A BUILDING INFORMATION MODELLING (BIM) APPROACH TO IMPROVING COLLABORATION AMONG CONSTRUCTION STAKEHOLDERS IN GHANA

BY

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DECLARATION

I hereby declare that this submission is my own work towards the MSc Construction Management and that, to the best of my knowledge, it contains no material previously published by another person, nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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ABSTRACT

Collaboration is essential to the success of construction projects but there seems to be no clear guide on the process of collaboration creating difficulties for stakeholders to effectively interact and achieve a common project goal within the bounds of cost, quality and time. The construction industry has most often used Collaboration as innovative tool towards the attainment of project objectives. This study sought to identify how Collaborative practices among Stakeholders in the Ghanaian Construction Industry can be improved using a Building Information Modelling (BIM) approach. Guided by the research objectives, this study elicited responses from construction professionals who have worked as consultants in their line of work. The data was analyzed with the help of Statistical Package for Social Sciences (SPSS), descriptive statistical tools and measures which included tables, mean and standard deviation. In identifying the challenges of the conventional collaboration, it emerged from this research that Lack of long-term relationship, Lack of reciprocal commitment, Lack of Resource sharing, The Fear of micromanagement in collaboration, Differences in organizational culture of partners, Undefined roles and responsibilities of partners, Lack of Management commitment, Incentive Alignment, Poor management by partners, and Interpersonal relationship emerged as the top ten (10) challenges. Data analyzed revealed that, the uncertainty/high initial cost of BIM, Lack of standardized guidelines and protocols for practice, Lack of Financial Resources, Lack of Professionals with BIM knowledge, Resistance to change, Lack of clarity on who bares possible incremental project cost, Information Accuracy, Lack of industry digitization, Lack of BIM training for professionals and Lack of network capabilities are the ten (10) topmost challenges to BIM adoption and implementation. In conclusion. The study concluded that collaboration is an essential part of the construction industry because of its fragmented nature which seems to converge so many professionals to a construction project with project success as its goal. Hence, Management of Consultancy firms must invest resources into obtaining Building Information Modelling (BIM) and train their professionals to be well equipped in its usage and Construction professionals must not allow their personal indifferences or disagreements to affect the efficient collaboration needed on construction projects.

Keywords: Collaboration, BIM, Consultancy firms, Fragmentation, Integrated Project Delivery, Information systems

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This research work is dedicated to God Almighty, my parents Mr. and Mrs. Gandaa Faaku and my dearest wife Miss Veronica Doe Badzie.

CHAPTER ONE

INTRODUCTION

1.1 Background to Research

The Construction industry is hugely characterized by fragmentation and interdependency of work activities across the phases of a project's life cycle. Scott, (2018). The successful management of the work activities (i.e. conception stage to demolition stage) across the phases of the project impacts positively on the project objectives. Inherently, the work activities present threats that result in cost overruns, low productivity, litigation, ineffective communication and construction delays (Agyekum *et. al.,* 2017). Past research has therefore tried to identify techniques to mitigate the associated risks with the work activities and also employed innovative measures in other to remedy the weaknesses of the conventional collaboration approache in the construction industry. The construction industry has most often used Collaboration as innovative tool towards the attainment of project objectives (Rahman *et. al.,* 2013). It further explains that collaboration is essential to the success of construction projects; the project participants are realizing that sharing of knowledge and information is one of the key elements of a successful contractual relationship. According to a global study from Project Management Institute (PMI), 2013 poor communications account for more than half of the money at risk on any given project. Project Management Institute (PMI), 2013 further sought to explain that Companies risk $135 million for every $1 billion spent on a project – $75 million of that at-risk figure is down to poor communication. Put another way, better collaboration would potentially save $75million for every billion spent on a project. The study also mentions that poor collaboration was the main cause of project failure, at least a third of the time, and negatively impacted project successes more than half the time.

Staykova and Underwood (2017) explains that Collaboration on construction projects must be facilitated by people alongside practice of continuous performance assessment and improvement. However, available assessment tools fail to explicitly define appropriate behaviours and actions due to a poor understanding of project objectives and what it means to collaborate. This has usually contributed to cost overruns, low productivity, litigation, ineffective communication and construction delays (Agyekum *et. al.,* 2017). It is therefore imperative to consider innovative tools and techniques to curtail these negative effects in the construction industry.

Modelling Collaboration

The introduction of Integrated Project Delivery (IPD) into the construction industry presents an approach to modelling collaboration in other to remedy the pitfalls in the conventional approaches and also harness its full potentials to positively impact project objectives. Integrated Project Delivery (IPD) which advocates the collective harnessing of all project participants' talents and insights, is one approach that many in the industry think can make the process more collaborative (Scott, 2014). Integrated Project Delivery IPD allows discussion at the commencement of the project to create stronger links between all the various stages. It's extremely important to break down the silos that exist in the industry (Gadonniex, 2017). A central aspect of Integrated Project Delivery (IPD) is Building Information Modelling (BIM), which Watts (2016) describes as "a real force for collaboration, because it can't really operate unless the entire team is assembled on board at the earliest possible stage – which encourages much earlier contractor involvement". Facilitating collaboration among project stakeholders in the construction industry is one of the central tenants of Building Information modelling (BIM) (Erik *et al.*, 2017). Building Information Modelling (BIM) is a single digitally enabled integrated model of a building's designs and specifications that allows all the various people involved in a project to see what has gone before and what needs to be done (Watts, 2016). The adoption and implementation of Building Information Modelling (BIM) presents enormous benefits at the design, construction and operational stages of a project. It provides higher efficiency, reduces variation in design, provides financial benefits and resolves design clashes in programming before construction begins (Akwaah, 2015). The system also benefits all stakeholders providing increased clarity in design intent, better communication among team members, minimise project costs, permits smoother and well thought planned construction process that reduces the latent for faults and struggles through integrated project delivery (Arayici, et al., 2011; Ahzar et al., 2012).

1.2 Problem Statement

Despite the enormous groundswell of interest in collaboration in recent years, there has been comparatively little research that has set out to investigate systematically the nature, feasibility, benefits and limitations of forms of project stakeholder collaboration. Bresnen and Marshall (2000). Anderson (2019) opines that, although research has outlined the enormous benefits of collaboration in the construction industry, it also presents the barriers to its smooth incorporation of which Ghana is not an exception. Watts (2013) explains that typically, a Client engages the services of an Architect, Engineer and other allied professionals in a fragmented way whiles separately procuring a Contractor to undertake the works. And with no understanding of the project's bigger vision, the contractor and other stakeholders have little motivation to do anything more than their 'job', just delivering the bare minimum within the shortest possible time (Gadonniex, 2017). This presents a gap of not allowing the stakeholders a common platform to adequately collaborate by way of interacting and sharing vital information which could inform project decision. It is therefore important to identify the challenges with the implementation of the conventional approach of collaboration in the Ghanaian construction industry. Collaboration is essential to the success of construction projects but there appears to be no clear guide on the process of collaboration making it difficult for stakeholders to effectively interact and achieve a common project goal within the bounds of cost, quality and time. (Rahman *et al*., 2014).

Building information modelling (BIM) has been identified as a technology-enabled process for more efficient and effective management of information in a digital and virtual environment to achieve project objectives in terms of cost, time and quality delivery (Mahamadu et. al., 2017). It requires individuals with Building Information Modelling (BIM) skills and knowledge to effectively collaborate with project team members to achieve project success (Akwaah, 2015). However, (Wong et al., 2011) maintains that absence of individuals with Building Information Modelling (BIM) skills and knowledge is an important matter hampering the effective use of BIM hence its adoption of which Ghana is not an exception. Mahamadu et. al. (2017) believes that many challenges however, exist and undermines the effective implementation within the construction industry. Mahamadu et. al., (2017) further sought to maintain that the identification of these challenges is critical to the successful implementation and adoption of Building Information Modelling (BIM), especially in view of many implementation risks. Despite the critical role of the design phase to project delivery and Building Information Modelling (BIM) usage, few studies have sought to interrogate the challenges faced by stakeholders which is applicable to the construction industry in Ghana. The Ghanaian construction industry must therefore appreciate the need and value for stakeholders to adopt the Building Information Modelling (BIM) approach to harness the full potentials in a collaborative environment in order to meet or exceed project objectives.

1.3 Research Aim

This study sought to identify how Collaborative practices among Stakeholders in the Ghanaian Construction Industry can be improved using a Building Information Modelling (BIM) approach

1.3.1 Research Objectives

In an attempt to achieve the above aim, the following specific ends were set:

1. To examine the challenges of the conventional collaboration approach to consulting firms in the Ghanaian construction industry.
2. To assess the level of knowledge on Building Information Modelling (BIM) among consultancy firms in Ghana.
3. To evaluate the challenges of Building Information Modelling (BIM) implementation to Consultancy firms in Ghana.

1.3.2 Research Questions

1. What are the challenges of the conventional collaboration approach to consulting firms in the Ghanaian construction industry?
2. What is the level of knowledge on Building Information Modelling (BIM) among Consultancy firms in Ghana?
3. What are the challenges of Building Information Modelling (BIM) implementation to Consultancy firms in the Ghanaian construction industry?

1.4 Justification of Study

The research is purposely meant to identify the current challenges/barriers affecting

Collaboration among stakeholders in the Construction industry in Ghana. Considering the enormous potentials of collaboration in the construction industry it is imperative to adopt and implement appropriate and relevant techniques that will stretch collaboration to its elastic limit in order to harness its full potentials to impact positively on Construction in Ghana.

In an effort to achieve this, the research considers Building Information modeling (BIM) as an implementation technique to improving collaborative practices in the Ghanaian Construction industry. Additionally, the research sought to establish the awareness level of Building Information Modelling (BIM) among construction professionals, the challenges and barriers to its adoption and implementation. It also examines how the industry can take advantage of Building Information Modelling (BIM) to continuously improve construction performance to benefit the nation at large.

1.5 Scope of Study

The research focuses on Public and Private Sector Construction Consultants, duely registered under the laws of Ghana and with the appropriate professional institution. It considers Consultancy firms operating within the environs of the Ashanti and Brong Ahafo regions of Ghana. These locations were selected based on the kind of construction activities and the kind of infrastructural development undertaken within the locality. Again, these regions were mainly chosen due to accessibility of data and the limited time for the study. This affords an in-depth knowledge into the challenges with collaboration and the awareness level of Building Information Modelling (BIM) among building professionals and contractors. The research focus on collaborative practices from the initial design briefing stage, production of final drawings, procurement, contract award, Construction phase and post construction phase of projects. This affords a critical investigation into how the elements of collaboration are utilized among construction stakeholders from the conception stage through to the demolishing stage of projects in Ghana. The various stages were examined to determine the state of collaboration as well as the challenges and barriers in the Ghanaian construction industry. The findings were subjected to the Building Information Modelling (BIM) approach which involves digitization of the industry through standardisation, incorporating manufacturing and offsite assembly to optimize collaborative practices in Ghana. (RIAI Bim Pack, 2019).

1.6 Research Methodology

According to (Naoum, 1998), there are several determinants that are used to choose a type of research methodology; some of which include the objectives of the study, the purpose of the study and the type of the information required. In view of this, the study employs a quantitative approach of research with purposive and snowball sampling techniques for data collection and to identify the main respondents for the study. Data for the study was obtained from primary sources. Primary data was collected through the use of structured questionnaire which comprised of open-ended and closed-ended questions for purposes of standardization and efficient processing for statistical analysis to be conducted. The research was conducted by reviewing relevant literature in the area of study. The review focused on the introduction of the collaboration concept, implementation process of collaboration, barriers and relevance of collaboration. The review again looked at the development of Building Information modelling (BIM) and how it can be adopted as an approach to improve the conventional processes of implementing collaboration in the construction industry.

The data was analyzed with the help of Statistical Package for Social Sciences (SPSS) version 20, and Microsoft Excel 2016 software. In addition, various statistical tools were used in analyzing the data. The use of mean score and standard deviation was employed in the data analysis.

1.7 Research Organization

The research was carried out in five (5) chapters as outlined:

Chapter One: This chapter presents a background to the research highlighting the gaps. It explains the problem statement, research aim and objectives. Additionally, it presents the research questions, justification and defines the scope of the study for the research. Furthermore, the chapter sought to explain the research methodology as well as the organization of chapters.

Chapter Two: The chapter reviewed literature that are relevant to the area of the research highlighting gaps. It also looked at the introduction of Collaboration in the Construction industry; globally, in the Ghanaian construction set up, its contribution, implementation processes and challenges. It furthermore looked at the development of Building information modelling (BIM) and how it can be adopted to improve collaboration processes in the construction industry.

Chapter Three: This chapter explains the methodology that was used to conduct the research. A quantitative study approach was employed by the use of structured questionnaire. It also determines the sample size for the study as well as the methods of analyzing data for the study.

Chapter Four: The chapter presents and discusses results that were obtained from the data collected.

Chapter Five: This chapter is dedicated to concluding the overall research by way of summarizing, concluding and making recommendations based on the results of study for future

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Since the inception of the Building Information modelling (BIM) concept as far back as nineteen seventy's (1970s), large body of researcher have promoted Building Information modelling (BIM) as an innovative way to increasing the need for closer collaboration and more effective communication in the delivery of construction projects through its life-cycle (Penttila, 2006; Succar, 2008; Eastman et al., 2011). According to (Singh, 2010; Shafiq et. al., 2013), conventionally, collaboration efforts across construction disciplines have been based on the exchange of two dimensional (2D) drawings and documents which faces a huge challenge with respect to data sharing among project team members. A number of researchers have reported on the use of Building Information modelling (BIM) as an innovative approach to enhancing collaboration from various viewpoints. According to (Jung, 1999; Maunula, 2008; Succar, 2008) Building Information modelling (BIM), have been developed to efficiently improve and remedy the pitfalls of traditional collaboration efforts in the construction supply chain. Watts, (2016) has also reported that Building Information modelling (BIM) is a real force for collaboration because it can rarely operate unless the entire team is assembled on board at the earliest possible stage – which encourages much earlier stakeholder involvement. Erik *et al.*, (2017) has also opined that facilitating collaboration among project stakeholders in the construction industry is one of the central tenants of Building Information modelling (BIM). This chapter seeks to review relevant literature on collaboration in the construction industry, the evolution and outlook of Building Information Modeling (BIM), the BIM approach to improving collaboration among construction stakeholders, the challenges of the conventional collaboration, the knowledge level of Building Information Modeling (BIM) and the challenges to BIM adoption and implementation.

2.2 Collaboration in the Construction industry

Collaboration is essential to the success of construction projects but there seems to be no clear guide on the process of collaboration creating difficulties for stakeholders to effectively interact and achieve a common project goal within the bounds of cost, quality and time. (Rahman *et al*., 2013). This is affirmed by Staykova and Underwood (2017) that, Collaboration on construction projects must be facilitated by people alongside practice of continuous performance assessment and improvement. However, existing assessment tools have failed to explicitly define appropriate behaviours and actions due to the lack of clarity in project objectives and what it means to collaborate.

Cao and Zhang (2011) defines Collaboration as a partnership process where two or more autonomous firms work closely to plan and execute supply chain operations towards the attainment of common goals and mutual benefits. This definition is no different from Simatupang et al., (2004) who also explains Collaboration as a cooperative strategy of supply chain partners with a common goal of serving customer through integrated solutions for minimizing cost and increasing revenue. The above definitions by (Cao and Zhang (2011); Simatupang et al., (2004) highlights the need for willingness to work together, stakeholder involvement, establishment of a common goal and a defined plan towards the achievement of mutual and common benefit in any collaborative environment. Watts (2013) explains that typically, a Client engages the services of an Architect, Engineer and other allied professionals in a fragmented way whiles separately procuring a Contractor to undertake the works. And with no understanding of the project's bigger vision, the contractor has little motivation just to deliver the bare minimum within the shortest possible time (Gadonniex, 2017). This presents a gap of not allowing early stakeholder involvement and a common platform to adequately collaborate by way of interacting and sharing vital information which could inform project decision. Jung, (1999) has reported that the use of information systems in the construction industry has been an issue of great concern in order to improve the effectiveness of construction projects throughout their life-cycle and across diverse construction business function. In a corroborative view, Shafiq et. al., (2013) opines that, established collaboration practices in the construction industry are document centric and faces a huge challenge with respect to information/data sharing among team members to successfully meet project objectives. The construction supply chain recognizes collaboration as an integral component through which project objectives can be met (Rahman et. al., 2014). However, Rakhudu et. al., (2016) argues that it is through the continuous process of collaboration that common goals, common vision and realities are developed and maintained. Although some form of collaboration is often practised among members of the construction supply chain, yet the ability to collaborate consistently continues to be a huge challenge within the construction industry. According to Bankston and Glazer (2013), this does not allow a positive impact on the key dimensions of project objectives and organizational performance.

2.2.1 Collaboration at the Conceptual Level

According to aiim (n.d), there are eight (8) conceptual levels of collaboration which include Awareness, Motivation, Self-synchronization, Participation, Mediation, Reciprocity, Reflection and Engagement aiim (n.d). It further explained the eight (8) conceptual levels as follows:

- Awareness level of collaboration creates the sense of realization that parties have become part of a working entity with a shared purpose.
- Motivation stage ensures the drive to gain consensus in problem solving or development.
- Self-synchronization creates the platform where individuals make collective decisions as to when things should happen.
- Participation promotes the willingly involvement of a party in a collaborative approach with the expectation that other party(s) will also participate.
- Mediation level creates the sense of awareness that possible conflicts will always be resolved through the use of negotiation and non-confrontational approaches to reach amicable solutions.
- Reciprocity is the anticipation that parties involved in collaboration will share and expect sharing from other stakeholders in return through reciprocity because Collaboration relies on openness and knowledge sharing.
- Reflection involves the continuous planning by stakeholders in collaboration with periodic reviews for alternatives.
- Engagement involves proactively engaging stakeholders rather than waiting to see the adverse effects of events. It also advocates for the establishment and closing of team workspaces with task of responsibility for capturing the emergent results of the collaborative effort.

2.3 The benefits of collaboration in the construction industry

Agyekum et. al. (2017) explains that the benefits of collaboration are grounded in total cost perspective in collaboration, technical expertise by partners and availability of resources in collaboration in the Ghanaian construction industry. Total cost perspective in collaboration is the most anticipated benefit of collaboration which confirms the assertion by Cheung et. al., (2003) that firms in collaboration are better equipped to ensure that projects are completed within cost since each firm presents some expertise which tends to reduce the overall cost of the project.

This assertion is also reinforced by Bresnen and Marshall, (2000) which also places emphasis on the benefits of cost and schedule reduction, as well as improved buildability and greater responsiveness to user requirements. (Agyekum et. al., 2017) further sought to explain that financial security in collaboration and collective acceptance of collaboration are ranked very low by partners in terms of benefits. Bresnen and Marshall (2000) argues that construction stakeholders tends to focus on using more collaborative partnering and alliance in the construction industry. The application of a collaborative approach has enormous benefits to the contractor which includes: the prospect of future work and indirect advantages of marketing a proven track record (Bresnen and Marshall, 2000).

2.4 The impact of lack of collaboration in the construction industry i

Project Management Institute (PMI), 2013 has reported that most construction project failures as a result of the lack of collaboration. The report further sought to explain that Companies risk $135 million for every $1 billion spent on a project – $75 million of that at-risk figure is down to poor communication. Put another way, better collaboration would potentially save $75million for every billion spent on a project. The fragmentation of the construction industry presents high risk taking activities which requires collaborative instruments to mitigate the associated risks Scott, (2018). According to

Agyekum *et. al.,* (2017), the lack of collaboration in managing these inherent risks results in cost overruns, low productivity, litigation, ineffective communication, re-works and construction delays.

2.5 Collaboration Tool and Techniques in Construction

Bresnen and Marshall, (200) has identified various tools and techniques collaboration in the construction industry as: Frameworks, Contracts and Incentives, Contractor selection, Teambuilding charters and facilitation, Organising and managing the project team, managing internal and external organizational interfaces, managing user and other stakeholder relationships and Managing relationships with subcontractors.

2.5.1 Frameworks, Contracts and Incentives

According to (Bresnen and Marshall, 1998), this includes some form of incentive system, commonly based upon an agreed target cost with risk/reward element. The structure of these arrangements are mostly unique from project to project in a number of important respects (Bresnen and Marshall, 1999). However, joint target cost setting which is a common practice and is generally regarded as a useful means of accurate project costing because of the contractor's direct input is employed by stakeholders as a collaborative tool to meet project cost. It also assists cost or value engineering and helps gain the contractor's commitment to project objectives (provided that the target was seen as achievable and the formula equitable). Although establishing a target cost might be difficult in the early stages when the project scope is relatively undefined, it is still regarded as possible, provided there was a 'give and take attitude.

2.5.2 Contractor Selection

The selection of a contractor varies according to the nature of relationship and the objectives of an organization. Some contractors are selected through negotiation and others based on competitive tendering. Sometimes serial contracting and bidding for term agreements with project by project negotiation are also used in contractor selection. These selection processes are mostly geared toward creating a collaborative environment for projects to thrive according to (Bresnen and Marshall, 1998). Intense selection procedures, including interviews and presentations, are used in most cases and, management attitudes are often seen as important as technical and commercial criteria. The emphasis, however, varies, with considerably less emphasis being placed on judging attitudes in the closer, longer-term relationships. The difficulty, however, has been the measuring of these attitudes. The most thorough use of structured selection methods where a multi-stage selection process includes detailed questionnaires, presentations, interviews and site visits, shortlisted contractors are also requested to sample price a limited number of projects. The time and resources spent in selecting a partner(s) could be quite considerable over a longer period. However, selecting the right partner is considered critically important and, given the number of projects carried out under any one framework agreement, the savings in future tendering outlay could be considerable.

2.5.3 Team building, Charters and facilitation

Teambuilding is essential and is often used as a tool to foster collaboration on construction projects. It is usually structured in a formal and intense manner using team-building workshops and relying upon external facilitators. In most cases the process includes the agreement of charters or mission statements. Teambuilding should be initiated at the early stages, after which on-going interaction becomes the main ways of sustaining integration. Views on formal teambuilding ranges from enthusiasm to skepticism, however, there is considerable evidence that teambuilding had helps groups through formative early stages, promoting group identity and cohesion, encouraging feelings of ownership in the project and helping avoid the 'steep learning curve' where early team availability had not been possible.

2.5.4 Organising and managing the project team

One of the configuration of collaboration is the use of a 'tiered' team structure. A tiered team structure allows the separation of strategic and operational matters which encourages the resolution of conflicts and disputes at the lowest possible levels. Decentralization is thus an important element, that aims to promoting 'self-governing', 'self-policing' teams. A physical distance between team members reinforces cultural differences and creates communication problems. This can usually be mitigated by the use of joint project offices to co-locate teams. This have universal benefits due to the direct effect on communications and indirect effects in reinforcing collaborative behavior. The issue of integration is mostly rare among teams and steps should be taken to eliminate the role of duplication and levels of specialization with much emphasis placed upon flexibility in roles at site level. The Lack of clarity in the demarcation of roles, responsibilities and authority is eminent especially in the early project stages. The use of an 'open book approach' which usually allows strong expression of commitment to the sharing of information is an effective technique to overcome these problems. This presents positive views about the quality and openness of relationships and communications between clients, contractors and designers.

The use of information technology is often seen as important in supporting open communications and information sharing. However, the use of more sophisticated technology is surprisingly limited, with three (3) dimensional computer aided design CAD and electronic communications being limited mainly to email.

2.5.6 Managing internal and external organizational interfaces

This advocates for the creation of aa accessible platform to generally accommodate the inputs of clients, contractors and designers throughout the phases of the project. The direct involvement of clients prevents late design changes especially where speed is an objective and also achieves client's satisfaction. Contractors direct inputs at the early stages of projects are important in promoting value engineering and risk management which results in considerable savings.

2.5.7 Managing user and other stakeholder relationships

This involves instituting measures to enhance good internal relationships with users and other internal groups by addressing horizontal and vertical differentiation problems within the client organization (Bresnen and Marshall, 1998, 1999b). Critical emphasis should be placed on preventing persistent internal structural divisions/rigidities or broad cultural constraints, such as the tortuous internal consultation processes within a large, complex client

2.5.8 Managing relationships with subcontractors

Emphasis on subcontractors is critically in promoting collaborative behaviors in the construction supply chain. The absence of this encourages the tendency by subcontractors to revert to adversarial attitudes and behavior. Another point worth noting is that subcontractors not actually included in agreements perceived client-contractor collaboration as having very little, if any, effect on their own work.

2.6 Challenges of Collaboration in the Construction Industry I

Bresnen and Marshall (2000) reported that Collaboration is essential and considerable emphasis is placed upon developing a team culture and fostering the right attitudes. However, there are differences in the ways in which stakeholders set out to achieve this. Bresnen and Marshall, (1998) argues that long term, informal development of trust in the application of collaboration tends to yield substantial benefits as compared to short term alliances and development of trust in the application of collaborative practices in the construction industry. They indicated that senior management support is vital in making a collaborative approach both credible and legitimate. It requires a necessary culture change that needs to be extended throughout the organization, being led from and supported by senior management. However, whereas collaboration did not continue to receive strong senior management support, there are often considerable difficulties reported in diffusing the concept throughout the organization and in translating agreement reached at senior levels into practice. The Construction industry is hugely characterized by fragmentation and interdependency of work activities across the phases of a project's life cycle (Scott, 2018). The industry is also plunged with the problem of lack of understanding as a result of the fragmented multi-disciplinary teams (Munir and Jeffery, 2013). Maurer (2010) has reported that complex construction projects require inter-organizational associations. And to achieve success in inter organizational project ventures, trust between the different project partners is acknowledged as a key success factor. The nature of work in these inter-organizational ventures requires the need for a well-recognized better integration, cooperation, and coordination of construction project teams (Cicmil and Marshall, 2005, cited in Maunula, 2008). With these challenges, the construction industry has always sought to fall on the manufacturing industry for possible solutions. But this has not always worked because the construction industry remains unique in its operation and structure. Whereas product from the manufacturing industry usually remains repetitively same with the same project participants, construction products are distinct and teams are usually formed to undertake a project with little history of working together in the past. The fragmentation and interdependency of work activities have plunged the construction industry into inefficiencies such as conflicts between intra and multi-disciplinary teams, delays in projects, duplication of processes, cost and time overruns, lack of clarity etc. which have overwhelmed the industry (Munir and Jeffery, 2013). This is evidently echoed by the NBS (2018) that around thirty (30%) percent of building materials and forty (40%) percent of working hours are wasted as a result of these inefficiencies that has plagued the construction industry. Consequently, the industry records slim profit margins and the unpredictability of the process poses risk for all stakeholders in the construction supply chain. (Agyekum et. al., 2017) identifies fear of micromanagement, lack of common goals and past negative experience with collaboration, Complacency in collaboration, Lack of consultation among partners, Undefined roles and responsibilities of partners, Poor management by partners as some of the barriers to collaboration in the construction industry. Hudnurkar, et. al., (2013) also identifies the following as challenges to collaboration; Adaptation, Behavioral uncertainty, Differences in organizational culture of partners, Enabling technology, Incentive Alignment, Interpersonal relationship, Joint decision making, Lack of information sharing, Lack of knowledge sharing, Lack of long term relationship, Lack of processes integration, Lack of Management commitment, Lack of Resource sharing, Lack of trust among partners, Legal structure of Organizations /partners, Misunderstanding of collaboration concept.

Table 2.1 Identified Challenges of Collaborationplains

CHALLENGES	CHALLENGES EXPLAINED	SOURCE
Adaptation	As investments of a customer in the supplier's knowledge, structures, and processes to make use of its resources	Walter, (2003) Fynes et al. (2005)

Behavioral uncertainty	Behavioral uncertainty refers to the potential inherent in a situation for difficulty anticipating and understanding actions of partners	Chen et al. (2011)
Complacency in collaboration	Stakeholders in collaboration tend to relax on their expected roles and responsibilities, resulting in overwhelming	Agyekum et. al., (2017)
Differences in organizational culture of partners	Organizational culture is defined as a shared values and belief that can help to understand organizational functioning and provide behavioral norms.	Tan et al. (2006) Jin and Hong, (2007)
Enabling technology	Information technology used in supply chain is referred to enabling technology. Example MIS, TPS, DSS, ERP, EIS etc.	Angerhofer and Angelides, (2006) Lee et al. (2011)
Incentive Alignment	Incentive Alignment refers to the process of sharing costs, risks, and benefits among supply chain partners	Cao and Zhang, (2011) Simatupang and Sridharan, (2005)
Interpersonal relationship	The term refers to networks of informal, personal relationships and exchanges of favors that dominate business activities	Cai et al. (2010)
Lack of common goals	This refers to the mutually agreed end objectives that stakeholders seek to achieve.	Agyekum et. al., (2017)
Lack of consultation among partners	Liaising with all stakeholders in policy formulation, planning and implementation rather than making unilateral decisions.	Agyekum et. al., (2017)
Lack of information sharing	Information sharing refers to the exchange of critical, often proprietary, information between supply chain members through media such as faceto-face meetings, telephone, fax, mail, and the Internet. to the extent to which a firm shares a variety of relevant, accurate, complete, and confidential information in a timely manner with its supply chain partners.	Cai et al. (2010) Cao and Zhang, (2011)
Lack of knowledge sharing	Joint knowledge creation refers to the extent to which supply chain partners develop a better understanding of and response to the market and competitive environment by working together	Cao and Zhang, (2011)
Lack of long term relationship	This refers to the establishment of a long term standing relation among partners which tends to promote trust.	Brensen and Marshall (1998)

Lack of Management commitment	Commitment refers to the willingness of trading partners to exert effort on behalf of the relationship and suggests a future orientation in which firms attempt to build a relationship that can be sustained in the face of unanticipated problems.	Walter, (2003)
Lack of processes integration	Integrated supply chain processes refer to the extent to which the chain members design efficient supply chain processes that deliver products to end customers in a timely manner at lower costs.	Simatupang and Sridharan, (2008)
Lack of reciprocal commitment	This refers to the anticipated commitment from all stakeholders involved in the collaboration.	Walter, (2003)
Lack of Resource sharing	Resource sharing refers to the process of leveraging capabilities and assets and investing in capabilities and assets with supply chain partners. Resources include physical resources, such as manufacturing equipment, facility, and technology. Dedicated investments refer to investments made by a buyer or supplier that are dedicated to a relationship with a specific supplier or buyer, respectively. Cao	Cao and Zhang, (2011)
Lack of trust among partners	A positive belief, attitude, or expectation of one party concerning the likelihood that the action or outcomes of another will be satisfactory	Simatupang et al. (2004)
Legal structure of Organisations /partners	It depends on the extent to which detailed formal legal rules and doctrine exist, the structure and operations of the institutions that implement them, and the so-called legal culture encompassing customs, opinions, and the ways of doing and thinking that define people's practices of and attitudes toward laws. collaborative agreement is another essential element to manage differences in an integrative interfirm relationship coordinative structures and mechanisms consist of a series of activities, structurally	Cai et al. (2010) Jin and Hong, (2007)
Misunderstanding of collaboration concept	The lack of clear understanding of the collaboration concept.	Agyekum et. al., (2017)

Poor management by partners	Poor management skills of stakeholders involved in collaboration.	
Previous negative experience with collaboration	Past involvement with collaboration which yielded adverse effects on the objectives.	Agyekum et. al., (2017)
The Fear of micromanagement in collaboration	The tendency of one party controlling the entire affairs rather than collaborating with team members.	Agyekum et. al., (2017)
Undefined roles and responsibilities of partners	The lack of assigning clear role and responsibilities to partners in collaboration	Agyekum et. al., (2017)

Source: Hudnurkar et. al., (2013)

2.7 Building Information Modelling (Bim)

Eastman et. al., (2008) has reported that the concept of Building Information Modelling (BIM) has been in existence since the nineteen seventy's (1970s). Prior to the emergence of Building Information Modelling (BIM), terms such as Information systems (IS), Inter-organizational information systems (IOIS), Computer integrated construction (CIC), Vital for communication, etc. were developed by various researchers to efficiently improve the traditional collaboration efforts (Jung, 1999; Maunula, 2008; Succar, 2008). Majority of complex projects in Architecture, Engineering and Construction industries involve multi-disciplinary collaboration and the exchange of large building data set. Conventionally, collaboration efforts across the disciplines have been based on the exchange of two dimensional (2D) drawings and documents (Singh, 2010). This is affirmed by Shafiq et. al., (2013) that, established collaboration practices in the construction industry are document centric and faces a huge challenge with respect to information/data sharing among project team members. Penttila, (2006) defines Building information modelling (BIM) as a set of interacting policies, processes and technologies generating a Methodology to manage the essential building design and project data in a digital format throughout the building's life-cycle. The origin of BIM emanates from computer-aided design (CAD) which has been around for some time. Building information modelling (BIM) is recognized as a technology-enabled process for more efficient and effective management of information in digital and virtual environments (Mahamadu et. al., 2017). From the definition by Penttila (2006), Building information modelling (BIM) can be recognized in conjunction with project management framework such as Integrated Project Delivery (IPD), which increases the need for closer collaboration and more effective communication (Eastman et al., 2011). This is affirmed by Watts (2016) who describes Building information modelling (BIM) as a central aspect of Integrated Project Delivery (IPD) and as a real force for collaboration, because it can rarely operate unless the entire team is assembled on board at the earliest possible stage-which encourages much earlier stakeholder involvement.

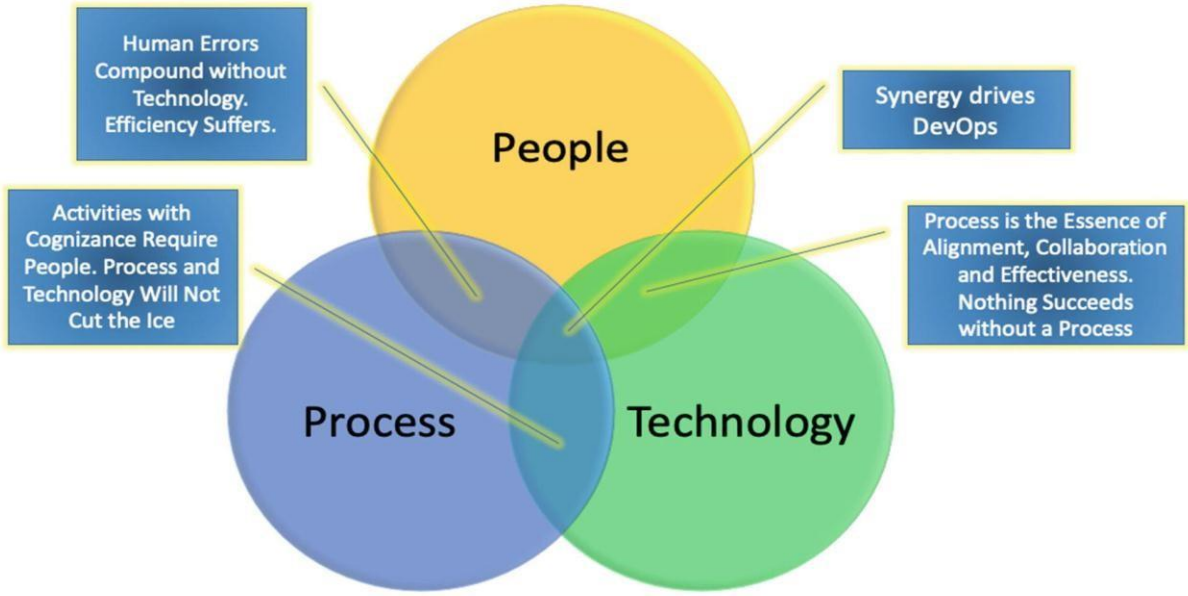
Whereas traditional building projects was largely dependent on two-dimensional designs, building information modelling (BIM) extends beyond three-dimensional designs which seeks to augment the three primary spatial dimensions. BIM is an evolution from the two-dimensional and three dimensional graphic modelling made to incorporate a fourth dimension (time), a fifth dimension (cost), a sixth dimension (building and sustainability analysis) and a seventh dimension for life-cycle facility management aspect (Deutsch, 2011). Building Information Modelling (BIM) provides overriding benefits in the construction supply chain. It serves as a catalyst for change (Bernstein, 2005), reduces the fragmentation in industry (CIWC, 2004), improves efficiency and effectiveness (Hampson and Brandon, 2004) and reduces the high cost of inadequate interoperability (NIST, 2004). However, (Succar, 2008) intimates that Building Information Modelling (BIM) is an expensive domain in the Architecture, Engineering, Construction and operations (AECO) industries. According to (McKinsey, 2015), to get the full benefit of BIM technology, project stakeholders need to incorporate Building Information Modelling (BIM) usage right at the design stage, and all stakeholders need to adopt standardized design and data reporting formats compactible with BIM. In addition, a strong dedication to committing resources and investing in capability building is required.

2.7.1 Key dimensions of BIM

The above definition highlights People, Process and Technology as the three (3) key dimensions of Building Information Modelling (BIM). The United Kingdom's experience with Building Information Modelling (BIM) has established an approximation of the relative importance of each of these key components as follows (Munir and Jeffery, 2013):

- People; seventy percent (70%) which advocates for the initial engagement of stakeholders or persons associated with projects.
- Process; twenty percent (20%) - the current processes have to be reviewed and understood so that Building Information Modelling (BIM) can be introduced in a timely and effective way.
- Technology; ten percent (10%) - the temptation is to procure software to solve 'problems' that have not been properly defined

Figure 1 below illustrate the three (3) key dimension of BIM



Source: (Krishna Kaiser 2018)

Figure 2. 1 The 3 key dimensions of BIM

Building Information Modelling (BIM) therefore is a way of working (rather than a piece of software), it requires skilled, knowledgeable, practitioners and as such requires the commitment of resources and investment in training (NBS, 2015). Consequently, Governments, practices and businesses in recent years have been getting up to speed with current changes in the construction industry by adopting Building Information Modelling (BIM), and by understanding it as a way of working rather than the use of technology for building design. The key concept of Building Information Modelling (BIM) is to have electronic data available in readily accessible format so that useful information can be obtained from it at the right times in the process and re-used when necessary by the stakeholders (Munir and Jeffery, 2013). According to Bryde et. al., (2012), despite the extensive studies of the Building Information Modelling (BIM) concept by academics such as (Aouad et al., 2006; Lee, 2008; Succar, 2009), professional (McGraw-Hill, 2009; BSI, 2010); groups and by software vendors (Bentley, 2003; Autodesk, 2007), literature on project management have not placed much emphasis on Building Information Modelling (BIM) from the project management perspective. Despite this argument, claims of exception is made by Bryde et. al., (2012) to Allison (2010) who is reported to have addressed Building Information Modelling (BIM) potentials as a direct tool of project management by describing ten (10) reasons why project managers should champion the five dimensional (5D) on Building Information Modelling (BIM). In a Corroborative view, Aouad et al. (2006) has defined this multidimensional capacity of Building Information Modelling (BIM) as "nD" modelling, because it allows the addition of an almost infinite number of dimensions to the Building Model. Allison (2010) has further reinforced the argument by stating the advantages of Building Information Modelling (BIM) for project management practitioners as a useful starting point in

Table 1 below.

Table 2. 1: Potential benefit of using BIM for project managers

Potential benefit for PMs	Why?
Organize the project schedule and budget	An integrated 5D BIM model immediately updates both the schedule and budget when any design change occurs.
Work well with the Design Team	By using the integrated 5D BIM model to visualize and explore the impact of changes, s/he can keep project scope in check and become a trustworthy liaison between the designers and Owner.
Hiring and controlling the Subcontractors	Having a handle on clash detection and coordination plays a key role in keeping Subcontractors' work predictable.
Requests For Information (RFIs) and Change Orders	Utilizing Coordination Resolution in preconstruction, these numbers can be brought to near zero.

Optimize the Owner's experience and satisfaction	Owner received a big injection of confidence in the GC when the PM showed him/her how design decisions impacted cost and schedule.
Project closeout	PM to present a 6D BIM – a facilities resource with information on warranties, specifications, maintenance schedules, and other valuable information
Profit margin	By thoroughly understanding the project in 5D, the PM has more tools at his disposal to keep tight reins, and more reports to monitor progress
Progressive Owners are mandating BIM on their projects	Becoming the BIM expert, in both preconstruction and out in the field, makes the PM invaluable and a key player.
PM Firm Growth	Project's success with 5D BIM means the opportunity to grow the firm's reputation and helps the corporate team win new business.

(Source Bryde et. al., 2012)

2.7.2 Levels/Stages of BIM

Building Information Modelling (BIM) has diverse potential use and different levels which can be applied at all stages of the project life-cycle (Grilo and Jardim-Goncalves, 2010; Porwal & Hewage, 2013). The levels of Building Information Modelling (BIM) consist of four (4) levels. The levels of Building Information Modelling (BIM) levels provide an organized charter for the classification of BIM implementation which serves as standard gears for evaluation of information and levels reached at in BIM implementation. Level zero (0) is considered as a pre-BIM where Building Information Modelling (BIM) values and philosophies have not been accepted or adopted yet whiles Levels one (1) to three (3) are considered levels of maturity for Building Information Modelling (BIM) (Succar (2009).

1. Level zero (0)

At this level an unmanaged two dimensional (2D) CAD drafting is employed for the production of information. Most of the data about a facility will be two dimensional

(2D) CAD drawings and any exchange of information is done through paperwork. It represents lack of collaboration between the parties collating information about a built facility. This level also represents the lack of Building Information Modelling (NBS, 2017).

2. Level one (1)

This stage means that data has assumed a form of structure and the CAD is now in either three dimensional (3D) or two-dimensional (2D) and operates within a common data environment. It involves models which comprises of documents and uses concerted software in data exchange. However, there is still some distance to collaboration among different parties involved (NBS, 2017). According to the Scottish Futures Trust, the following should be achieved in order to reach BIM level one (1):

- Roles and responsibilities should be agreed upon
- Naming conventions should be adopted
- Arrangements should be put in place to create and maintain the project specific codes and project spatial co-ordination
- A "Common Data Environment" (CDE) for example a project extranet or electronic document management system (EDMS) should be adopted, to allow information to be shared between all members of the project team
- A suitable information hierarchy should be agreed which supports the concepts of the CDE and the document repository.

3. Level two (2)

Level two (2) of BIM is essentially managed in a three dimensional (3D) setting but created in a separate discipline-based model with devoted data. The separate models are brought together at agreed intervals to form a federated model, but do not lose their identity or integrity. Data at this level may include construction sequencing (4D) and cost (5D) information. At Level 2, collaboration has been introduced among project team members and the process of BIM is being followed. However, there is still a lack of a single source of data, but more importantly there is exchange and sharing of data among teams. There is commonality in the data structure which enables a federated BIM model to be produced.

At this level any CAD software that is been used by each party should be capable of exporting to one of the common file formats.

4. Level three (3)

Level three (3) BIM represents the stage where complete and total collaboration in the planning, construction and operational life cycle of any built asset is achieved. There is full collaboration and better integration among stakeholders who inter-relate timely to produce actual BIM values (Porwal & Hewage 2013; Succar 2009). This is the level where data is collected, shared and stored using a single source of data. At this stage all stakeholders can readily access data on a built asset from a centralized digital platform. This is referred to as 'open BIM' which is the ultimate goal of the construction industry (National BIM Report, 2007)

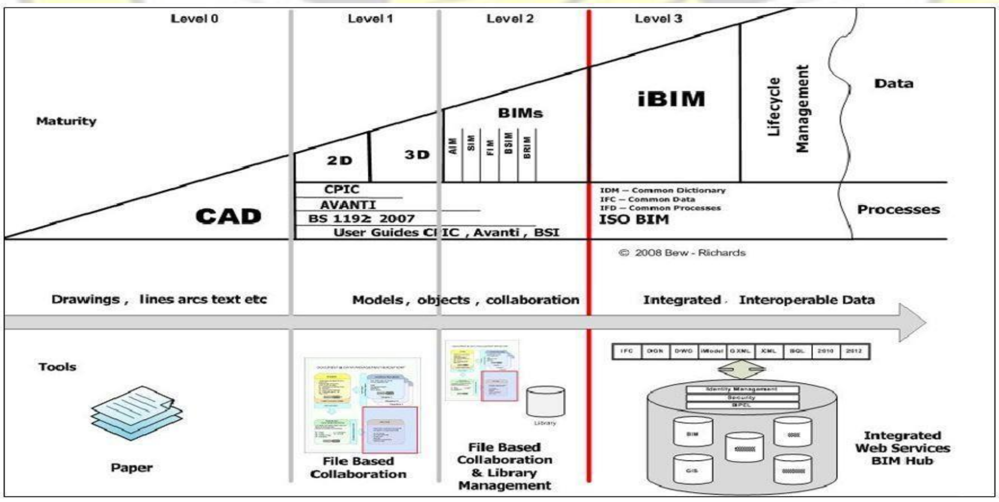


Figure 2. 2: BIM Maturity Levels (Bew and Richards, 2008)

2.7 Benefits of Bim

The usefulness of Building Information Modelling (BIM) is not only limited to the geometric modelling of a building's performance but it also assists in the management of construction projects (Bryde et. al., 2013). This is underscored by Grilo and JardimGoncalves (2010) that Building Information Modelling (BIM) can be employed by project participants at all the phases of a project's life-cycle: by the owner to understand project requirements, by the design team to analyze, by the contractor to manage the construction of the project and by the facility manager to develop operation/maintenance manuals and decommissioning phases.

Reports of the positive impacts of Building Information Modelling (BIM) in the UK's construction industry in respect of reduced transaction costs and less opportunity for errors by Cabinet Office, (2011) confirms the good prospects that projects stand to derive from Building Information Modelling (BIM) adoption and implementation. Che Ibrahim, (2018) has also reported of the benefits of Building Information Modelling (BIM) to include, greater visualization of project information and communications across multi organizations. It provides object based models in a three dimensional (3D) environment with distinct data for visualization (Bew and Richards, 2008). Building Information Modelling (BIM) furthermore serves as an initiative to enhance the platform of collaboration and management of information throughout the building life cycle

(Merschbrock and Munkvold, 2015; Liu et. al., 2017). According to Grilo and JardimGoncalves (2010), Building Information Modelling (BIM) adoption and implementation
has diverse benefits to all the project participants. This is corroborated by Mahamadu et. al. (2017) who underscores some benefits that are specific to project participants in ***Table 2*** below.

Table 2. 2: BIM benefits to various project participants

Project participant	**BIM benefits**	**Source**
Clients/Owners	• Improved visualisation due to communication of proposals in 3D and 4D models	(Arayici et al., 2012b; Eastman et al., 2011)
	• Enhanced client requirement capturing due to better communication with design team	
	• Better quality of as-built information at handingover for facilities management	
Designers	• Increased clarity in design intent	(Arayici, et al., 2011; Azhar, 2011)
	• Easy testing of design options	
	• Easily handled and distributable design documentation and communication across the teams	
	• Informed decision making for optimising sustainability, cost, health and safety objectives	
	• Linking construction schedule data to BIM	
	• Extracting quantities from a BIM model to prepare estimates and costs for project	
	• Using BIM data to minimise project costs and enhance value for money	

Quantity surveyors	• Using BIM to keep track of any variations to the contract that may affect costs and create reports to show profitability	(RICS, 2013; Eastman, et al., 2011; BCIS, 2011)
Contractors and subcontractors	• Better quality information for estimation and bidding	(Sulankivi et al., 2012; Sebastian, 2010; Suermann, 2009;)
	• Early involvement to contribute to constructability and effective scheduling	
Manufacturers	Ease of usage of model data for downstream activities (i.e. manufacturing/assembling)	(Arayici et al., 2012b; Azhar; 2011
	• Product specification compliance during design stage	
	• Better coordination and incorporation of product data for operation and maintenance	
Facilities managers	Enhanced quality of as-built and handing over information and easier integration into computer aided facilities management (CAFM) systems	(Arayici et al., 2012b; Azhar; 2011)
	Easy post-occupancy evaluations for analysis of current use, space and energy assessments	
	• Easier communication of maintenance requirements during design	

Source: (Mahamadu et. al., 2017)

2.8 Overview of Bim in Ghana

Some high majority of professionals in the Ghanaian construction industry have knowledge about the prospects of Building Information Modelling (BIM), but surprisingly with a few firms practicing it on a small scale. Undoubtedly, the knowledge of BIM is spreading in Ghana but on a gradual acceptance and eventually fully adopting it (Akwaah, 2015). (Akwaah, 2015) intimates, the Ghanaian construction industry have some knowledge of understanding about the BIM concept and BIM software application skills. However, the knowledge level on the understanding of BIM standard is very low among industry players. This promises good prospects of a possible Building Information Modelling (BIM) adoption in the Ghanaian construction industry. The adoption of BIM has an overall cost reduction to contractors in Ghana. This variable is observed as very important significant factor of BIM in Ghanaian construction industry. Other significant variables of BIM include: ease of construction documentation, reduction in rework, possible drawing errors and omissions, quality control and assurance and unifier of all technical construction experts. According to Akwaah (2015), some of the common BIM tools or software used in the Ghanaian construction industry includes but not limited to Architectural Modeling, Modeling/Scheduling, Estimating and Audit and Analysis tools. The Architectural Modeling tool (i.e. AutoCAD, Autodesk Architectural Desktop, Autodesk Revit, Bentley Systems etc.) is the most familiar and frequently used BIM software in the construction industry.

2.9 BIM Approach to Improving Collaboration in the Construction Industry

Chan et al. (2004) has reported that Construction projects are becoming much more complex and difficult to manage. One of such complexities is the reciprocal interdependencies between different stakeholders, such as financing bodies, authorities, architects, engineers, lawyers, contractors, suppliers and trades and that of work activities (Clough et al., 2008). The construction industry has most often used Collaboration as innovative tool in the management of such complexities in a quest to meet project objectives (Agyekum *et. al.,* 2017). However, the capabilities of the conventional collaborative approaches have been limited in diverse ways (Shafiq, et. al., 2013). As a result of the increasing complexity of projects, information and communication technology (ICT) has been developing at a very fast pace to augment the collaborative environment in the construction industry (Taxén and Lilliesköld, 2008).

Building Information Modelling (BIM) presents a new way of approaching the design, construction and maintenance of buildings (Succar, 2009). It basically thrives on the utilization of an Integrated Project Delivery (IPD) approach which advocates the collective harnessing of all project participants' talents and insights at the early phase of projects. It is one approach that many in the industry think can make the process more collaborative Scott (2014). The inter-dependency of the different project stakeholders and that of project work activities are better enhanced with the adoption of Building Information Modelling (BIM) approach. Most importantly, the use of a model sever with the BIM concept allows and facilitates the different stakeholders within the construction supply chain to perform collaboration operations on model data using a common platform (Jorgensen et al., 2008). This create intelligent building information models which has improved the visualization, coordination and management of project life-cycle information within an improved collaborative environment (Shafiq, et. al., 2013). Most complex projects in Architecture, Engineering and Construction (AEC) industries involve multi-disciplinary collaboration and the exchange of large building data set. Conventionally, collaboration efforts across the disciplines have been based on the exchange of two dimensional (2) drawings and documents (Singh, 2010). This is affirmed by Shafiq et. al., (2013) that, established collaboration practices in the construction industry are document centric and faces a huge challenge with respect to information/data sharing among project team members. In a response to this challenge document management collaboration system such as Extranets have been employed to in recent years but with limited capabilities for model collaboration (Shafiq, et. al., 2013). Furthermore, documentation of project characteristics is a requirement in the construction industry among the different stakeholders involved in collaboration. Traditionally, this documentation is carried out in an unstructured stream of text or graphic entities and on paper or document basis with enormous challenges of interpreting (BSI, 2010; Ajam et al., 2010). This situation presents the lack of proper integration in the exchange and sharing of project data which inhibits the full potentials of collaboration to be realized on projects. According to Ajam et al. (2010) the adoption of Building Information Modelling (BIM) could be the key approach to ensure this integration and shift from the document paradigm to the Integrated Database paradigm. This system of BIM facilitates the sharing of diverse types of information in an accurate and timely way, which is a key to achieving successful project outcomes (Anumba et.al.,2008). Essentially, the Building Information Modelling (BIM) approach takes the traditional paper-based tools of construction projects, places them on a virtual environment and allows a level of efficiency, communication and collaboration that exceeds those of traditional construction processes. It is an ideal process to develop collaboration techniques and a commitment protocol among the team members (Lee, 2008).

Building Information Modelling (BIM) implementation on projects has a strong advantage in modelling the weakness of the traditional collaboration approaches in the construction industry. The National BIM Report, (2018) has indicated that solutions to the pitfalls in the traditional collaboration approach is not in the squeezing of the supply chain- that has been tried previously without success or in compromising on the performance of the assets, networks and systems. It further advocates that, through the adoption and implementation of the BIM approach, the components of construction assets can be delivered to the site at the right time, in the right sequence with the correct information to be assembled by fewer and trained personnel. This present a better collaborative working platform where integrated solutions use standard components configured using standard processes to give bespoke assets. It contrasts with the traditional model with an enhanced collaborative environment. The concept of Building Information Modelling (BIM) is not only limited to the geometrical modelling and the input of information but also from project management related tools and processes. This therefore captures BIM into the construction project management domain. It has the potential use for construction project managers in improving collaboration between stakeholders, reducing the time needed for documentation of the project and, hence, producing beneficial project outcomes (Bryde, et. al., 2012; Allison (2010).

BIM has also been linked to the development of lean approaches in the management of projects towards the goal of reducing non-value-adding activities (Olatunji,2011). Olatunji, (2011) acknowledges that the key element towards the attainment of the lean goal is the enhanced collaboration and information sharing that BIM offers through the use of digitized model server with devoted data. Bryde, et. al. (2013) has suggested BIM as a catalyst for Project Managers to reengineer their processes to better integrate the different stakeholders involved in modern construction projects. The re-engineering of processes highlights the strength of BIM to re- model the shortfalls of the traditional approach of collaboration through a better integrated platform with the life cycle the facility in perspective.

In another study by Redmond et al. (2012), BIM is reported as an innovative approach towards improving the traditional approach of collaboration in the construction industry. The focus of the study was on the importance of having an integrated platform for BIM applications (i.e. BIM Cloud) to enhance the BIM usability experience across the multi-organisations. They suggested the existence of such exchange mechanism will foster effective collaboration through sharing and exchanging data in order to provide more effective key decisions over time.

2.10 Global Knowledge Level and Development of Bim

Building Information Modelling (BIM) knowledge has consistently been on the rise and enjoys global attention from countries such as the United Kingdom, United States, France Germany, Spain, Hong Kong, china, Dubai, Canada, Ireland, Malaysia etc. (McAuley et. al. (2017)

The global knowledge level, adoption and development of rate of Building Information modelling (BIM) have been reported from various viewpoints. According to Bentein and Pittman (2004) BIM knowledge is gradually permeating the circles of the construction environment although it is often faced with slow pace for adoption. However, according to (McGraw-Hill, 2009; 2007), BIM adoption rate differs from country to country. Building Information Modelling (BIM) has enjoyed great global attention and adoption from countries such as the United Kingdom, United states, Canada, Ireland, Malaysia, France, Germany who have recorded tremendous benefits from the use of BIM on projects. Although the United Kingdom is pursuing to be a front liner in Building Information Modelling (BIM) with its globally influential programmes, the Scandinavian countries have promulgated BIM regulations for almost decade. Countries such as France, Germany and Spain have rapidly evolving programmes. Whiles China, Hong Kong, Dubai and Singapore had their regulations in place before the UK. According to Underwood and Isikdag (2011), the public and private sectors in the USA are collaborating to promote BIM's use. In the quest of the UK's Government in promoting the use of BIM since 2011, it has instituted a 'BIM' mandate where all public contracts awarded would require the supply chain members to work collaboratively through the use of "fully collaborative 3D" BIM (i.e. maturity level two) by 2016 (CabinetOffice,2011:14). This road map is in anticipation towards a universal adoption of BIM the UK. (BIS, 2011). The NBS National BIM Report (2018) indicates that BIM Level 2 is now part of government and often private sector procurement, and the components of this approach have entered common parlance. The report further reveals BIM adoption and implementation by large Estate developers who recognize Building Information Modelling (BIM) as a catalyst for better coordinated and effective asset management systems. As a result, Governments, practices and businesses in recent years is been expedited in the construction industry. The Government now understand BIM as a way of working rather than the use of technology for building design. Furthermore, the report indicates the fascinating insights into the way that BIM and the digital built environment are developing around the world outside the UK market. Some high majority of professionals in the Ghanaian construction industry have knowledge about the prospects of Building Information Modelling (BIM), but surprisingly with a few firms practicing it on a small scale and also using it as tool rather than a way of working. Undoubtedly, the knowledge of BIM is spreading in Ghana but on a gradual acceptance and eventually fully adopting it (Akwaah, 2015). (Akwaah, 2015) intimates, the Ghanaian construction industry have some knowledge of understanding about the BIM concept and BIM software application skills. However, the knowledge level on the understanding of BIM standard is very low among industry players. McAuley et. al., (2017) conducted a survey which mainly focused on the evidence of BIM knowledge and regulation within selected countries. The findings of this report are summarized in the table 2.4 below:

Table 2. 3: Global BIM Knowledge and Regulation Evolution

COUNTRY	STATUS
Austria	Likely to be in place 2018
Belgium	No regulation to-date
Brazil	Roadmap under review / consideration
Canada	No regulation to-date
Chile	BIM Mandated for 2020
China	BIM required through the 12th national Five-Year Plan
Czech Republic	No regulation to-date
Denmark	Mandatory requirement since 2007 (extended adoption in 2011)
Dubai	Mandated since 2013
Finland	Senate Properties 2007 Finish Transport Agency – Inframodel 3 (LandXML) (2014)
France	Mandated for 2017
Germany	Mandated for 2020
Hong Kong	Mandated in place since 2014
Ireland	Roadmap to Digital Transition for 2018 to 2021
Italy	Mandated for 2019
Netherlands	No Mandate
New Zealand	No regulation to-date
Norway	Mandated since 2016
Portugal	No BIM requirement planned
Qatar	No regulation to-date
Scotland	Mandated for 2017
Singapore	Mandate in place since 2015
Spain	Mandated for 2018
Sweden	Mandated for Swedish Transportation Administration
Switzerland	No Regulation to-date
United Kingdom	Mandated since 2016
USA	Multiple Mandates through different states

Source: McAuley et. al. (2017)

2.11 Challenges of BIM Adoption and Implementation in the Construction Industry

Porwal and Hewage (2013) have opined that the adoption of new technologies in any industry faces diverse challenges of which Building Information Modelling (BIM) is not an exception. Despite the enormous benefits Building Information Modelling (BIM) to the construction industry (Bryde et. al., 2013; Cabinet Office 2011; Eastman et al., 2011; Che Ibrahim 2018), there are also serious challenges that needs to be overcome if effective multi-disciplinary collaborative team working, supported by the optimal use of BIM, is to be achieved. Mahamadu et al. (2013) classifies the challenges to BIM adoption as technological, organisational and environmental factors. The technology factors refer to technical problems concerning the characteristics and capabilities of the (BIM) technology. The organisational factors refer to internal organisational concerns (i.e. structure, resources, leadership and people) as well as to the social stimulus of technology adoption (Davies and Harty, 2013; Mahamadu et al., 2013). The environmental factors include all other issues, mainly macro level facilitating conditions such as the industry and market environments provided by governments, professional institutions and software vendors to facilitate ease of BIM implementation (Mahamadu et al., 2013).

2.11.1 TechnologicaL challenges

Challenges such as synchronization of BIM applications still exist, there are recognised problems whereby different BIM applications are not communicating with each other as a result of technical and non-technical factors. This limits the integration process across the engineering disciplines (Redmond et. al., 2012; Oesterreich and Teuteberg, 2016). According to (Mahamadu et al., 2017; Eastman et al., 2011; Singh et al., 2011), the lack of Information Technology resources and network capability to run BIM applications are

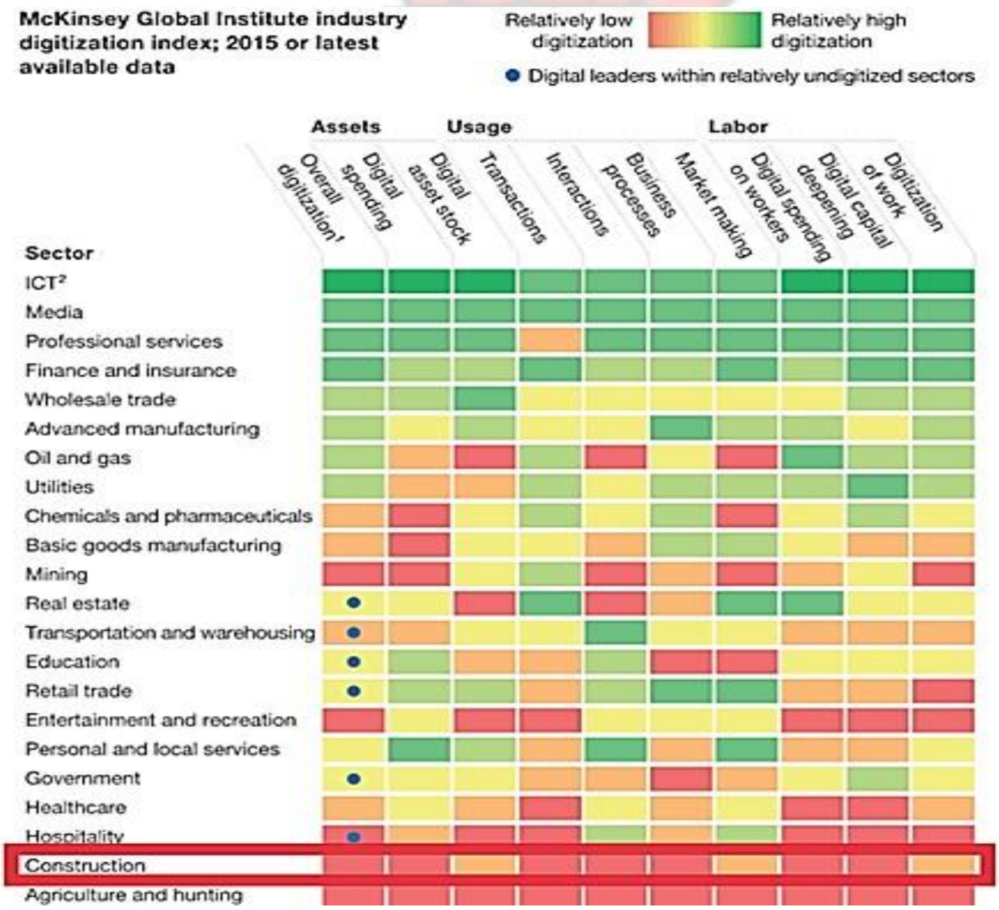
some of the related challenges to BIM. Gu and London, (2010) identifies the interoperability of software and systems as one of the prominent challenges to BIM which impedes the effective transfer and sharing of data across different proprietary information systems and software amidst a lack of software standardization. According to Zahiroddiny (2012), the slow advancement of the BIM technology poses a huge challenge for it to be used as a single model due to bandwidth limitations, and interoperability between different software platforms. He submits that most often BIM has been used as a tool rather than as a centralised source of information. Data protection uncertainty, information accessibility and accuracy have been cited by Singh et al., (2011) as some technical challenges to BIM adoption. AEC professionals have most often expressed reservation with data security risk amidst issues regarding accessibility of the pervasive open virtual environment BIM introduces (Mahamadu et al, 2013).

2.11.2 Organizational challenges

Some of the challenges include adaptation (from existing to new processes) as a result of the changing roles of key parties, such as clients, architects, contractors, sub-contractors, suppliers (Sebastian, 2011). For example, the introduction of Building Information Modelling (BIM) is likely to affect the role of the Project Manager with the usage of an enhanced technology on daily basis on projects. Meanwhile the ultimate impact of the BIM technology on the outputs and outcome of the project are still not clear (ArandaMena et al., 2009). This situation creates challenges to the adoption of Building Information Modelling (BIM) on projects since the support of senior management is a critical factor for a successful implementation (Bresnen and Marshall 1998). According to Porwal and Hewage (2013), one of the greatest challenge for BIM implementation is the Organizational and people centered issues which includes the endemic resistance to change. This is because Maturity and adoption of BIM depends mainly on the client or the owner in construction projects. Again, Public sector clients often perceive that the market is not ready for BIM and are therefore no ready to increase project cost by limiting competition. Moreover, BIM has limited power if the contractor is not integrated in the project at the design phase. In a collaborative view, Liu et. al. (2017) also explains that the complexity of the organizational behaviour, self-interest, isolated working practices and trusting the old system to realizing the value of digital transformation are some possible reason that contribute to this challenge. Despite the potential benefits of BIM, it is still saddled with the problem of continuous and consistent collaborative practice in BIM projects. The high initial and uncertainty about the costs of BIM implementation and the lack of clarity on who bares possible incremental project cost have been cited by Azhar, (2011) as some challenges to BIM. The perception of losing authority and control over information as a result of the involvement of different stakeholders in the information delivery process contributes to the challenges of BIM (Mahamadu et al., 2013). In building the capacity of contractors for the adoption of BIM requires project team members to exhibit good knowledge of BIM which can be achieved through training for professionals by the organization (Akwaah, 2015).

2.11.3 Environmental challenges

For the construction industry to take full advantage of the Building Information Modelling (BIM) technology, it requires the digitization of the industry through standardization (RIAI BIM Pack, 2019) which is further emphasized by McKinsey and Company (2015) as a major hurdle to the successful adoption and implementation of Building Information Modelling (BIM). Succar (2009) explains that, during the last decade, a major shift in ICT for the construction industry has been the proliferation of Building Information Modelling (BIM) in industrial and academic circles as the new Computer Aided Design (CAD) paradigm. However, McKinsey's index of digitization (2015) dissenting on this assertion argues that the Construction industry is one of the least digitized sectors as it only surpasses the agriculture and hunting sectors. Figure 1 below shows the level of digitization for various industries.



Source: McKinsey & Company

Figure 2. 3: (Global levels of industry digitization)

The report from Figure 1 above further highlights some of the most noteworthy statistics which depicts the troubling situation that construction find itself:

- **1% IT spend**: Construction is one of the least digitized sectors. Only agriculture and hunting are less digitized than the Construction sector.

30% wrench time: The efficiency rate in construction is concerningly low. During the last five decades, productivity in construction declines by 0.3% on average on a yearly basis. Only in the US, the labor productivity growth rate doesn't exceed 0.1% (the lowest rate compared to other similar industries).

The new contractual relationships and legal provision with BIM are some of the challenges to BIM adoption. This include the kind procurement systems that is incorporated in the delivery of projects (Sebastian, 2011). The fragmented nature of the construction industry poses another challenge to the adoption of BIM in the sense that knowledge gained by a team during the execution of a project is mostly not retained and used on future projects. There is no clear evidence whether BIM is able to overcome this structural problem (Lindner and Wald, 2011). The case for BIM is totally not proven and its overall effectiveness and utilization is still not completely justified (Jung and Joo, 2010). The promotion of standardised guidelines, protocols and other forms of implementation support enhances the successful adoption of BIM. The lack of these guidelines and protocols have always posed challenges to BIM adoption (Fischer and Kunz (2006). The facilitating conditions for the promotion of these guidelines and protocols requires wider Government and industry support for a successful BIM adoption and implementation (Gu and London, 2010). Furthermore, the lack of

Professionals with BIM knowledge has been cited as one of the challenges to BIM adoption. According to Underwood and Ayoade, (2015) the availability of professionals with BIM knowledge is important to the adoption of BIM since this tends to whip up the interest of individuals and organisations' BIM proficiency.

2.12 Chapter Summary

Collaboration is an important component of all facets of academic, professional and industrial endeavours which includes the construction industry (Rakhudu et. al., 2016). The construction industry has most often used Collaboration as innovative tool towards the attainment of project objectives due to the level of fragmentation and documentation centricity of the industry (Scott, 2018; Shafiq, et. al., 2013; Agyekum *et. al.,* 2017). Although the use of conventional approaches of collaboration in the construction industry has recorded some benefits, it is limited in its capacity to the fully integrate all the project stakeholders through the project's life cycle (Shafiq, et. al., 2013). The increasing complexities and fragmentation in the industry has consistently exposed the shortfalls of the conventional approaches of collaboration. As a result of the increasing complexity of projects, information and communication technology (ICT) has been developing at a very fast pace to augment the collaborative environment in the construction industry (Taxén and Lilliesköld, 2008). This chapter reviewed literature on the concept of collaboration in the construction industry, identifying the challenges and benefits of collaboration in the construction industry. The chapter further looked at the evolution and outlook of Building Information Modeling (BIM) concept, identifying the benefits, challenges and level of knowledge within the construction environment. Emphasis was placed on the global knowledge level, adoption and implementation of Building Information Modeling (BIM) in the construction supply chain with an overview of the Ghanaian construction industry. Furthermore, it concludes on the adoption and implementation of Building Information Modeling (BIM) as an innovative way to ensuring better integration and the sharing of project data across inter- disciplinary and multi-disciplinary construction stakeholders hence improving the collaborative environment that drives the construction industry. Thus introducing the Building Information Modeling (BIM) approach to improving collaboration among construction stakeholders. Finally, the chapter reviewed relevant literature on the research objectives identifying various challenges to the conventional approach of collaboration, BIM knowledge level and some of the challenges to the adoption and implementation of BIM.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

Research methodology has been defined by Knight and Ruddock (2008) as the principles, procedures and logical thought processes that can be employed for scientific enquiry. It is imperative to select an appropriate methodology since it enhances the standard, validity of claims and conclusion that are presented by a research study (Yin, 2003). It further ensures an ethical approach to enquiry and analysis of research results (Fellows and Liu, 2009).

Based on a literature review from the previous chapter, this chapter discusses the context and reasons for selecting a type of research methodology and the various steps used to reach the objectives of the research study. The chapter places emphasis on proposed research method comprising; research design, research procedure, population size, target group and sample size determination. This largely helped to achieve the research aim of identifying how collaborative practices among construction stakeholders in Ghana can be improved using a Building Information Modelling approach. Again the chapter discusses methods and techniques used in the design of questionnaires, data collection, data sources and data analytical tool to be employed for the research study. The procedure employs the use of survey questionnaires to be served on various Consultancy firms and their staff from both the Public and Private sectors within the Ashanti and Brong Ahafo Regions of Ghana. These regions were mainly chosen due to accessibility of data and the limited time for the study. Information from the respective firms and their personnel were fetched, processed and analysed.

3.2 Research Design

Research design has been defined by researchers from various viewpoints. According to Polit and Hungler (1999), it is a general plan for deriving answers to the questions being studied and for the management of some of the difficult issues in the process of a research study. Naoum (1998) opined that the objectives, purpose of a research and the type of information required are among various determinants of a particular type of research method. In view of the research objectives, a Quantitative approach of research is deemed most appropriate for the study. Purposive and snowball sampling techniques was adopted for data collection and to identify the main respondents for the study. A survey questionnaire which according to Naoum, (1998) helps to elicits facts, opinions and views from various respondents was administered as a tool for collecting data. Data for the study was obtained from primary sources. Primary data was collected through the use of structured questionnaire which comprised of open ended and closed ended questions for purposes of standardization and efficient processing for statistical analysis to be undertaken. The survey questionnaire was adapted to obtain feedbacks on the views of respondents about challenges of the conventional approach of collaboration, the level of knowledge on Building Information Modelling (BIM) and challenges associated to the adoption and implementation of BIM in the Ghanaian Construction industry. Secondary data will be gathered from documented facts.

3.3 Sources of Data

An extensive review of literature by the researcher sought to provide enough grounds for the derivation of information for this study. The study also relied on data that was gathered from respondents through the uses of questionnaires.

3.4 Research Instrument

Data gathering for this research was done through the administering of questionnires. Electronic Survey monkey questinnaires were sent out to respondents who were mainly construction professionals working in various Consultancy firms in the Ashanti and Brong Ahafo Regions of Ghana.

3.4.1 Questionnaire Design

According to Denscombe (2010), the collection of data through questionnaires allows the anonymity of respondents to be maintained whiles obtaining facts and opinion from them. Furthermore, it helps to collect data in a standardize way which when collected from a representative sample of distinct population allows an inference of its outcome to be generalized on a broader population (Rattray & Jones, 2005). The questionnaire which consisted of four (4) parts was designed to solicit the views and opinions of respondents on the various challenges affecting the conventional approach of collaboration within the construction industry. Again the questionnaire sought to find out from respondents their knowledge level on Building Information Modelling (BIM) and the challenges to its adoption and implementation in Ghana.

3.4.2 Structure of Questionnaire

Part 1: Background Information

Part 2: Challenges of the conventional Collaboration to Consultancy firms in Ghana.

Part 3: The level of BIM knowledge among Consultancy firms in Ghana.

Part 4: The challenges of BIM adoption and implementation to Consultancy firms in Ghana.

The questionnaire development started with a brief introduction of the researcher and clearly stating the research theme, aims and objectives. It also stated to the respondents the purpose for which the research is been conducted. This was aimed at assuring the anonymity of respondents and also confidentiality of their responses to answers in the questionnaire. The questionnaire adopted closed-ended questions which required respondents to answer by ticking the appropriate boxes. Respondents were also provided with adequate guidelines in very simples English terms to enhanced their appreciation of questions thereof. Respondents were asked to tick from multiple choice answers in (Part 1) and tick appropriate answers on a Likert scale from (Parts 2-4).

Part 1: This part of the questionnaire sought to establish the background information/demography of respondents. This was aimed at ensuring that respondents are captured within the category of person(s) working in Consultancy firms within the Ghanaian Construction Industry. Questions included educational and professional qualifications as well as background information of firm.

Part 2: This part focused on the Challenges of conventional Collaboration to Consultancy firms in Ghana. Based on some challenges that were identified from the literature review, respondents were asked to answer question by ticking on a Likert scale of 1-5 factors that affect the convention collaboration in the construction industry (1=Highly Insignificant, 2- Insignificant, 3=Neutral, 4= Significant, 5= Highly Significant). The challenges were presented in a table format for ease of reading to guide respondents through their answers.

Part 3: The researcher sought to use this part of the questionnaire to assess the level of BIM knowledge by professionals working in Consultancy firms and the Consultancy firm as a body. The Literature review on BIM concept and evolution presented a thorough understanding which were presented in statement forms in the questionnaire. Respondents were required to indicate their level of knowledge and their extent of familiarity with the statement by ticking appropriate boxes on a Likert scale of 1 – 5. (1= Highly unfamiliar, 2= Unfamiliar, 3= Not sure, 4= Somehow familiar, 5= Very familiar)

Part 4: The focus here was to identify the Challenges to the adoption and implementation of BIM from professionals working in Consultancy firms in Ghana. Based on some challenges that were identified from the literature review, respondents were asked to answer question by ticking on a Likert scale of 1-5 factors that affect BIM adoption and implementation in the construction industry in Ghana. (1=Highly Insignificant, 2- Insignificant, 3=Neutral, 4= Significant, 5= Highly Significant). The challenges were presented in a table format for ease of reading to guide respondents through their answers.

3.4.3 Pilot questionnaire

A distribution of a drafted questionnaire was preceded by administering the main questionnaire. The drafted version of the main questionnaire was piloted on two (2) consultancy firms in Sunyani to obtain responses that will help test the wordings of the questionnaire. This was aimed at identifying ambiguous questions and furnish the researcher as to how much time will be required by respondents to complete the questionnaire. The structure and content of the final questionnaire was developed based on feedbacks from the piloted questionnaire prior to administering it.

3.4.4 Distribution of main questionnaire

The final survey questionnaires were personally distributed to respondents using snowball and purposive sampling approach. This ensured that questionnaires were delivered to the relevant target group to achieve a representative sample from a distinct population. Subsequent follow ups were made to retrieve the questionnaires from respondents.

3.5 Target population

The target population for this study consisted of Construction professionals working in both Public and Private consultancy firms duly registered by statutory laws of Ghana working within the building, roads and civil Engineering sectors in the Ashanti and Brong Ahafo Regions of Ghana. According to www.ppaghana.org, there are 14 private consultancy firms in good standing and 4 Government Consultancy firms in both the Ashanti and Brong Ahafo Regions of Ghana who are in good standing. This gives a total of 18 firms in the two Regions.

3.6 Sample size determination

It has been reported by Miaoulis and Michener (1976) that, there are several approaches used in determining a sample size, these include the level of precision, the level of confidence and the degree of variability in the attributes being measured. However, the determinant of a sample size is not limited to the above factors alone. Isreal (1992) have extended the factors to include: the purpose of the study, population size, the risk of selecting a bad sample and the allowable sampling error. The sample size was derived from the various targeted population from above. Since the Private firms formed the majority of the population three (3) Construction professionals were considered from each of the Private firm (i.e. 3 x 14 = 42) whiles two (2) Construction professionals were considered from the Government firms (i.e. 2 x 4 = 8). The above calculation gives a total of 50 professionals. In view of this a targeted sample size of 50 was considered for the study. This consisted of construction professionals working in various consultancy firms in the two Regions. However, 33 questionnaires were retrieved from the respondents.

3.7 Data Analysis

The data obtained from completed questionnaires was edited to ensure completeness, consistency and readability. The data was organized in a format that allowed for ease of analysis. Codes were assigned to quantifiable data and inputs were made using Statistical Package for Social Science (SPSS) version 20. This was later conveyed into Microsoft Excel for further analysis using descriptive statistical tools and measures which will include tables, mean and standard deviation. Mean score and standard deviation were used to analyze data collected on the challenges of the conventional collaboration approach, challenges of BIM adoption and implementation and the Level of knowledge on BIM.

Mean score

Data obtained from the challenges of the conventional collaboration approach, challenges of BIM adoption and implementation and the level of BIM knowledge were ranked according to their mean scores. The mean score was used in ranking the variables of interest based on the scores assigned by the respondents. The factors were ranked using the formula below:

Mean score formula is as follows:

$$\text{Mean Score } (I) = \frac{\sum a_1 x_1}{\sum x_i}$$

Where:

I = Mean score

a = Rank of event i

x = frequency of event i

This formula is very popular with researchers in the construction management field (Egbu and Botterrill, 2002; McCaffer and Edum-Fotwe, 2001)

Standard deviation

The data was analyzed using Standard deviation (SD) for the ranking of the challenges of the conventional collaboration approach, the level of BIM knowledge and the challenges to BIM adoption and implementation from the Consultancy firms point of view. The factors were ranked using the formula below:

Standard deviation formula is as follows:

$$\mathrm{SD} = \sqrt{\frac{\sum |x - \bar{x}|^2}{n}}$$

Where

SD = standard deviation

∑ = summation

x = the return observed in one period (one observation in the data set)

x = arithmetic mean

n = number of observations

3.8 Chapter Summary

The chapter presents the research methodology and the procedure used for conducting this study. It also outlines the research design explaining sources of data, questionnaire, population, selection of sample, description of the technique used in designing the research instrument and collection of data. The chapter further provides justification for the selection of respective statistical measure employed for analyzing data obtained.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND DISCUSSION

4.1 Introduction

This chapter is dedicated to the analysis of the data obtained from the field. The first section describes the information obtained on the respondents that gives credibility to the study. This chapter also demonstrates the results from every section of the survey instrument. The results from the analysis were discussed thoroughly by the researcher.

4.2 Demographic Background of Respondents

The reliability of any research is partly dependent on the source of data and the rigorousness of the analysis employed. In order to provide reliability and have confidence from the findings, questions were posed in the questionnaire that aimed at gathering information on the respondents as shown in the table 4.1 below.

Table 4.1 Demographic Background of Respondents

Background Information	Frequency	Percentage
Professional Background		
Architect	12	36.4
Quantity Surveyor	10	30.3
Structural Engineer	6	18.2
Road Surveyor	2	6.1
Quality Control	3	9.1
Highest Level Of Education		
HND	5	15.2
Bachelor's Degree	11	33.3
Master's Degree	12	36.4
Doctorate Degree	2	6.1
PGDip	3	9.1
Years of experience		
1-5 years	8	24.2
6-10 years	16	48.5

11-15 years	2	6.1
16-20 years	5	15.2
Above 20 years	2	6.1
Professional Affiliation		
Ghana Institution of Surveyors	9	27.3
Ghana Institute of Architects	11	33.3
Ghana Institution of Engineers	8	24.2
Institution of Engineering and Technology	5	15.2
Type Of Your Organization.		
Public Organisation	23	69.7
Private Organisation	10	30.3
Firm's Area Of Work		
Building Works	16	48.5
Civil Works	9	27.3
Road Works	8	24.2
Number of years working in your firm		
1-5 years	20	60.6
6-10 years	9	27.3
11-15 years	2	6.1
Above 20 years	2	6.1
1-5 years	20	60.6

Source: Field Survey (2019)

4.3 Challenges of Collaboration to Consultancy Firms in Ghana

Collaboration is an important component of all facets of academic, professional and industrial endeavors. It is through the continuous process of collaboration that common goals, common vision and realities are developed and maintained (Rakhudu et. al., 2016). Collaboration is essential to the success of construction projects but there seems to be no clear guide on the process of collaboration creating difficulties for stakeholders to effectively interact and achieve a common project goal within the bounds of cost, quality and time (Rahman *et. al*., 2013).

4.3.1 The Use of Collaboration with Other Construction Stakeholders

Respondents were asked if the companies that they work in collaborates with other construction stakeholders on a construction project. The construction industry is fragmented with professionals like engineers, project managers, landscape designers etc. and at a point during the construction project, these professionals from different companies would be required to collaborate so as to make the project successful. TwentyEight (28) of the respondents said that they collaborate with other construction stakeholders and Five (5) said they do not collaborate with construction stakeholders. Concerning the respondents who said they do not collaborate with other stakeholders, it can therefore be deduced that these respondent might have rough and unpleasant working relationships from previous collaboration with other construction stakeholders.

Table 4.2 The Use of Collaboration with Other Construction Stakeholders

The Use of Collaboration	Frequency	Percentage
Yes	28	84.8
No	5	15.2

Source: Field Survey (2019)

4.3.2 Challenges of Collaboration to Consultancy Firms in Ghana

The respondents were asked to identify some of the challenges that they encounter when they collaborate with consultancy firms. *Lack of long term relationships* was ranked as 1st with a mean of 4.79. When companies do not have any previous working relationship with consultants, their first collaboration is with mixed feelings as they may not know what to expect and even how to deal with them. This is because every company is unique and brings on board their principles which might differ from that of the consultants. *Lack of reciprocal commitment* emerged 2nd with a mean of 4.45. Construction companies may be committed to ensuring that both parties are able to deliver their responsibilities to ensure the project success. However, there is the challenge of the consultancy firms dragging their feet in working with them by exhibiting lackadaisical attitude. *Lack of resource* sharing was ranked as 3rd with a mean of 4.06. *The fear of micromanagement in* *collaboration* was also ranked 4th with a mean of 3.85. *Difference in organizational culture of partners* was ranked 5th with a mean of 3.82.

Table 4.3 Challenges of Collaboration to Consultancy Firms in Ghana

	Mean	Std. Deviation	Ranking
Lack of long term relationship	4.79	.941	1
Lack of reciprocal commitment	4.45	1.044	2
Lack of Resource sharing	4.06	.966	3
The Fear of micromanagement in collaboration	3.85	.906	4
Differences in organizational culture of partners	3.82	1.014	5
Lack of Management commitment	3.76	.830	6
Undefined roles and responsibilities of partners	3.76	1.226	7
Poor management by partners	3.67	.957	8
Lack of processes integration	3.64	.822	9
Challenges of Conventional Approach	3.64	.962	10
Interpersonal relationship	3.64	1.113	11
Previous negative experience with collaboration	3.64	1.270	12
Behavioural uncertainty	3.61	1.171	14
Misunderstanding of collaboration concept	3.61	1.088	15
Legal structure of Organisations /partners	3.61	1.088	16
Lack of trust among partners	3.61	1.248	17
Lack of consultation among partners	3.52	1.121	18
Complacency in collaboration	3.45	1.175	19
Lack of common goals	3.42	1.062	20
Lack of information sharing	3.39	.864	21
Lack of knowledge sharing	3.36	1.141	22
Enabling technology	3.33	1.109	23
Adaptation	3.18	1.185	24

Source: Field Survey (2019)

4.4 The Knowledge Level of Building Information Modelling (Bim) Among Consultancy Firms in Ghana

Building information modelling (BIM) can be recognized in conjunction with project management framework such as Integrated Project Delivery (IPD), which increases the need for closer collaboration and more effective communication (Eastman et al., 2011). Therefore, it was necessary to ascertain the level of knowledge of the respondents with BIM by asking series of questions like; if they have heard of BIM before, the period that they heard about BIM, whether the firm they work in employ the use of BIM in its activities and how often the firm uses BIM. The table 2.5 gives a breakdown of the frequency of the questions asked.

Table 4.4 Awareness of BIM

Awareness of BIM	**Frequency**	**Percentage**
Have Never Heard of BIM	9	27.3
Have Heard of BIM	14	42.4
Have Heard of BIM and have a fair understanding of what it means	3	9.1
I am familiar with the BIM concept	7	21.2
Have Never Heard of BIM	9	27.3
The First Time You Heard Of BIM		
1-5 years	21	63.6
6-10 years	6	18.2
Never	6	18.2
Does your firm employ the use of BIM in its consultancy activities?		
Yes	13	39.4
No	20	60.6
How often Does your firm employ the use of BIM in its consultancy activities?		
Always	5	15.2
Usually	3	9.1
Sometimes	5	15.2
Never	20	60.6

Source: Field Survey (2019)

4.4.1 General Statements on BIM

In ascertaining the level of knowledge of respondents on BIM, it was necessary to test their knowledge level by providing certain statements for them to rate on a scale of 1-5 with **1=** Highly unfamiliar, 2= Unfamiliar, 3= Not sure, 4= Somehow familiar, = Very familiar. These general statements were grouped under 2 categories; general BIM concept and BIM dimensions. Table 2.6 below illustrates the breakdown of the how the respondents responded to the general BIM statements.

Table 4. 4 General Statements on BIM

	Mean	Std. Deviation	Ranking
GENERAL BIM CONCEPT			
Software applications such as Autodesk Revit, AutoCad, ArchiCAD, Bentley systems, Graphisoft, Autodesk Naviswork etc. are only BIM tools and not BIM itself?	3.73	1.153	1
BIM is a new way of approaching building design, planning, construction, operation and maintenance through life-cycle.	3.64	1.141	2
BIM is a set of interacting policies, processes and technologies to produce a methodology to manage the essential building design and project data in a centralized digital format through the life-cycle of a project.	3.52	1.253	3
BIM extends beyond 3D modelling and it's not only limed to the use of software or ICT for design.	3.45	1.301	4
BIM is not only the use of technology for designs?	3.42	1.370	5
The main concept of BIM is to have electronic data available in an accessible format so that useful information can be derived and re-used as require by stakeholders.	3.27	1.353	7
BIM is a way of working rather than a piece of software application.	3.24	1.146	8
BIM DIMENSIONS			

2D represents two dimensional views usually vertical and horizontal lines or line in the X and Y axis.	3.33	1.555	1
3D indicates three dimensional views of objects for better visualization. (i.e. X, Y and Z axis)	3.18	1.550	2
1D is usually a one dimensional view (ie. A single line)	3.15	1.642	3
6D captures " Building and sustainably analysis"	3.09	1.588	4
5D- (Cost) provides data to extract accurate cost information for a facility.	3.00	1.500	5
BIM consists of Seven dimensions namely: 1D,2D,3D,4D,5D,6D,7D	3.00	1.541	6
4D - (time) indicates the Construction sequencing or Scheduling.	2.88	1.616	7

Source: Field Survey (2019)

4.4.2 Levels of BIM

Also in ascertaining the level of knowledge of respondents on BIM, they were asked to rate their level of familiarity with the levels of BIM on a scale of 1-5 with 1= Highly unfamiliar, 2= Unfamiliar, 3= Not sure, 4= Somehow familiar, = Very familiar. Building Information Modelling (BIM) has diverse potential use and different levels which can be applied at all stages of the project life-cycle (Grilo and Jardim-Goncalves, 2010; Porwal & Hewage, 2013). The levels of Building Information Modelling (BIM) consist of four (4) levels which are; Level 0, Level 1, Level 2 and Level 3.

Table 4 .5 Levels of BIM

	Mean	Std. Deviation	Ranking
LEVEL 0			
BIM consist of four (4) levels (i.e. Levels 0 - 3)	2.45	1.325	1
BIM Level zero (0) comprises of an unmanaged two dimensional (2D) drafting for data/information production	2.42	1.091	2
The Exchange data in BIM level zero (0) is usually done through paper work and also represents lack of collaboration among parties.	2.33	1.451	3
Level zero (0) represents total lack BIM	2.12	1.139	4

LEVEL 1			
The Exchange of data in BIM level one (1) involves models that come with documents using a jointly agreed software.	2.48	1.253	1
BIM level one (1) means data has assumed a structure, CAD is either in a 3D or 2D and operates within a common data environment.	2.39	1.248	2
BIM level one (1) still exhibits some form of distance to collaboration between parties	2.30	1.311	3

Source: Field Survey (2019)

Table 4 .6 Levels of BIM Contd.

	Mean	**Std. Deviation**	**Ranking**
LEVEL 2			
BIM level two (2) is managed within a three dimensional (3D) environment with attached data but in a separate discipline based model.	2.48	1.326	1
At BIM level two (2) any CAD software used by parties should be able to be exported to a common file format.	2.45	1.301	2
Data in BIM level two (2) may include construction sequence (4D) and cost information (5D).	2.39	1.321	3
At BIM level two (2) collaboration has been introduced among parties and there is strict adherence to BIM processes but lack of a single data source.	2.30	1.159	4
BIM level two (2) achieves a common data structure which allows federated models to be produced.	2.12	1.219	5
At BIM level two (2) there is exchange and sharing of a building's data among project teams.	2.03	1.185	6

Source: Field Survey (2019)

Table 4 .7 Levels of BIM Contd.

	Mean	**Std. Deviation**	**Ranking**
LEVEL 3			

The levels of BIM (0-3) are used as a charter for the categorization of BIM implementation which serve as standards for Maturity levels.	3.09	1.331	1
At BIM level 3 all stakeholders can readily access data on a built asset from a centralized digital platform	2.52	1.642	2
The successful achievement of all the element at BIM level 3 is referred to as "Open BIM" which is the ultimate goal of the construction industry	2.45	1.301	3
BIM level 3 achieves full collaboration and better integration among stakeholders who inter-relate timely to produce actual BIM values	2.45	1.371	4
BIM level 3 is the stage where data is collected, shared and stored using a single source of data.	2.42	1.582	5
BIM level 3 represents the stage where complete and total collaboration in the planning, construction and operational life cycle of any built asset is achieved	2.15	1.349	6

Source: Field Survey (2019)

4.3 Types of BIM Software

Furthermore, the respondents were asked to identify as many as they can from the questionnaires, the types of BIM software that thy are familiar with. All these are towards ascertaining their level of knowledge of BIM software as a collaboration tool, therefore, this question was necessary. Table 4.7 below details the frequency of familiarity that these respondents had with the types pf BIM software.

Table 4. 8 Types of BIM Software

	Frequency	Percentage
AutoCAD	24	73
Autodesk Architectural Desktop	17	52
Autodesk Revit	3	9
ArchiCAD	14	42
Bentley	5	15
Graphisoft	4	12
Nemetscherk	0	0

Beck Dprofiler	5	15
SketchUp	10	30
Vectorworks	5	15
Aecosum	3	9
BIMx	3	9
None of the above	4	12

Source: Field Survey (2019)

4.5 Challenges of Building Information Modelling (Bim) Adoption and Implementation to Consultancy Firms in Ghana

Despite the enormous benefits Building Information Modelling (BIM) to the construction industry (Bryde et. al., 2013; Cabinet Office 2011), there are also serious challenges that needs to be overcome if effective multi-disciplinary collaborative team working, supported by the optimal use of BIM, is to be achieved. From the table 2.9 below, it can be seen that *the uncertainty/initial cost of BIM* was ranked 1st with a mean of 3.91. *Lack of standardized guidelines and protocols for practice* emerged 2nd with a mean of 3.76. Whereas *Lack of Financial Resources* was ranked 3rd with a mean of 3.73. *Lack of Professionals with BIM knowledge* was ranked 4th with a mean of 3.73. Standard deviations on a statistical data imply the measure of variability and consistency linked with interpreting the variables by respondents (Field, 2009). Standard deviations lower than 1.0 linked with the mean values being measured imply high consistency and low variability between respondents in interpreting the variables

(Motulsky; Field, 2009), whereas, standard deviation above 1.0 imply low consistency and high variability between respondents in interpreting variables. In the instance where two or more factors have the same mean values, standard deviation values are used to rank them with factor with the least standard deviation among the two is ranked higher. *Resistance to change* was ranked as 5th with a mean of 3.70. *Lack of clarity on who bares possible incremental project cost* was ranked 6th with a mean of 3.61. *Information*

Accuracy was ranked 7th with a mean of 3.61. *Lack of industry digitization* was ranked 8th with a mean of 3.58. *Lack of BIM training for professionals* was also ranked 9th with a mean of 3.58. *Lack of network capabilities* was ranked 10th with a mean of 3.58.

Table 4. 9 Challenges of Building Information Modelling (BIM) Adoption and Implementation

	Mean	Std. Deviation	Ranking
The uncertainty/high initial cost of BIM	3.91	.947	1
Lack of standardized guidelines and protocols for practice	3.76	1.032	2
Lack of Financial Resources	3.73	1.039	3
Lack of Professionals with BIM knowledge	3.73	1.180	4
Resistance to change	3.70	1.045	5
Lack of clarity on who bares possible incremental project cost	3.61	.788	6
Information Accuracy	3.61	.933	7
Lack of industry digitization	3.58	1.032	8
Lack of BIM training for professionals	3.58	1.119	9
Lack of network capabilities	3.58	.969	10
Lack of software Standardization	3.55	1.227	11
Contractual and legal provisions with BIM	3.52	1.093	12
Perceived loss of authority and control over information	3.48	.906	13
Non-retention and use of BIM knowledge gained by a team on future projects.	3.48	1.176	14
Adaptation	3.48	1.034	15
Information accessibility	3.48	1.176	16
Organisational interoperability	3.45	.794	17
Interoperability of software and systems	3.45	.794	18
Lack of Management support	3.42	1.062	19
BIM proprietary and related issues	3.42	.867	20
Lack of IT resources	3.42	1.200	21
Slow advancement of BIM to be used as a single model	3.39	.998	22
Information Security	3.33	1.109	23
Lack of Government and Industry support	3.30	1.015	24
Lack of BIM Knowledge	3.27	1.126	25
Data protection uncertainty	3.24	.936	26

Source: Filed Survey (2019)

4.6 Chapter Summary

This chapter presents the results from every section of the survey instrument which was obtained from SPSS. The results were further discussed and supported with literature where necessary.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Introduction

This chapter presents the summary and major findings of the study, the conclusions drawn from the study and the recommendations made. The findings that were made from this study were summarized under each respective objective.

5.2 Summary of Findings

5.2.1 Objective One: To identify the challenges of the conventional collaboration approach to consulting firms in the Ghanaian construction industry

In identifying the challenges of using the conventional collaboration, it emerged from this research that Lack of long term relationship, Lack of reciprocal commitment, Lack of Resource sharing, The Fear of micromanagement in collaboration, Differences in organizational culture of partners, Undefined roles and responsibilities of partners, Lack of Management commitment, Incentive Alignment, Poor management by partners, and Interpersonal relationship emerged as the top 10 challenges that construction professionals encounter in using the conventional collaboration approach. This is in consonance with Agyekum et. al., (2017) who also shares similar view in identifying the fear of micromanagement, lack of Mnagement and reciprocal commitments as some of the critical challenges to using the conventional collaboration approach among construction professionals.

5.2.2 Objective two: To assess the level of knowledge on Building Information Modelling (BIM) among consultancy firms in Ghana

In assessing the level of knowledge on BIM, the respondents were asked questions which focused; if they have heard of BIM before, the period that they heard about BIM, whether the firm they work in employ the use of BIM in its activities and how often the firm uses BIM.

For the awareness of BIM, majority of the respondents said that they have heard of BIM. Majority of the respondents ticked that though they have heard of BIM, their firms do not use it. This actually resonates or further complement the next question which was asked on the frequency with which their firms use BIM, and the majority of the respondents ticked 'never', meaning their firms have never used BIM before. In ascertaining the level of knowledge of respondents on BIM, it was also necessary to test their knowledge level by providing certain statements for them to rate their familiarity with BIM on a scale. These general statements were categorised under; General BIM Concept, BIM Dimensions, Levels of BIM, and Types of BIM Software.

5.2.3 Objective three: To identify the challenges of Building Information Modelling (BIM) implementation to Consultancy firms in Ghana

In this study, challenges of Building Information Modelling Implementations were identified through questionnaires and the ten topmost challenges were; The uncertainty/high initial cost of BIM, Lack of standardized guidelines and protocols for practice, Lack of Financial Resources, Lack of Professionals with BIM knowledge, Resistance to change, Lack of clarity on who bares possible incremental project cost, Information Accuracy, Lack of industry digitization, Lack of BIM training for professionals, Lack of network capabilities

5.3 Conclusion

Collaboration is an essential part of the construction industry because of its fragmented nature which seems to converge so many professionals to a construction project with project success as its goal. Lack of collaboration will only frustrate the efforts of all construction professionals involved in the project and curtail their roles which will eventually affect the project success. Therefore, the essence of BIM must not be underestimated as it can foster effective collaboration among construction professionals. By so doing, all construction professionals must be familiar with the use of BIM so as achieve the common goal with is project success.

5.4 Recommendations

1. Management of Construction firms must invest resources into obtaining BIM and train their professionals to be well equipped in its usage

2. Construction professionals must not allow their personal indifferences or disagreements to affect the efficient collaboration needed on construction projects.

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APPENDIX

KWAME NKRUMAH UNIVERSITY OF SCIENECE AND TECHNOLOGY

DEPARTMENT OF CONSTRUCTION TECHNOLOGY AND MANAGEMENT

QUESTIONAIRE

RESEARCH TOPIC*: A Building Information Modelling (BIM) Approach to Improving Collaboration Among Construction Stakeholders in Ghana*

Dear Sir/Madam,

My name is Ash-shaiku Faaku Mohammed from the Department of Construction and Technology. I am currently conducting a Post graduate research with the title ***" A Building Information Modelling (BIM) Approach to Improving Collaboration among Construction stakeholders in Ghana".*** The research is in part fulfilment of requirement of award of MSc. Construction Management at the Kwame Nkrumah University of Science and Technology

OBJECTIVES OF THE STUDY

1. To identify the challenges of the conventional collaboration approach to consulting firms in the Ghanaian construction industry.

2. To assess the level of knowledge on Building Information Modelling (BIM) among consultancy firms in Ghana.
3. To identify the challenges of Building Information Modelling (BIM) implementation to Consultancy firms in Ghana.

As a stakeholder in the construction industry, your response is highly anticipated. I would be very glad if you could spare me a little of your precious schedule in answering this questionnaire.

Please note that all your responses and contribution to the research will be treated with uttermost confidentiality. Please find attached a questionnaire to be completed by Consultancy firms in the Construction industry in Ghana.

Thank you

Ash-shaiku Faaku Mohammed

Email: ashfaaku@gmail.com Contact: 0242505809/0269506053

Department of Construction Technology and Management

PART 1: BACKGROUND INFORMATION

1. What is your professional background?

   [ ] Architect

   [ ] Quantity Surveyor

   [ ] Structural Engineer

   [ ] Land Surveyor

   [ ] Services Engineer

   [ ] Mechanical Engineer

   Other, please specify……………………..

2. What is your highest level of education?

[ ] HND

[ ] Bachelor's Degree

[ ] Master's Degree

[ ] Doctorate Degree

Other, please specify……………………

3. How long have you been in your profession?

[ ] 1 – 5years

[ ] 6 – 10years

[ ] 11 – 15years

[ ] 16 – 20years

[ ] Above 20years

4. Please specify your professional affiliation

[ ] Ghana Institution of Surveyors

[ ] Ghana Institute of Architects

[ ] Ghana Institution of Engineers

[ ] Ghana Institution of Construction

[ ] Institution of Engineering and Technology

Other, please specify……………………..

5. Please specify the type of your organization.

[ ] Public Organisation

[ ] Private Organisation

Other, please specify……………………..

6. Please specify your firm's area of work

[ ] Building works

[ ] Civil works

[ ] Road works

Other, please specify……………………..

7. How long have you been working with your firm?

   [ ] 1-5years

   [ ] 6-10years

   [ ] 11-15years

   [ ] 16-20years

   [ ] Above 20years

8. How long have you worked in your current job position?

   [ ] 1-5years

   [ ] 6-10years

   [ ] 11-15years

   [ ] 16-20years

   [ ] Above 20years

PART 2: CHALLENGES OF CONVENTIONAL COLLABORATION APPROACH TO CONSULTANCY FIRMS IN GHANA

9. Does your firm employ the use of collaboration with other construction stakeholders?

   [ ] YES

   [ ] NO

10. How often does your firm use collaboration with other construction stakeholders?

   [ ] Always

   [ ] Usually

   [ ] Sometimes

[ ] Rarely

[ ] Never

11.	Below are some challenges to the conventional Collaboration approach. Kindly indicate the level to which the under listed challenges affect the conventional Collaboration approach by ticking the appropriate box on a Likert scale of 1 to 5.					
	Please tick the appropriate boxes					
	1=Highly Insignificant, 2- Insignificant, 3=Neutral, 4= Significant, 5= Highly Significant.					
	CHALLENGES	**1**	**2**	**3**	**4**	**5**
1	Adaptation					
2	Behavioral uncertainty					
3	Complacency in collaboration					
4	Differences in organizational culture of partners					
5	Enabling technology					
6	Incentive Alignment					
7	Interpersonal relationship					
8	Lack of common goals					
9	Lack of consultation among partners					
10	Lack of information sharing					
11	Lack of knowledge sharing					
12	Lack of long term relationship					
13	Lack of Management commitment					
14	Lack of processes integration					
15	Lack of reciprocal commitment					
16	Lack of Resource sharing					
17	Lack of trust among partners					
18	Legal structure of Organisations /partners					
19	Misunderstanding of collaboration concept					
20	Poor management by partners					
21	Previous negative experience with collaboration					
22	The Fear of micromanagement in collaboration					
23	Undefined roles and responsibilities of partners					

PART 3: THE KNOWLEDGE LEVEL OF BUILDING INFORMATION

MODELLING (BIM) AMONG CONSULTANCY FIRMS IN GHANA

14. How aware are you of BIM?

[ ] Have never heard of BIM

[ ] Have heard of BIM

[ ] Have heard of BIM and have a fair understanding of what it means

[ ] I am familiar with the BIM concept

[ ] I am familiar with the BIM concept and standard

12. When was the first time you heard of BIM?

[ ] 1 - 5years ago

[ ] 6 - 10years ago

[ ] 11 - 15years ago

[ ] 16 - 20years

[ ] 21 years and above

13. Does your firm employ the use of BIM in its consultancy activities?

[ ] YES

[ ] NO

14. If YES, how often?

[ ] Always

[ ] Usually

[ ] Sometimes

[ ] Rarely

[ ] Never

15	Below are various statements about BIM. Kindly state your level of knowledge and extent of familiarity with the statements by ticking the appropriate box on a Likert scale of 1 to 5					
	1= Highly unfamiliar, 2= Unfamiliar, 3= Not sure, 4= Somehow familiar, 5= Very familiar.					
	STATEMENTS	**1**	**2**	**3**	**4**	**5**
	GENERAL BIM CONCEPT					
1	BIM is a way of working rather than a piece of software application.					
2	Software applications such as Autodesk Revit, AutoCad, ArchiCAD, Bentley systems, Graphisoft, Autodesk Naviswork etc. are only BIM tools and not BIM itself?					
3	BIM is not only the use of technology for designs?					
4	BIM extends beyond 3D modelling and it's not only limed to the use of software or ICT for design.					
5	BIM is a new way of approaching building design, planning, construction, operation and maintenance through life-cycle.					
6	BIM is a set of interacting policies, processes and technologies to produce a methodology to manage the essential building design and project data in a centralized digital format through the life-cycle of a project.					
7	The main concept of BIM is to have electronic data available in an accessible format so that useful information can be derived and re-used as require by stakeholders.					
8	The three (3) key elements of BIM comprises of People, Process and Technology hence requires skilled, knowledgeable practitioners and commitment of resources and investment in training.					
	BIM DIAMENSIONS					

16	Do you know of the dimensions of BIM? [ ] YES [ ] NO					
	Please proceed to the following statements if your answer was YES.					
1	BIM consists of Seven dimensions namely: 1D,2D,3D,4D,5D,6D,7D					
3	1D is usually a one dimensional view (ie. A single line)					
4	2D represents two dimensional views usually vertical and horizontal lines or line in the X and Y axis.					
5	3D indicates three dimensional views of objects for better visualization. (i.e. X, Y and Z axis)					
6	4D - (time) indicates the Construction sequencing or Scheduling.					
7	5D- (Cost) provides data to extract accurate cost information for a facility.					
8	6D captures " Building and sustainably analysis"					
9	7D captures "Operations and facility management"					
	LEVELS OF BIM					
17	Do you know of the Levels/Stages of BIM? [ ] YES [ ] NO					
	Please proceed to the following statements if your answer was YES.					
	Level 0					
1	BIM consist of four (4) levels (i.e. Levels 0 - 4)					
2	BIM Level zero (0) comprises of an unmanaged two dimensional (2D) drafting for data/information production					
3	The Exchange data in BIM level zero (0) is usually done through paper work and also represents lack of collaboration among parties.					
4	Level zero (0) represents total lack BIM					
	Level 1					
1	BIM level one (1) means data has assumed a structure, CAD is either in a 3D or 2D and operates within a common data environment.					
2	The Exchange of data in BIM level one (1) involves models that come with documents using a jointly agreed software.					
3	BIM level one (1) still exhibits some form of distance to collaboration between parties					
	Level 2					

1	BIM level two (2) is managed within a three dimensional (3D) environment with attached data but in a separate discipline based model.					
2	At BIM level two (2) there is exchange and sharing of a building's data among project teams.					
3	Data in BIM level two (2) may include construction sequence (4D) and cost information (5D).					
4	At BIM level two (2) collaboration has been introduced among parties and there is strict adherence to BIM processes but lack of a single data source.					
6	BIM level two (2) achieves a common data structure which allows federated models to be produced.					
7	At BIM level two (2) any CAD software used by parties should be able to be exported to a common file format.					
	Level 3					
1	BIM level 3 represents the stage where complete and total collaboration in the planning, construction and operational life cycle of any built asset is achieved					
2	BIM level 3 achieves full collaboration and better integration among stakeholders who inter-relate timely to produce actual BIM values					
3	BIM level 3 is the stage where data is collected, shared and stored using a single source of data.					
4	At BIM level 3 all stakeholders can readily access data on a built asset from a centralized digital platform					
5	The successful achievement of all the element at BIM level 3 is referred to as "Open BIM" which is the ultimate goal of the construction industry					
6	The levels of BIM (0-3) are used as a charter for the categorization of BIM implementation which serve as standards for Maturity levels.					

BIM SOFTWARE/TOOLS USAGE

21. Are you familiar with BIM Softwares/tools for application?

[ ] YES

[ ] NO

Please proceed to the following statements if your answer was YES.

18.	Below are some statements about BIM. Kindly state your level of knowledge and extent of familiarity with the statements by ticking the appropriate box on a Likert scale of 1 to 5

	1= Highly unfamiliar, 2= Unfamiliar, 3= Not sure, 4= Somehow familiar, 5= Very familiar.					
	STATEMENTS	**1**	**2**	**3**	**4**	**5**
	BIM software/tools can generally be classified as, Architectural modelling, Estimating, Audit and Analysis and Scheduling/Modelling.					

19. The following are some of BIM software in use. Kindly tick as many as you are familiar with.

Architectural Modelling software

[ ] AutoCAD

[ ] Autodesk Architectural Desktop

[ ] Autodesk Revit

[ ] ArchiCAD

[ ] Bentley

[ ] Graphisoft

[ ] Nemetscherk

[ ] Beck Dprofiler

[ ] SketchUp

[ ] Vectorworks

[ ] Aecosim

[ ] BIMx

Audit and Analysis software

[ ] Antodesk Navisworks

[ ] Ecotect

[ ] Solibri Model Checker

Estimating Software

[ ] Quantity Take Off

[ ] Back Dprofiler

[ ] Innovaya

Scheduling/Modelling software

[ ] Autodesk Navisworks

[ ] Synchron Ltd

[ ] Vico Control

	PART 4: CHALLENGES OF BUILDING INFORMATION MODELLING (BIM) ADOPTION AND IMPLEMENTATION TO CONSULTANCY FIRMS IN GHANA					
20.	Below are some challenges to the Adoption and Implementation BIM. Kindly rate each of the challenge under a characteristic on a Likert scale of 1 to 5.					
	Please tick the appropriate boxes					
	1=Highly Insignificant, 2- Insignificant, 3=Neutral, 4= Significant, 5= Highly Significant.					
	CHALLENGES	**1**	**2**	**3**	**4**	**5**
	TECHNOLOGICAL					
1	Data protection uncertainty					
2	Information accessibility					
3	Information Accuracy					
4	Information Security					
5	Interoperability of software and systems					
6	Lack of IT resources					
7	Lack of network capabilities					
8	Lack of software Standardization					
9	Slow advancement of BIM to be used as a single model					
	ORGANISATIONAL					
1	Adaptation					
2	BIM proprietary and related issues					
3	Lack of BIM Knowledge					
4	Lack of BIM training for professionals					
5	Lack of clarity on who bares possible incremental project cost					
6	Lack of Financial Resources					
7	Lack of Management support					
8	Organisational interoperability					
9	Perceived loss of authority and control over information					
10	Resistance to change					
11	The uncertainty/high initial cost of BIM					
	ENVIRONMENTAL					
1	Lack of Government and Industry support					
2	Contractual and legal provisions with BIM					
3	Lack of standardized guidelines and protocols for practice					
4	Non-retention and use of BIM knowledge gained by a team on future projects.					
5	Lack of Professionals with BIM knowledge					
6	Procurement Systems					
7	Lack of industry digitization					