quality Assurance and Control						
Finalization of BIM execution plan (product and services)	*30*	*111*	*3.70*	*0.651*	*74*	*1*
Monitoring matrix systems	*30*	*109*	*3.63*	*0.615*	*73*	*2*
Factor 5: Regulations and Legislations			***3.62***	***0.768***	***72***	***5***
Legal instrument and contractual agreement	*30*	*109*	*3.63*	*0.765*	*73*	*1*
BIM laws and regulations (Legal instruments or framework)	*30*	*108*	*3.60*	*0.770*	*72*	*2*
Factor 6: Data Collaboration			***3.50***	***0.572***	***70***	***6***
Local Data utilization and Collaboration across industries	*30*	*105*	*3.50*	*0.572*	*70*	*1*

The Table 4.11 shows the Component Transformation Matrix of the six components extracted from the 25 variables obtained for the study.

Table 4.11: Component Transformation Matrix

Component	**1**	**2**	**3**	**4**	**5**	**6**
1	*0.601*	*0.474*	*0.514*	*0.207*	*0.321*	*0.065*
2	*-0.521*	*0.644*	*0.294*	*-0.217*	*-0.354*	*0.235*
3	*-0.340*	*0.121*	*-0.140*	*0.917*	*0.079*	*0.056*
4	*0.485*	*0.320*	*-0.554*	*0.096*	*-0.579*	*0.107*
5	*-0.069*	*0.231*	*-0.491*	*-0.215*	*0.604*	*0.538*
6	*0.109*	*-0.436*	*0.287*	*0.115*	*-0.257*	*0.797*

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

In developing guidelines for BIM implementation, twenty-five variables were used for the measurement. Running relative index of these variables demonstrated significant importance. Factor analysis was used to condense and summarized the items. Principal component analysis was conducted to identify the underlying principal factors for its simplicity and distinctive capacity of data reduction.

The communalities indicate the amount of variance in each variable that is accounted for. The initials indicate the estimate of the variance in each variable accounted for by all the factors, it is set to 1.00 for correlation analysis. Factor eigenvalue of more than 0.5 indicates that the variable is significant and the higher the eigenvalue towards 1.00, the more significant the variable. The extractions are all high showing that the variables are all significant and are good representative of the explained.

Component 1- Managements Component

The first component extracted had nine (9) variables which contributed to 48.581% of the total extracted variances. The variables were labeled management and include institutional structure, BIM protocol and standard practices, project bidding, leadership, data collection, ownership, project funding, quality assurance and control procedure and public education and advocacy with variance extraction ranging from 0.572 to 0.863. These variables are all management based, hence prudent management become a source of success to construction project delivery and viseversa.

Leadership

Robust and effective leadership is the fulcrum of every organization. Leadership is the course of persuading an individual or group of people to follow a set of intentions of that leader. BIM as a new technology in construction requires strong leadership.

Leadership has been identified to drive the implementation of BIM (Building and Construction Authority, 2013). Therefore they must be willing and prepared to adopt this new technology by providing resources evolving, and holding capable staff and technical resources. In BIM adoption in developing countries Leadership therefore, need to specify specific roles and duties. Again for successful BIM practice, effective technical personnel should lead in the team of BIM, with the required IT, software and specific expertise to BIM (Messuer *et al.*, 2012).

Institutional structure

There is the need to have an established Institutional structure to drive BIM adoption with in construction firms. Within the firm there must be department such as Architectural structural engineering, Quantities services departments willing to learn and work on BIM principles and software's. BIM infrastructure within construction firms must be well set out to enable collaborations amongst construction personnel's. It is important to note that without Institutional structure BIM practices cannot operate successfully implying that construction firms in developing countries must be encouraged to establish working structure within firms to streamlines operations and responsibility of each department to the general success of BIM.

Public education and advocacy

Public education and advocacy is a vital attribute of the successful adoption and implementation of BIM (Edgar, 2008; Henderson & Jordan, 2009). Imbibing the knowledge of BIM in all construction stakeholders is surely important to BIM advocacy. Also, the inclusion of BIM curriculum of educational institution to further train and expand the knowledge base of construction professionals should be encouraged. This is because the more people are aware of contractors using BIM, how it works and its benefits will attract client to the organization with other opportunities to the country as a whole (De Vit *et al.*, 2002). Its been exstablish that organizations without outreach are the ones most likely to struggle and eventually fail in achieving their organizational mission and goals of BIM adoption (Galaskiewicz & Bielefeld, 1998). Management is therefore required to collaboratively disseminate BIM information to all its stakeholders through seminars and short courses to be able to adopt and implement it in their project delivery.

Project Funding

BIM comes with high cost in adoption (as in training personnel, hardware and software) (Xu, *et al.*, 2014; McNell *et al.*, 2011). Firms yet to practice BIM need financial resources for BIM related investment or else remain malignant to the adoption (Both & Kindsvater, 2012). To Gronbjerg (1993), Smith & Lipsky (1993), the nature of resource used in an organization is dependent on the organization's mission as well as the extent of funding streams available to it. Therefore sound project funding in developing countries will effectively enhance BIM adoption since inadequate finance and credit facilities for contractors is a challenge to contractors in Ghana for instance (Ahadzie & Amoa-Mensah, 2010; Laryea 2010).

Project funding and cash flows has been identified as an area which needs considerations during BIM adoption. It is essential to create project milestone forecast, to appreciate when cost will be incurred and in what way to fund the project. This approach varies from the traditional delivery technique in that additional resource and efforts are spent in the earlier method to confirm better proficiency in the cause of construction. Presently, trends have shown extraordinary budget of software application and hardware in the area of exceptional computers tied to the high cost of specialized training and preparation to allow smooth adoption of this new technology.

BIM projects are known to have lesser completion cost but have great cost for effecting a spatial organization and production fitting drawing after bidding as compared to conventional techniques. It has been established that modest pricing for gears, resources and joint technique selection is a major key element specially provided to enhance value stream of project. In addition to this the question that model owners continuous to contend with is who is to fund BIM project. Firms yet to accept BIM contend that funding resources for BIM in the area of investment remains malignant to the adoption of BIM.

The budget of using BIM has always included buying software, getting supporting personnel's, modernizations of hardware, network configuration and initial high cost of training professionals. Therefore, all these costs elements must always be considered if BIM is to be adopted in developing countries. Construction firms in developing countries must provide funding for training personnel, buying of soft and hard ware.

Legislative Implications and Insurance

BIM is faced with the problem of ownership in its adoption and implementation. Therefore stakeholders must address the issues of who is the lead professional to the team of professionals on BIM. It has been confirmed that, BIM is challenged with ownership issues because it is a pool of professionals coming together to build a single model. Studies have proposed that, stakeholders to BIM should collectively agree not to protect BIM with a copyright law and other legal issues for its effective utilization (Thomson & Miner, 2006).

BIM agreements are design to vary from conventional contracting techniques known in the construction industry and might necessitate review of legislation and indemnity insurance arrangements to safeguard compliance with corporate environment. The issues of collaboration and distribution of information, the problem of accountability between stakeholders, require legislative solutions. For this reason contract forms, agreement, and procurement system ought to be reviewed such as what the US and UK have done. This means that conventional technique of measurement, BIM information data insertion in agreement; suitable sections and clauses must be integrated in BIM contract for easy understanding and compliance. BIM technology is very significant but is not devoid of dangers including ineffective and expensive insurance policies. The present difficulties and concerns of BIM project has been proprietorship and content control since it permits all stakeholders to have access to work of the other member's intellectual property. The situation bring about errors in the model and it might be problematic to know who and under what condition the error happened. Therefore, developing countries must be made to understand these difficulties and solution be made available. For instance there has been some court cases presenting an insight into BIM legislation, risk and accountability for future use.

Yet, the legislative regulation of the building industry on this new know-how is in evolution and developing.

Presently, some governments in developed countries have promulgated laws to enforce the adoption of BIM. They have made BIM a key requirement in the delivery of projects and have instituted targets to phase out conventional practices. This implies that BIM adoption and accomplishment in any nation is dependent on the legislations of that country. For instance, developing countries will greatly and best appreciate the BIM technology when supported by the legislations of these countries.

Furthermore, there is the need to advocate for indemnity on the know-how since financing an unaccustomed technology in developing countries is risky and attract higher cost of insurance. Nonetheless, complete adoption of BIM know-how will moderate faults and oversights.

BIM project advances imperative contractual matters in relation to duties, danger, contractual protections, patents and usage of documents not inconsonance with normal industrial contract form. Intellectual Property (IP) and patent matters can be relieved through more consciousness and legislative actions. BIM Intellectual Property is a legislative matter which is no longer different from IP issues prevailing in current practice.

Organizational and legislative BIM framework varies from country to country. Current contractual arrangements cause disagreements and inadequacies since it inspires stakeholders to worry themselves with its individual benefits. It is thus significant to resource the inner legitimate personnel's and train more legal personnel to address the apprehensions and seek explanation that will essentially enhance BIM process to attain its benefits. Several construction firms in developing countries, for instance Ghana, has legislative limitations that prohibit a unified form of contract, however a collaborative development can take place under any kind of contract and this must be considered if BIM is to be adopted by construction firms.

Standards

Also, it is important that standard practices and protocol are adhered to, to simplify and secure contracting in case of model variation for ease extraction of data (Booth & Kindsvater, 2012). Isikdag *et al.,* (2007) assert that BIM is heavily dependent on standards thereby making standards a key enabler and facilitator of BIM model.

Component 2- Technology and Training Component

The second component extracted had five (5) variables contributing 12.882% to the total extracted variances. The variables were labeled technology and training. It included BIM knowledge and training programmes (Outreach), Work process of BIM (Strategic IT in Construction), Network configuration (Strategic IT in Construction), Repository Library (Single portal System) and BIM Procurement system with variance extraction ranging from 0.596 to 0.819. These variables connote technology and training; hence prudent consideration of technology and training that will lead to a successful BIM adoption.

BIM knowledge and training programmes

On BIM adoption in developing countries, inadequate staff and training within the construction industry to work on BIM model has been eminent. Hence the need to have long-term goals by construction firms to address the problem of inadequate staff and training since BIM provides disconcerting supremacy to an existing defragmented building industry that concerns itself with a smaller volume of security. The new technological processes to improve automated design and construction expert must recognize the distinct danger connected to such a new technology. The fact that the technology is emerging, older professionals are lagging behind in its usage. Therefore in order to enhance the construction process, construction experts must take note of the individual risks associated with such a new technology as BIM. Lega (2008) Conversation on BIM concepts, software application and evidence on accomplishments have caused an adaptive response by people (Edgar, 2008; Henderson & Jordan, 2009) even though there is lack of awareness on information about BIM success. To avert this situation, there must be an expansion and modification of current training in education of building experts.

Work Process of BIM

BIM is a new technological process meant to improve construction automation and design. The process is described as a series of activities taken towards attaining a particular goal. The work process of BIM is based on collaborations which is described as working together in a unified manner among construction professionals such as architects, quantity surveyors, planners, engineers contractors and subcontractors to share their technical know-how in a definitive manner, for the purpose of attaining the set up objectives of the project as defined by the client.

The effective adoption of BIM is dependent on BIM working processes. These processes must be understood by building professionals within construction firm in developing countries. On the work process of BIM (Strategic IT in Construction) Liang & Cohen, (1994); Porter & Millar (1985) and Anthony (1965) indicate that it requires Business Process Re-engineering (BPR) to drive construction firms to modify their career pathways, training, enlistment and strategies in developing countries to effectively enhance BIM adoption.

Therefore, institutional training, reward, communication, research and development are drivers for Business Process Re-engineering hence BIM adoption. For this reason firms must consider the level and skill of their technical expertise in software knowledge, experience, and training of personnel (Messner *et al.*, 2012).

BIM Procurement system

BIM Procurement system is an area to be looked at if BIM is to be adopted. This explains why the UK government has established radical construction procurement systems that require construction firms to adopt BIM practices to enable them qualify to bid for any public work by the year 2016 (Construction Industry Council, 2013; British Standards Institute, 2012). This is in consonance with the quest for governance to lead in BIM adoption in construction works to promote efficiency and great benefit to allow contractors practicing BIM to legally bid for public works (National BIM Report, 2012; BIM Industry Working Group 2011). Procurement system in developing countries must be restructured to give advantage to construction firm willing to adopt BIM. Contractors must be made to understand how to bid for BIM projects.

Repository library and network configuration.

Repository library and its workings requires an attention if BIM is to be adopted. The survey agrees with Construction Industry Council (2013) the need for stakeholders to create a repository library to showcase, share documents, standards and best practices to reconcile design construction, operation and maintenace under a single portal sytem. Education on how to acess repository library must be given to stakeholders of professional contractors for effective utilization of the library.

Since BIM is based on collaboration among construction personnel, there is the need to have insight into software purchase, staff support, hardware upgrades and network configuration.

Component 3 - Planning and Execution

The third component extracted had five (5) variables contributing 9.206% to the total extracted variances. These variables were labeled planning and execution. These include project pre planning, BIM execution plan, BIM contract provisions, internal professional training, software and hardware training (technological) BIM expertise or technical staff (skills and knowledge) with variance extraction ranging from 0.503 to 0.799. All the variables extracted to the factor are related to Planning and Execution, hence prudent planning and execution can contribute to the success of BIM project delivery and vise-versa. For this reason there is the need to build capacity in these areas.

Planning describes how a project is to be executed, supervised and organized along BIM processes (Bloomberg, *et al.,* 2012) while BIM execution plan is the strategy and tactical tool to plan the social interactions of the BIM team from the early planning stage, through to the design and construction period.

Project pre-planning

For BIM adoption, capacity building in the area of project pre-planning is essential.

It has long been the hallmark for effective project execution. This is essentially paramount as well as an ingredient for successful adoption and use of BIM on a project. Therefore, contractors must be made to understand what goes into project preplanning. It has been established that before the execution of BIM, there is the need to assemble the right team members especially on projects using BIM as well as setting the right standards. It further confirms that good pre-planning will reveal best timing for selecting stakeholders for a BIM model and the extent of information needed from them within a specific time frame (CURT, 2010).

BIM Project Execution Plan

This is a tactical tool which aid in planning an effective communication of the BIM team from the early planning stage, to the design and construction period. It is an important tool that assists with post-construction information which defines the project inputs and uses (National BIM Standard, 2012). Also, it summarizes how a project is to be organized, executed and ministered with BIM processes and further provides data for management and the planning team (Bloomberg *et al.*, 2012). Therefore BIM project execution plan helps stakeholders to have a better understanding of the whole BIM implementation. It offers in details the responsibilities and roles of all stakeholders to enhance growth in BIM development, hence improvement in construction delivery.

It contains a complete project brief from the client, which is further developed through the collaboration of all construction stakeholders. During the execution planning process, stakeholders on construction project must always get involved in order to guarantee model accuracy. Also thoughtful style to BIM execution plan ought to set a strong and clear expectation amongst team players. The execution plan must inculcate the following platforms and is anticipated to guide successfully the client and project stakeholder by providing complete and reliable project plans.

- ***Identify high value goals and uses for a project of BIM***

The first point in the planning stage of every project is to identify the appropriate technical personnel of BIM users, with the project demands, goals and the possible risk allocation into consideration. This aid in specifying an implementation plan and goal for BIM which are linked to the performance of the project inclusive increase efficiency and productivity of the processes, eliminating delays, enhancing excellent produce and services, and budget impact reduction of projects for effective control of the facility.

 Designing the Project Execution Process of BIM

The design plan for BIM implementation is important. It outlines the processes and inputs that must exist among the basic BIM users in project delivery. This enhances an appropriate meaning to the implementation of BIM and effective tasks performance within the team**.**

 Develop Information Exchange Requirements and Deliverables

As soon as the precise process plans is developed, the info deliverables and exchange requirements ought to be clearly acknowledged. Info deliverables and interactions within the processes of project are lethal to a successful BIM implementation and stakeholders working within construction firms must be made to understand. This is vital to project stakeholders in order to understand the information content for each information exchange contract. In addition, the understanding of the information flow to the team is crucial to users of BIM. Hence, it is important to specify the right information in time to promote BIM.

 Define BIM implementation supporting infrastructure

Project stakeholders are responsible to acquire the required systems and structure towards the support of BIM process, besides needs to outline the implementation structure, agreements, contractual linguistic, communiqué processes, and technological groundwork. It is important to note that achieving high quality information models will require quality control identification procedures if BIM is to be adopted among developing countries.

BIM contract provisions

Construction firms in developing countries must have better understanding of BIM contract provisions to enhance BIM adoption. Contract provisions should be revised to meet the current contract agreement and procurement system such as what the US and UK has done. This means that Standard Method of Measurement, BIM data inclusion in contract, suitable clauses to integrate BIM, and payment practices to enable BIM adoption is an easy means to BIM adoption among stakeholders (Construction Industry Council, 2013; Porwal & Hewage, 2013; Smith, 2012). Too this end lawyers must be trained and educated through seminars and short courses to have better understanding in BIM contract provisions.

Internal professional training

Even though construction firms in developing countries have some level of BIM training and practices among construction professionals, there is the need for internal professional training, in software and hardware in their respective professions. In other words, contractors must consider the level and skill of their technical expertise in software knowledge, experience, and training of personnel. Furthermore, BIM training programmes must be provided for professionals with the view to generating awareness and usage of BIM. Presently, the conservative nature of construction professionals to change in developing countries also poses a great challenge to BIM adoption by firms. This situation must be worked on (CREAM 2014) to have more and qualified staff to frequently update BIM model.

Component 4- Quality Assurance and Control

The fourth component extracted had only two (2) variables contributing 5.762% to the total extracted variances. The variables had Quality Assurance and Control as its name.

Finalization of BIM execution plan (product and services) and Monitoring matrix systems are components of quality assurance and Control with variance extraction of 0.899 and 0.912. Quality assurance and control variable is required for a successful BIM project delivery.

Finalization of Execution Plan

For successful adoption of BIM stakeholders must understand how to finalize the BIM execution plan. This process provides checkpoints and metrics for regular measurement and assessment to ensure compliance with budget, schedule, and quality considerations. Therefore, it requires that milestone dates for design decisions, submittals, approvals, and deliverables must be monitored (Autodesk, 2010). At this stage, decision-making process should be open, collaborative, and timely.

Stakeholders must therefore define exactly how success is to be measured.

Monitoring Matrix

Successful BIM adoption is largely dependent on monitoring matrix system. It is for measuring project success at the project pre-planning stage and also monitor regularly against project goals and project delivery methods. The metrics include milestone dates, improved safety, performance goals, sustainability outcomes, change orders, value, schedule, budget, and other measures deemed valuable to the project team (CURT, 2010). Therefore, stakeholders need to build their capacity in these areas if BIM adoption is to be considered.

Factor 5 - Regulations and Legislations

The fifth component extracted had only two (2) variables contributing 5.149% to the total extracted variances. The variables are described as Regulations and Legislations. These are Legal instrument and contractual agreement, BIM laws and regulations

(Legal instruments or framework) had variance extraction of 0.899 and 0.912. Regulations and Legislations variable is required for a successful BIM project delivery.

Legal instrument, Contractual Agreement and BIM laws and Regulations These are eminent Legal issues required for BIM technology adoption. It is for this reason that radical changes have been introduced in construction procurement systems in the UK. It requires that contractors adopt BIM practices to enable them qualify to legally bid for any public work by the year 2016. (Construction Industry Council, 2013; British Standards Institute, 2012; National BIM Report, 2012; BIM Industry Working Group, 2011) and must be delivered to a BIM maturity level 2 by 2016 (Business Innovation and Skills 2011; Thurairajah & Goucher, 2013.

The survey support Porwal & Hewage (2013); Boon (2009); Thomson & Miner (2006), that BIM in construction project raises a lot of important contractual issues in relation to ownership, maintenance, project responsibilities and risk, contractual indemnities, copyrights and use of documents that are to be addressed by the standard industrial contract form. Since these unsettled legal issues continue to put fear in most stakeholders for BIM adoption (Eastman *et al.*, 2008) Therefore, there is the need to build capacity in these area to prevent legal tussle when BIM is to be adopted. Again, there is the need to resource the internal legal staff and train more legal personnel to address the apprehensions and seek explanation that will essentially enhance BIM process to achieve its benefits (CURT, 2010).

Component 6 - Data Collaboration

The sixth and the last component extracted had only one (1) variables contributing 4.299 % to the total extracted variances. The variable is described as Data Collaboration with variance extraction of 0.877. Data collaboration is required for a successful BIM project delivery as illustrated in the Figure 4.2 below. Data collaboration is required for a successful BIM project delivery. Contractors in developing countries must be made to understand how to collaborate among themselves. Also local data utilization and collaboration across industries has been identified as a variable that would be required for BIM adoption. It confirms researchers such as Hobbs (1996) and Anumba & Newnham, (2000) that stakeholders must collaborate and integrate to have BIM models. Gu & London (2010) confirms with the survey that collaboration is more effective and needed once undertaken a project at an inception stage. Again, it supports Construction Industry Council (2013), that stakeholders must create a repository library to showcase, share documents and standards and best practices; also to reconcile design and construction, and operation and maintenace under a single portal to eliminate possible craches (Aakanksha, 2010).

4.4 Summary of Guidelines for Capacity Building of Contractors for BIM Adoption and Implementation in Ghana

Building the capacity of contractors in Ghana for BIM adoption and implementation will require management decision. Management must provide and ensure the use of BIM technology and data collaboration among stakeholders.

Also there must be regulation and legislation to guide BIM adoption to prevent legal tussles since BIM is based on collaboration among building professionals.

When all these are in place, there is the need to ensure planning and execution. This is the hallmark and an ingredient for effective project execution.

At the planning and execution stage there is the need to ensure quality assurance and control. These provide checkpoint and matrices for regular measurement and assessments to ensure compliance with budgetary, schedules and quality considerations.

Management, technology and training, regulation and legislation data collaboration, planning and execution, quality assurance and control will lead to full capacity guideline for BIM adoption and implementation. The Guidelines for Capacity Building of Contractors for BIM Adoption and Implementation in Ghana is shown in Figur4.2 below.

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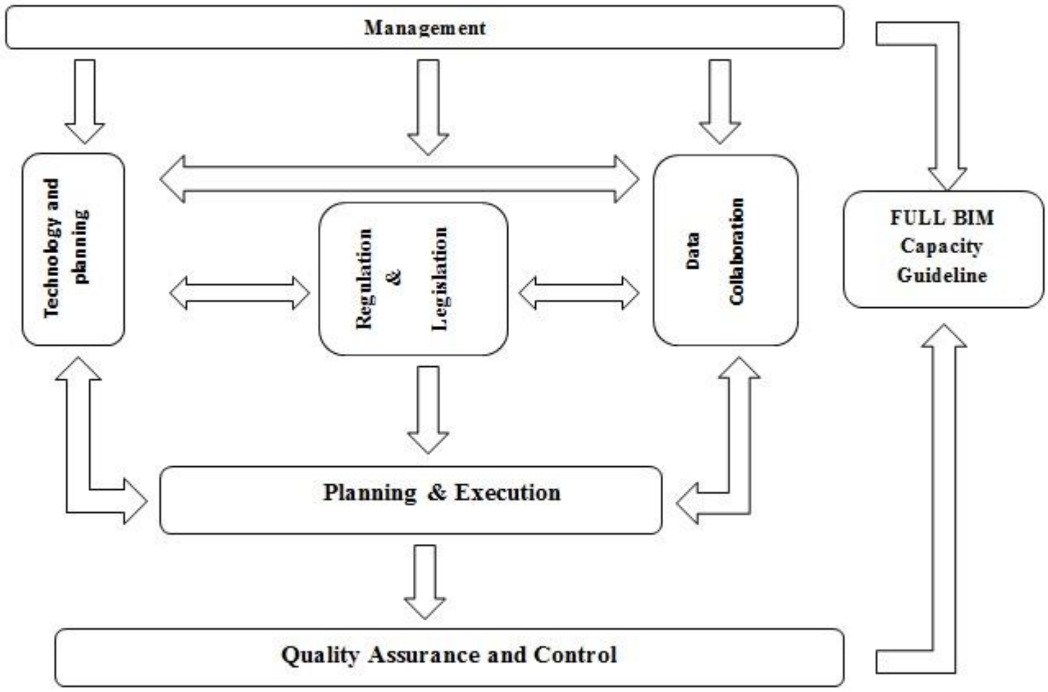

Figure: 4.2 Guidelines for Capacity Building of Contractors for BIM Adoption and Implementation

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The research is anchored on the aim developing guidelines to support capacity building of construction firm (contractors) to adopt and implement BIM. To achieve this, objectives were set-forth guided by a set of research questions. The chapter also reconsiders the set objectives and research questions with the intent to highlight the level to which they have been achieved considering the various stages of the research. This chapter outlines recommendations based on the research findings and the challenges encountered during the research.

5.2 Research Concept

The research has its grounded on the observation of Eastman *et al.,* (2011) that BIM is recognized as an emerging information technological tool with the capability to coordinate the building industry and to realize the effects of the four- dimension (time) and the five- dimension (cost) on construction activities. BIM technology is maintained to be a facilitator for change in the AEC industry as against the charged that the industry is highly fragmented (Bernstein and Pittman, 2005).

5.3 Review of Findings

5.3.1 Fundamental Requirement for BIM adoption and implementation

To identify the fundamental requirement for BIM adoption and implementation by construction firm is the fore most objectives. This was successfully achieved through extensive review of literature on BIM principles and work processes or procedure (see chapter 2 of the study). The literature revealed fundamental requirements such as trained or qualified experts in BIM, working space, hard and software applications, repository library and screens

5.3.2 State of BIM adoption and implementation in Ghanaian Construction Industry

The second objective which is to determine the state of BIM implementation by construction firms in Ghana was largely achieved through literature and more especially through questionnaire survey and analysis. Largely, it was identified that contractors in Ghana are within level 0 and 1 of BIM adoption and implementation. This implies that the maturity levels of these firms are low. Contractors have knowledge of BIM but remain in CAD and modeling without collaboration to start the drive of BIM.

5.3.3 Relevance and Challenges to adoption and implementation of BIM by contractors in Ghana

This objective was achieved through literature and more especially questionnaire survey and analysis. The implementation of BIM brings huge financial benefits to contractors, eases of project documentation, eliminates variation in design, save a lot of time, quality control and assurance and unifies all the technical construction professionals, perfect bid and project pricing, ease in estimation of resources such as materials labour, cost time. (See Table 4.5 and Section 2.2)

However implementing BIM is challenged by its high startup investments cost hardware, software and personnel training, legal issues in relation to ownership of model and lack of knowledge to the enormous benefits of BIM (See Table 4.5 and Section 2.2)

5.3.4 Factors necessary for building the capacity of contractors in Ghana for BIM adoption and implementation

This objective was achieved through factor analysis and mean score questionnaire survey and analysis. The study established that twenty-five (25) component variables need consideration during capacity building of contractors for BIM adoption in Ghana. The guidelines for building capacity have their base in management component, technology and training component, planning and execution component, quality assurance and control component, regulations and legislation component and data collaboration component (See Figure 4.2) and a practical hierarchy for building the capacity of contractors in Ghana with the elaborated components in Figure 5.1

5.4 Contribution to Knowledge in Ghanaian Setting

The outcome of this research has contributed to the following

- The research has revealed facts associated with BIM adoption in Ghana.
- The study has helped to expose the relevance and has reduced the myth connected to BIM adoption in Ghana.
- The research revealed the readiness of construction firms for adoption of BIM in Ghana.
- The research established six (6) strategies for effective development of capacity building of Ghanaian contractors for BIM adoption.

Additionally, a book on BIM adoption by construction firms in developing countries has been developed and has gone for review and accepted for publication. Also, a conference paper on Guidelines for Capacity Building of construction Firms for Building Information Modeling Adoption in Ghana has been developed and published.

5.5 Research Limitations

Several difficulties were encountered during the fieldwork stage of the research. These posed serious limitations to the implementation of the study. Most construction firms are not prepared to give information since they considered the researcher an outsider. They had to be persuaded severally before response was give. Also, meeting authorities of the construction firm and personnel require following strict protocol. Again, the identification of offices of contractors was unbearable due to bad descriptive directions to firm's location. Lastly, there is also problem of sampling and quantitative faults and the effects of these faults on the data collected.

5.6 Research Conclusion

The following conclusions were made based on the findings of the research

1. The fundamental requirements for BIM adoption include trained or qualified experts in BIM, working space, hard and software applications, repository library and large screens.
2. Most contractors are not utilizing BIM technology in the Ghanaian construction industry.
3. Some of the relevance of BIM to contractors include overall cost reduction, ease construction documentation, reduction in rework, high productivity. However, the obstacles that prevent contractors from using BIM include contract provision with BIM, procurement system, standardization of practices, and shortage of professional.

4. To ensure the adoption and implementation of BIM in the Ghanaian context, the guidelines include management, technology, regulation and legislation, data collaboration, planning and execution and quality assurance and control. As shown in Figure 5.1

Figure 5.1: Pyramidal steps for capacity Building of Ghanaian construction for BIM adoption and implementation.

5.7 Recommendations

Considering the findings of the research, the following recommendations are to help develop the capacity of the construction firms in Ghana.

1. **Education and training:**

This is recommended for BIM adoption. Professionals in or for the construction industry must be introduced to BIM practice as part of the curricular of tertiary and technical education. This implies that educators in the construction industry namely architecture, building technology, civil engineering, etc. must add BIM related course and training to the school curricula.

Professional institutions including Ghana Institutions of Architects, Ghana Institute of Surveyor, Ghana Institute of engineering and others must partner BIM software developers such as Bently system, Autodesk etc. to train members in BIM technology. This will enhance Continuous Professional Development (CPD).

Professionals within Quantity Surveying practices must be encouraged to learn BIM soft wares such as Back Dprofiler, Quantity Take-Off and Innovaya. Through workshops, seminars and conferences, the public or clients should be made aware of the immense significance of BIM adoption to the contractor and the client. Such awareness must diffuse the myth associated with the new technology and highlight the advantages of the technology.

2. Government must develop legislations and regulations

Legislation and regulations for BIM adoption with respect to contract forms, contractual indemnities, procurement systems, copyright, error responsibilities, contractual agreement and time lines to the construction industry must be developed due to its immense importance to contractors and the economy of Ghana as a whole. To qualify legally to bid for any public work, contractors must be BIM compliant and the projects must be delivered to a particlar BIM maturity level for instance level two. Implying that contractors must manage projects in three-dimension settings and holds a distinct BIM model with devoted data where Information exchange occurs amongst stakeholders on the BIM platform.

Resource the internal legal staff and train more legal personnel to address the apprehensions.

3. Establish regulatory bodies

A regulatory body must be established to regulate and set BIM standards for stakeholders, thus a common platform to operate. The regulatory body is to set up guidelines, standards, and time lines for achieving the ultimate maturity level (level-3).

4. Establish technology platform

Government must institute high end information technology for distance collaboration for BIM stakeholders. For example cloud systems and ITP. Thus real time collaboration platform for all stakeholders.

5.8 Future Research Recommendations

It is recommended that further research could be carried out to compare BIM projects and conventional projects.

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APPENDICES

APPENDIX 1

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY-KUMASI

COLLEGE OF ARCHITECTURE AND PLANNING

DEPARTMENT OF BUILDING TECHNOLOGY

QUESTIONNAIRE FOR CONSTRUCTION STAKEHOLDERS (QSs, ENGINEERS, ARCHITECTS, PMs) ON BIM ADOPTION AND IMPLEMENTATION

PROJECT TOPIC: *GUIDELINE FOR ADOPTION AND IMPLEMENTATION OF*

BUILDING INFORMATION MODELING (BIM) BY CONTRACTORS IN GHANA.

PREAMBLE

My name is Akwaah George from the Department of Building Technology KNUST. I am conducting a Postgraduate research with the title ***"Guidelines for Building the Capacity of Contractors for the Adoption and Implementation of Building Information Modeling (BIM) in Ghana."*** Please find a questionnaire to be completed by Construction Stakeholders or Senior Managers in the Ghanaian Construction Industry.

KEY OBJECTIVE OF THE STUDY

To develop a guideline to support capacity building of Contractors to adopt and implement BIM.

RELEVANCE OF THE STUDY

- The findings would provide empirical data to establish state and level of BIM implementation in Ghana by construction stakeholders.
- The findings would inform stakeholder in the construction industry on challenges and barriers to BIM implementation and further explore the benefits of BIM to stakeholders in Ghana.
- The study will streamline guidelines, implementation strategies needed to develop the capacity of Ghanaian construction firms for the adoption and implementation of BIM.
- Finally, provide knowledge and skills that has to be provided by educators to the construction industry.

I recognize that, these questionnaires would take part of your busy schedule nonetheless I would be very glad if you could spare me a little of your precious schedule in selecting the appropriate box to each item provided below. You are assured of the strictest of confidentiality to answers given. For further enquiries, recommendations and contributions to this research, please contact the researcher below.

Thank you.

Akwaah George.

Department Of Building Technology

Private – mailbag

KNUST- Kumasi

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SECTION A: Demography

Please select the appropriate options

Q1. Kindly state your professional background

[ ] Quantity Surveyor

[ ] Structural Engineer

[ ] Civil Engineer

[ ] Architect

[ ] Project Manager

[ ] M, E& P

[ ] …………………

Q2. How many years have you practiced this profession?

[ ] under 5 years

[ ] 6 – 10 years

[ ] 11 – 15 years

[ ] 16 – 20 years

[ ] over 21 years

Q3. Please specify the type of your organization?

[ ] Small Renovation Contractors

[ ] General Contractors

[ ] Owner-Builders

[ ] Real Estate Developers

Q4. Kindly check the number of departments in your firm?

[ ] Quantity Surveying

[ ] Structural/Civil Engineering

[ ] Geodetic/ Geomatic Engineering

[ ] Mechanical/Electrical/Plumbing

[ ] Architectural

[ ] Project Management

[ ] Procurement

[ ] Logistics and Store/Supply

Q5. Kindly check your education level?

[ ] Post Graduate [ ] First Degree [ ] Higher National Diploma

[ ] Construction Technician Certificate [ ] Advance in Construction Certificate

[ ] Technical [ ] ……………………………….

Q6. Kindly check your membership to the professional bodies below?

[ ] Ghana Institute of Architect [ ] Ghana Institution of Surveyors

[ ] Ghana Institute of Engineers [ ] Ghana Institution of Construction

[ ] ……………………………….

Q7. What are your organizational BIM priorities for attracting staff?

[ ] BIM Software application skills

[ ] Knowledge of BIM concept

[ ] Understanding BIM standards

Q8. What level of training is being provided in the use of BIM in your organization?

[ ] BIM Software application skill

[ ] Knowledge of BIM concept

[ ] Understanding BIM standards

SECTION - B CHALLENGES OF BIM TO THE GHANAIAN CONTRACTORS					
Q9. Which of the following challenges does your firm face in the adoption and implementation of BIM?					
Please tick the appropriate boxes	**Levels of Challenges**				
1- not a challenge at all, 2- no challenge, 3- neutral, 4- critical challenge, 5- very critical challenge					
JOB CHALLENGES	**1**	**2**	**3**	**4**	**5**
1. Lack of Information Management Standard practice					
2. Information Security					
3. Information Accuracy					
4. Lack of External Communication					
5. Lack of Internal Communication					
6. Information Timeline					
7. Lack of Financial Resources					
8. Lack of Managerial Capacity					
9. Technical Inefficiencies					
10. Shortage of Professionals					
11. Lack of Professional with BIM knowledge					
12. No Collaboration with Other Professionals					
13. One man Enterprise					
14. Contract Provision with BIM					
15. Procurement Systems					
16. Standardization of Practice					
17. Laws of the Land					
18. BIM Knowledge					
19. Adjustment of Current Practices					
20. Logistics					
21. Investment in BIM Technology					
22. Innovation					
23. Education/CPD					
24. High Initial Cost					
25. Corruption and Bribery					
26. Poor Technological Edge					

Others (Specified)					

SECTION - C **RELEVANCE OF BIM TO GHANAIAN CONTRACTORS**					
Q10. What are the Significance of BIM to your firm, the construction industry and the entire infrastructural development in Ghana?					
Please tick the appropriate boxes	**Levels of Significance**				
1- not very important, 2- not important, 3- average, 4important, 5- very important					
SIGNIFICANT FACTORS	**1**	**2**	**3**	**4**	**5**
1. High Productivity					
2. Better Coordination of Stakeholders					
3. Quality Control					
4. On-Time Completion					
5. Safety					
6. Overall Cost Reduction					
7. Ease Construction Documentation					
8. Better Clarity and Time Management					
9. Logical/Better Project Management					
10. Reduction in rework, possible drawing errors and omissions					
11. Clash Detection					
12. Premise and early cost estimation					
13. High financial benefit					
14. Accurate Accounting and Price Modeling					
15. Accuracy of bids and project pricing					
16. Unifier of all technical construction experts					
Others (Specified)					

SECTION - D SOFTWARE USAGE IN BIM					
Q11. What is the Level Of Usage Of The Following Technological BIM Software/Tools Used In Your Firm?					
Please tick the appropriate boxes	**Level of Software Usage**				
1- Not Heard Of It, 2- No Usage, 3- Average Usage, 4-High Usage, 5-Very High Usage					
BIM TOOLS/SOFTWARE	**1**	**2**	**3**	**4**	**5**
Architectural Modeling					
1. AutoCAD					
2. Autodesk Architectural Desktop					
3. Autodesk Revit					
4. Bentley Systems					
5. Graphisoft					
6. ArchiCAD					
7. Nemetscherk					
8. Beck Dprofiler					
Modeling/Scheduling					
9. Autodesk Navisworks					
10. Synchron Ltd					
11. Vico Control					
Estimating					
12. Back Dprofiler					
13. Quantity Take Off					
14. Innovaya					
Audit and Analysis					
15. AntodeskNavisworks					
16. Solibri Model Checker					
17. Ecotect					

Others (Specified)					

SECTION - E **FACTORS FOR CAPACITY DEVELOPMENT FOR BIM ADOPTION AND IMPLEMENTATION APPROACHES**					
Q12. What is the current capacity of your firm for BIM adoption and implementation?					
Please tick the appropriate boxes	**Levels of capacity development**				
1-not heard of it, 2- not available, 3- available but not used, 4- average used, 5- extensively used					
CAPACITY DEVELOPMENTS OF CONSTRUCTION FIRM	**1**	**2**	**3**	**4**	**5**
1 Software					
2 Hardware (Special Computers)					
3 BIM Expertise or Technical Staff (skills and knowledge)					
4 Institutional or Organizational Structure					
5 Data utilization and Collaboration					
6 BIM usage in Project deliverance					
7 Local collaboration across industries					
8 Legal instrument and contractual agreement					
9 Protocol and standard practices					
10 BIM Contract provisions					
11 Project bidding					
12 BIM knowledge and training programmes					
13 Continuous professional development					
14 Network configuration					
15 Leadership (effective managerial team)					
16 Project pre planning					
17 Repository Library (Single portal System)					
18 BIM execution plan					
19 Work process of BIM					
20 Procurement system of BIM					
21 Ownership (Copyrights and Control content)					
22 BIM laws and regulations (Legal instruments or framework)					
23 Project Funding					
24 Monitoring matrix systems					
25 Quality assurance and Quality Control procedures					
Others (Specified)					
