BUILDING COLLABORATION AMONG CONSTRUCTION PROFESSIONALS ON BUILDING INFORMATION MODELLING IMPLEMENTATION IN ABUJA, NIGERIA

ABSTRACT

Building Information Modelling (BIM) is one of the most promising technology in the construction industry today. The implementation of BIM has increased significantly over the years; the professionals in construction industry have realized that sharing of knowledge and information is one of the key elements of a successful contractual relationship among professionals in the construction activity in the whole life cycle of a project, lack of collaborative participation among stakeholders have resulted to project delay, material waste, rework and low quality of work. This research aims to create a guiding principle for active participation among professionals in order to improve BIM implementation proficiency. A total of 115 questionnaires were distributed to Architects, Quantity surveyors, Structural engineers, and Builders. Eighty-five (85) questionnaires were returned and analysed, accounting for 73.9 percent of the total. The data obtained was analysed using descriptive analysis (chart, table, relative important index and mean item score). This study identified ‘reduction/avoidance of project failure and team building as a result of active collaboration, in addition the researcher assessed the advantages and challenges associated with collaboration in addition professional successes due to BIM collaboration were investigated. Lastly the professional’s engagement can minimize project delays and improve project delivery time and quality. If efficiency, project completion on time, quality, and cost remain the organization's priorities for successful delivery, it was recommended that deliberate technique be instituted during the construction process to effectively develop and assess the binding relationship and performance among all parties in the construction sector.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

Companies, joint ventures, public and private enterprises, and tactical deals are all becoming more relevant in the construction industry (Akintoye and Main, 2007). According to the study by AbdullRahaman *et al.* (2013), in the early 1990s, the assertion for cooperation between businesses in the construction industry was very strong, The call for cooperation has shifted from profit motives to increased competition, increased demand for innovation and technological growth, and increased demand for industry internationalization (Akintoye and Main, 2007).

International demand, rivalry, risk, and uncertainty within the business setting are all factors that induce collaboration around the world, according to AbdullRahaman *et al.* (2013), while the Construction Industry is realizing the need to collaborate in order to subsist (Bocerik-Gerber *et al.*, 2010)[1].

Building information modelling (BIM) is a strong collaborative environment that has been attracting the responsiveness of Architectural Engineers and Construction (AEC) Industry. Building design and construction industry (BDCI) is one of the industry's most talented technological innovations (BDCI) (Himmati, 2017)[1]. The evolution of ArchiCAD software was regarded as the true foundation of BIM, and the use of Revit software saw a move toward BIM implementation (Hartmann, 2012). After a comprehensive literature analysis, BIM has a variety of ability to assist operatives, organization and cooperation of various disciplines in “Architects, Engineers, Contractors, Sub-contractors, Facility Management” (Conway, 2010).

BIM is a 3D-object data base that can be easily visualized and contains rich and organized information which can also be applied to building results, sustainability, schedule, and costing analyses (Edirisinghe, 2015). However, BIM was originally applied to the construction stage of building projects, but it has since expanded to include the service and maintenance phases, as well as mega infrastructures. It has developed a range of marching technologies, as well as a method for representing buildings and infrastructures over their entire life cycle (Ahn and Kim, 2016). This research aims to find out how BIM technology-assisted collaboration improves the activities of construction projects.

BIM has reinvented the construction industry over the past two decades, BIM has progressed from 3 dimensioning to 4 dimensioning, 5 dimensioning and even n dimensioning modelling programme, linked to the building process and integrating cost data. It is generally assumed that the model play an important part in incorporating the different stages in the entire construction project lifecycle (Tabassi *et al*., 2012).

Over the last two decades, BIM has reinvented the construction industry. Building design and Construction Industry (BDCI) is one of the industry's most talented technological innovations (BDCI) (Hinmati, 2017). Nonetheless, proper research on BIM adoption and implementation in the construction stage in terms of benefits and barriers has been completed (Hinmati, 2017). As a result, it is thought worthwhile to investigate the social aspects of management and organization, as they seem to be understudied in comparison to the technical aspects and processes that can play a key role in BIM implementation (Hardin, 2009). However, the focus of this study trend on improving collaboration among project participants and how the organization's philosophy evolves in response to the trend shift to BIM implementation in the building stage of construction projects.

1.2 Statement of Research Problem

According to a study by Hardin (2009), BIM implementation has increased significantly over the last decade. AbdulRahaman *et al.* (2013) and Hinmati (2017), on the other hand, argued that: There appears to be no straightforward guide on how participants in the implementation of BIM in construction activities can collaborate, making it difficult to effectively interrelate to achieve a common project goal.

According to a study by Sitti-Hamidah (2013), inadequate participation, lack of project quality, delay in project completion and excessive cost accumulation due to rework have all been linked to a lack of interaction among stakeholders in the building industry.

As a result of this; the study intends to close the gap by placing a greater focus on factors that will enhance stakeholder cooperation in order to achieve a shared project target in BIM implementation in the construction industry, as well as shifting organizations' minds about embracing the paradigm shift to the BIM technology platform.

1.3 Research Questions

1. What are the advantages of working on a building project using BIM?

2. What obstacles do you see in the way of BIM cooperation in building projects?

3. What factors contribute to the success of BIM collaboration among stakeholders in the industry?

4. What are the most important primary success metrics for assessing stakeholder cooperation in BIM implementation on building projects?

1.4 Aim

Aim of this study was to establish the guiding principles for active participation among professionals in order to improve BIM implementation proficiency.

1.5 Objectives of the Study

i. To determine the construction industry's advantages of BIM collaboration.

ii. To examine the challenges to the BIM implementation collaboration in construction industry

iii. To examine the success factors of collaboration by professionals to stimulate proficiency in BIM implementation within the construction industry.

iv. To analyse the key performance indicators to ascertain the most importance factors to be used in measuring performance in BIM implementation within the construction industry.

1.6 Justification for the Study

Owing to the presence of transnational corporations in the country, the building industry is undergoing an extraordinary transformation as a consequence of numerous administration creativities, with building projects being all-encompassing, multifaceted, fast-moving, and enormously challenging (Cao, 2014).

The construction industry has long been associated with delays, waste, and inefficiency, particularly during the construction phase of projects, when the majority of physical activities, communication flow, knowledge, and teamwork are required (AbdullRahaman *et al.*, 2013). He went on to claim that the explanation for this was rarely technical; instead, more scientific focuses on the technological phase of construction, missing or underestimating the organizational and human factors that play a crucial role in construction.

While, according to a study by Anifowose *et al.* (2018), BIM adoption in Nigeria is still in its early stages since the majority of BIM expertise is still theoretical, the permanent shift towards collaborative working and interest in the adoption of collaborative technologies is too good to be overlooked. According to a report by (AbdullRahaman *et al.*, 2013), there is no simple guidance on the process of cooperation between participants in the implementation of BIM in construction projects, making it difficult to effectively interrelate in order to achieve common project goals in construction activities.

The participants accepted that exchange of experience and data is one of the significant rudiments of a positive predetermined bond after a study it was shown that active working together is essential to the completion of building projects (AbdullRahaman *et al.* 2013). BIM is a hot topic of discussion among construction professionals in various countries around the world. BIM describes the usage of computer generated dimensional models (CGDM) to simulate the development, design, building, and task of a project, and it represents a paradigm shift and upturn in the construction process (Anifowose *et al*, 2018). Method, technology, organization, and personal behaviour are the core factors affecting partnership in BIM implementation, according to Hardin, (2009) and Hinmati, (2017). However this thesis focused basically as a road map to guide professionals to partner successfully for effective and efficient productivity. This study added to the work stressed by Hinmati, (2017) which acknowledged the benefit and barriers hindering BIM collaboration in the construction project especially at the construction stage of projects within Abuja Nigeria to improve interaction among the stakeholders to achieve a common project goal. The study would, however, make a major contribution to the body of information and boost successful and productive team coordination in BIM implementation at the construction stage of projects, as well as the construction industry as a whole.

1.7 Scope and Limitation

This research work is based on the activities relating to collaboration among participants' involvement in BIM implementation at the construction level of work, where most of the physical activities are expected in the construction projects within Abuja Nigeria. The literature review was conducted through primary sources, and the respondents targeted were Architects, Quantity surveyors Builders and Structural engineers. Furthermore the study is only limited to professionals interaction at the construction stage of a projects to achieve common goal.

1.8 Thesis Structure

The research questions were halted, and the objectives were extracted and targeted in order to achieve the study's goal at the end. The context of the analysis, problem statement, research issues, purpose and goals, rationale, scope and limitation, and thesis structure are all included in chapter one.

The second chapter contains a broad literature review on the construction industry, partnership networks, BIM concept, BIM dimension, and benefits, acceptance and implementation of BIM and the factors influencing it, and performance evaluation in BIM activities and at the construction level.

This chapter shows the reader where the study starts and finishes during the time span under examination, as well as the research methodology, data collection, and data analysis process.

The key analytical findings of the analysed questionnaire outputs, which include data presentation, debates, and interpretation, are presented in Chapter four.

Chapter five contains summary, discussions, recommendations and area of further studies.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Construction Project

Agreeing to the National Centre for Construction Education and Research (NCCER), project development in the construction industry is separated into three steps: pre-construction step, construction step, and post-construction step (Davis and Soger, 2008). These three steps are referred to as a Project Life Cycle, and they include a variety of tasks and participants. Construction projects are fraught with issues; incorporating BIM will help the construction industry evolve by promoting modern construction, increasing efficiency, as well as bringing value to a diverse range of sectors (Rogers *et al*, 2015). The enormous quantities of information and digital technology needed to realize the significant benefits from data and numerical technology are parts of the building aspects required (Davies and Harty, 2013). The design and construction processes of projects have slowed due to issues such as organizational, legal, and economic issues. Though, studies have shown that buildings can be built more speedily and efficiently through computerised gathering and enhanced processes which significantly reduce construction accident and dispute and improve construction efficiency (Lee *et al.*, 2012). Bringing the right knowledge to the right location is one of the problems of organizational fragmentation in building projects (Davies and Harty, 2013).

Over the last two decades, BIM has revolutionized the building industry. From 3D modelling to 4D programming linked to the construction process, 5D modelling with cost data, and even nD modelling, the idea of BIM has evolved. BIM is commonly thought to play an important role in incorporating the different phases of growth across a construction project's entire lifecycle (Ahn and Kim, 2016). As a result of introducing and integrating emerging technologies such as BIM into building projects, benefits such as lower business costs and reduced errors can be realized (Cabinet Office, 2011).

Construction projects are fraught with challenges. Implementing BIM will help the construction industry grow by allowing for more modern construction, growing efficiency, and adding value across multiple departments (Rogers *et al*., 2015). Massive quantities of data are one of the construction features that are desirable to realize the major benefits from information and numerical technology (Davies and Harty, 2013).

2.2 Teamwork and Networking in Construction Stage

Teamwork is a method of working in which professionals collaborate for the common goal of achieving a collective objective. According to a study by Hooper (2015), cooperation affects relations for better teamwork, increases information sharing among all team members, and improves overall project efficiency.

In BIM, collaboration is a prerequisite in which various professionals share their expertise and skills in a distinct model. BIM facilitates the delivery of mixed-use projects by offering a forum and tools for collaborative design and project management (AbdulRahaman *et al.* 2013). Procedures for collaboration must be in place for collaboration to be tested. Several primary performance indicators (KPIs) for construction management have been established. Price, time, and efficiency are among them, as are team success, communication, participant, and human resource management. Ku (2011) identified characteristics in a successful team that can lead to collaboration. Creativity, efficiency, co-location, dedication, multidisciplinary work, decision authority, positive climate, preparation, transparency, consensus leader selection, aligned people and organization, and aligned process and practices are just a few examples. To evaluate collaboration, Siti-Hamida (2013) created a collaboration assessment method. Thus; when assessing team members, individual and group strengths, planning, human to human dealings, human to computer relations, communication systems, and bodily roles of professionals are all things to consider, when assessing teamwork in BIM, the effect of teamwork on productivity in the construction industry must be considered too (Siti-Hamida, 2013).

From a case study, Kassem *et al.* (2015) developed some KPIs centred on the commercial effect of BIM, such as increased productivity, enhanced skills and knowledge, cost savings, travel, printing, document shipping, and improved architecture and deliverables. Measures of collaboration in BIM must be established to address the challenges of an ineffective interactions between professionals and there activities in the building industry. Personal and team attributes, human experiences within the BIM model, channels of contact for team members, and physical positions of team members will all be considered when measuring teamwork in BIM. These factors include the impact on development speed, efficiency, completion time, change reduction, and cost.

Features such as structural, legal, and profitable concerns have troubled activities in the design and construction stages; to unlock the levels of integration; studies have shown that buildings can be built more rapidly and accurately through computerized process and improved methods, which would greatly reduce construction accidents and disputes, and increase the quality of the project (Lee *et al.*, 2012). One of the issues with structural disintegration in construction projects is bringing the right expertise to the right position (Davies and Harty, 2013).

Collaboration, according to McGrew (2014), is the mechanism by which a community of professionals shares their common experience, expertise, and skills. This happens in a climate of conviction, transparency, and integrity, with the goal of delivering the fundamental objectives to meets the needs of all the parties. Misunderstandings, misinterpretation of data and increased rework can occur as a result of a lack of appropriate teamwork practices in construction projects. Active collaboration and management of activities are needed for effective BIM implementation and reaping its full benefits (Migilinkas *et al.*, 2010). Struggling to incorporate BIM with a lack of collaboration, according to Ashcraft (2008), just "scratches the surface. ""Given the importance of teamwork in BIM, attempting to promote cooperation in BIM has been a hot topic of research for the past two decades (Singalov and Konig, 2016). From a contractual perspective, the most popular methods sought in the current literature for stimulating cooperation in BIM can be divided into four categories (Singalov and Konig, 2016). Traditional concepts of obligation and the traditional legal system leading the construction projects, according to Kasim *et al.* (2017), have hampered the collaborative work within BIM. Similarly, the legal risks associated with BIM model liability and intellectual property rights should be addressed, according to Roulston (2010), by designing detailed contractual agreements that took into account collaborative requirements in BIM.

Adapting and adjusting predetermined features of BIM-enabled projects appears to be a promising vision (Roulston, 2010),

2.3 Definition of BIM

Study by Karen (2014) described BIM as a organized alphanumeric database comprised of 3 dimension (3D) parametric objects that allows for inter-operability and is informed by the professionals in the construction industry. BIM is a process and tool that incorporates a variety of virtual components, concepts, and systems (Azhar *et al.*, 2012). In the most basic words, Azhar and Salman (2008) saw BIM as the practice of a database setup to abridge designed facilities with unique professional perspectives.

Because of the rapid changes in the construction industry, the concept of BIM is constantly changing (Migilinskas *et al.*, 2013). BIM has been referred to as a variety of things as a result of this evolution, although there is still some ambiguity (Lee *et al.*, 2013). BIM was first described as a structured model that represented building elements in the early 2000s and its application ranged from pre-construction to post-construction (Latiffi *et al*, 2014).

BIM was implemented in the late 2000s as a technology that enhanced communication, teamwork, efficiency, and effectiveness in the construction industry by improving documentation supervision. BIM has evolved into a technology that affects the whole industry and helps in project management up to now (Latiffi *et al*, 2014).

The use of rational 3D virtual models for product delivery in various dimensions such as project inception, design, assessment, processing, service, and demolition is one of the concepts of BIM (Migilinskas *et al.* 2013). To put it another way, BIM is a digitally integrated data set that represents all building details during a project's lifecycle (Gu and London, 2010). “BIM is a new dimension to control and improve the construction productivity in completing and maintaining the project," according to Lattifi *et al*., (2014). The current Bim technology, on the other hand, focuses on BIM as a mechanism for the industry that affects all aspects of a project across its entire construction development process (Luth *et al.*, 2014). In the early 1980s, BIM was first suggested. It had also started to use CAD software when academics began to describe it theoretically and integrate it into working software in CAD programs (Migilinskas *et al.*, 2013). Due to technological limitations, it was not widely used until the middle of the 1990s (Abbasnejad and Izadi, 2013). In modern times, BIM's foundational Product Lifecycle Management (PLM) has grown from three to four, five, and six dimensions, allowing for the expansion of knowledge capability embedded in three-dimensional (3D) models (Migilinskas *et al.*, 2013).

2.4 Dimensions in BIM.

A simple Building Information Model is a 3D object-oriented model with different implementations and uses during the project life cycle. It may also be a 4D, 5D, or nD model, allowing for the expansion of BIM implementations during the life cycle of a project. In the literature, these are referred to as BIM dimensions, and they are briefly defined in the following sections (Migilinskas *et al*., 2013).

2.4.1 Three dimensional (3D) model

A basic view of the design is achieved by making a three dimensional (3D) model of a construction at the design stage, and is referred to as XYZ. Clients, architects, and contractors may use 3D models for design coordination and task clash detection, according to Shangvi (2012). These benefits allow for the design to be developed at an early stage prior to construction, saving time (Abbasnejad and Moud, 2013).

2.4.2 Four dimensional (4D) scheduling model.

The tallying of “time” to three dimensional (3D) models is referred to as the "4D process." Many participants may predict the movement of activity at the construction stage or the length of an operation in real time by linking the construction schedule to the 3D model, resulting in full construction coordination as well as better cooperation and the detection of possible bottlenecks (Azhar, 2011). Azhar (2011) went on to say that by using 4D models, a contractor can determine where staff, equipment, materials, and space will be required on a daily basis, and for what period/duration, thereby shortening the project timeline.

2.4.3 Five dimension (5D) cost model.

The five-dimensional (5D) model, which includes "cost" as well as the four-dimensional (4D) models, is written as "time and cost." Its main purpose is to figure out how much something costs. The total cost of a construction project can be measured in 5D using cost data for materials, labour, position, and size; cost information can be entered into each item of the model, resulting in automated cost estimation. In addition, team members will meet online to discuss design changes, which could result in an immediate cost adjustment, but a cost estimator will calculate the total project cost (Abbasnejad and Moud, 2013).

2.4.4 Six dimension (6D) sustainability models.

As a result of technical advances, BIM has reached a new sixth dimension (6D). The 6D covers everything related to building sustainability, such as energy analysis. The use of 6D technology would assist designers in estimating energy accurately and fully early in the design process, resulting in a reduction in overall energy usage (Azhar, 2011).

2.4.5 Seven dimension (7D) facility management models.

Facility management, also known as 7D, or the seventh dimension, is used in BIM technology and is referred to as an as-built model since the contractor changes the model during the construction phase (Abbasnejad and Moud, 2008).

2.5 BIM Implementation and its Benefits

In the construction sector, BIM assists in the preservation of graphical features and delivers a data processing situation (Lee *et al.*, 2013). Both quantity and consistency elements are linked to the BIM. For instance, BIM has inclined quantity aspects such as schedule, cost and material inventory, all of which add to speedy decision-making, while quality aspects involve evaluating data. For example, all UK government contracts awarded since 2014 onwards necessitate the input of complete collaborative 3D model into construction projects, according to a report (Cabinet Office, 2011). The use of BIM in project management can be useful because it reduces the time it takes to complete documentation tasks and increases communication between participants (Bryde *et al.*, 2013).

One of the key drivers of BIM's increasing popularity among industries is its ability to simplify knowledge sharing and contribute to reuse of this information during the project life cycle (Lee *et al.*, 2013). Building knowledge modelling can help the construction industry become more efficient by improving teamwork among project participants, reducing disputes, and reducing the amount of time spent on variation and correction (Migilinkas *et al.*, 2013). Though BIM has many advantages for large-scale projects such as the London 2012 Olympic Stadium, it can also be used for smaller employment (Bryde *et al*., 2013). Furthermore, as a result of the increased usage of

BIM to solve different tasks, large and medium-sized businesses can become accustomed to and use automated construction procedures (ACP) (Migilinskas *et al*., 2013).

Agreeing to the study by Hooper (2015), project managers can benefit from using BIM as a management tool in organizing schedules and budgets, coordinating with design teams and subcontractors, and increasing owner satisfaction, all of which are linked to BIM tool. A review of previous studies of BIM-enabled building works indicates that the greatest affirmative effects of BIM depend on cost and time, communication, teamwork, and proficiency (Brydee and colleagues, 2013). By incorporating computer modelling and object simulation technology into developed processes, BIM typically leads to better strategies and techniques for building project design, construction, and facility management (Migilinskas *et al.*, 2013). This development opens up the possibility of securing the integrated management of the design and data operation through the concept and implementation of integrated software. BIM implementation aids in integrating individual tasks into teams and individual assignments into processes through distributing tools. It also allows for the management of building life-cycle operations quickly and efficiently (Hooper, 2015).

Table 2.1Benefits of BIM implementation

Benefit of BIM implementation	**Authors**
Design Stage	
Creates schematic detailed design Refining the demonstration of project to clients for	Azhar,*et al*, (2009), Hardin,(2009)
Easy judgement making	Barlish and Sullivan, (2012)

Perfect considerate nature and scope of effort to be done.	
Specifics analysis of energy , efficiency, cost estimates,	
Sustainability schedule and budget information of the structure.	
Construction Stage	
Schedule and work flow management	
Cost estimates, virtual construction logistics of materials on site.	Azhar, *et al*, (2012)
The target and scheduling of building scheme Scheduling of construction task Clash detection and reporting	Barlish,(2012)
Better quality of projects.	
Post construction stage	
Long range and annual facility planning	
Facility financial forecasting	
Work specification installation and space management.	
Real estate acquisition and disposal	Roger *et al*, (2015)
Architectural and engineering planning and design	Ahn and Kim, (2016)
New construction and renovation	
Maintenance and operational management	
Telecommunication, integration, security and general administrative services	

Source; Hinmatti, (2017).

2.6 BIM adoption and implementation in construction industry

In general, ICT (information and communication technology) is evolving, and this development affects all aspects of our everyday lives (Azhar and Ahmad, 2014). The goal of information and communication technology (ICT) is to use various computing technologies to create, store, exchange, and use information in a variety of ways. The decision to begin using emerging technology is one of the most significant factors shaping acceptance. Economic development can only be accomplished if a modern technology is generally adopted and used (Takim *et al*., 2013). These decisions are often made after weighing the unknown benefits of a new invention against the unknown costs of putting it into practice (Takim *et al*., 2013). Implementation of advanced technology is a key factor in enhancing business and sector competitiveness, as well as national economic development and living standards (Mitropoulos and Tatum, 1999). On the other hand, the construction industry is gradually adopting and implementing new technologies.

According to Rogers *et al*. (2015), BIM implementation needs a significant amount of commitment and analysis on the part of all project participants. The primary reasons for not successfully implementing organizational changes in the construction industry are cultural issues and people's resistance to change, which have been identified as major barriers to IT implementation (Davis and Songer, 2008). Furthermore, the unpredictability of opposition makes technological change implementation challenging.

Technology is a key factor in fostering knowledge integration in today's construction industry, but it only accounts for 20% of effective integrated projects, with the remaining 80% requiring changes in work processes (Azhar and Ahmad, 2014). The construction industry aspires to incorporate technologies that will improve performance and productivity (Takim *et al.*, 2013). As a result, in order to accept and implement the ICT revolution, the construction industry must help to reshape its own culture and institutions.

Many ICT techniques and tools in the fields of visualization, data processing, communications and collaboration, knowledge sharing and management, and information modelling have been adopted by the construction industry (Azhar and Ahmad, 2014). BIM, as an evolving technology for collaborating in various project stages such as design, planning, and operation, is receiving a lot of attention in the construction industry (Takim, *et al*., 2013). Client satisfaction increases when BIM is used in construction projects in terms of time, expense, protection, efficiency, and functionality. BIM encourages the inclusion of different stakeholders' positions in a project, resulting in increased competence and cooperation among project participants (Azhar, 2011).

2.6.1 BIM acceptance in construction industry

Organizational change is an important aspect to consider when adopting and implementing BIM (Ahn and Kim, 2016). Since BIM is a method, it has an effect on the operations, responsibilities, and relationships of the entire organization. As a consequence, when BIM is completely incorporated into an enterprise, it creates a revolution on the inside. As a contradiction, the most significant barrier to rapid BIM adoption is a lack of understanding, so enhancing BIM knowledge and raising awareness would assist in BIM acceptance. One crucial aspect that prevents collaborative design tools from achieving their objectives, according to Johnson *et al*., (2003), is a lack of acceptable motives and trust among stakeholders. Furthermore, effective employee planning, motivation, and development at all levels, as well as different organizational strategies, are crucial factors in evaluating a company's project performance consistency (Tabassi *et al*., 2012).

When it comes to motivation, it's important to remember that people are motivated for a variety of motives or goals (Ryan and Deci, 2000). The most important distinctions are between intrinsic and extrinsic motivation. Extrinsic motivation manifests itself in the form of a satisfying result or reward for completing a task, while intrinsic motivation manifests itself in the form of satisfaction or an interest in something (Ryan and Deci, 2000).

Furthermore, members' attitudes toward BIM are expressed in the Awareness of BIM, which includes appreciation, interest, and partiality (Ahn and Kim, 2016). The group's approach is influenced by the participants' interpretations of BIM, which has an effect on BIM's implementation and efficacy, the relatively high uncertainty surrounding BIM benefits and efficiencies is another aspect that makes it more difficult for organizations to make informed decisions regarding BIM adoption, Interoperability inefficiencies account for a significant portion of annual waste in the building sector, according to Cao *et al.*, (2004) and Lee *et al*., (2013). Re-entering and using new information and data, as well as duplicating business processes, trigger inefficiencies.

Individuals in an organization should not need to use BIM tools for their own activities in order to achieve BIM acceptance, but the organization should cooperate in using BIM and supporting co-workers or other organizations in a cooperative manner. BIM adoption varies by project and also by project level, such as design, creation, and delivery (Lee *et al*., 2013). Furthermore, BIM implementation necessitates careful consideration of stakeholders' desires, relationships, and goals (Lee *et al*, 2013).

Significant improvements in project management systems arise when BIM is introduced in a project or organization. This change in processes involves the spread of innovation as well as policy and culture diffusion (Lee *et al.*, 2013). As a result, individual BIM adoption as well as group awareness and decision-making sharing are critical components in fully embracing and incorporating BIM technology within businesses (Lee *et al*, 2013). The adoption process necessitates the creation of new managerial products, the creation of new roles, the effect of team involvement in a project on relationships, and finally, collaboration in the workplace is a prerequisite of this adoption (Lee *et al.*, 2013).

In general, the first step in completing a successful project is to choose suitable processes based on project objectives. Next, in order to meet the requirements, it's important to find a flexible strategy. Those who engage in the BIM practice association become stakeholders (Lee *et al*., 2013). Stakeholder's involvement in project as well as adequate communication with them, are crucial factors in meeting their expectations. Balancing scope, budget, quality, and resources across a project is a huge challenge; as BIM becomes more technologically advanced, new roles and alliances for stakeholders arise, as well as improvements in contract forms and project delivery systems (Hartmann, 2012).

2.6.2 BIM management in construction

Construction is focused on a project that requires teamwork, and BIM on construction sites is clearly limited to managers serving as consultants and informers for others (Hartmann, 2012). BIM is still not widely used on construction sites, according to Enshassi *et al*., (2016). The benefits of visualization, on the other hand, make it much easier for employees to comprehend the planned layout, while access to the BIM model ensures that employees still have the most up-to-date version of planned work. A core function that links design to construction is crucial in the process, and site managers play an important role in it (Hartmann, 2012). Inadequate or incorrect design plans are a common issue in the construction industry, and it is the responsibility of the site manager to repair or interpret these mistakes during the construction stage, wasting time and money. If BIM is introduced on site management operations, site managers' tools can be altered (Enshassi *et al*., 2016). It also has the ability to cause disruption to the work object, and it will most likely become more common in design management practices. This change necessitates a wider view of the entire construction process, leading to a more optimistic attitude toward design work (Hooper, 2015). It also necessitates further collaboration with other disciplines, such as design part and material suppliers. It's important to bear in mind that merely replacing drawings with a BIM model won't give you access to all of BIM's advantages (Hartmann, 2012).

Contractors, on the other hand, should cooperate closely with all subcontractors in this segment, encouraging them to use the BIM model as well. Furthermore, through sharing model information, numerous benefits such as savings in money, time, and accuracy, as well as offsite prefabrication, can be obtained (Cao *et al.*, 2004).

2.6.3 BIM standardization in construction

Construction is one of the industries that has been chastised for its slow acceptance of new and emerging technologies for a long time (Cao *et al*., 2004). In the vast majority of situations, emerging technologies are almost unusable at the time of their adoption and implementation (Hooper, 2015). This problem could expose problems and contingencies that were not expected prior to implementation and use, leading to uncertainty and resistance to new technology implementation, furthermore, the standards are used in the construction industry to improve safety and efficiency while lowering failure rates; these standards lead to a mutual and universal understanding and expectation in order to ensure proper communication and participation among project participants (Hooper, 2015).

In recent decades, academics and professionals have embraced BIM as a novel way to create, share, and use project life-cycle data (Cao *et al.*, 2004). The proper application of BIM will aid in the integration of design and operation processes, resulting in a variety of project advantages (Cao *et al.*, 2004). Improvements in performance and effectiveness include model-based quantity take-off and off-site fabrication, less design alignment errors, more energy-efficient design solutions, and lower construction costs, to name a few (Cao *et al*., 2004). To achieve these benefits, however, standardization and adoption process management are needed. Furthermore, achieving these advantages helps in the successful implementation of BIM and the spread of knowledge about the technology (Hooper, 2015). BIM adoption and implementation, on the other hand, are still in their early stages around the world, and many companies are still going in the opposite direction, especially during the construction process (Cao *et al.*, 2004).

Client help, which mediates this effect in a number of ways, is a major determinant of BIM adoption (Cao *et al*., 2004). In most construction projects, the next stage after operation is delivery to the client; as a result, the client's preferences can have a significant impact on project design and construction activities, including innovation adoptions. Other considerations, according to Hooper (2015), in order to implement BIM standardization in the organization include seeking a common language for communication, providing a common definition and classification of that concept, sharing information across neutral data model formats, and following the same protocol in the phases. There are three types of institutional isomorphic pressures that influence BIM adoption in construction projects, according to Cao *et al.*, (2004) three types of pressures can affect the amount of BIM adoption at different project levels: coercive, mimetic, and normative pressures. Coercive refers to the formal and informal pressure that an organization can receive from other dependent organizations. Mimetic forces, force the company to mimic and use the methods and structure of other effective organizations, normative pressure is related to the organization's professionals' ability to shape common standards and social objectives in accordance with technological advancement and environmental change (Cao *et al.*, 2004). Paying for BIM costs, adopting BIM, championing BIM use, and promoting process and organizational reform are all things the client must consider to facilitate BIM adoption (Hooper, 2015).

2.7 Challenges affecting the implementation of BIM

Roadblocks are issues that thwart the effective and secure implementation of BIM. According to Lee *et al*., (2013), the following impediments lead to the sluggish adoption of BIM in the construction industry:

1. The advantages of BIM in terms of process changes are uncertain.
2. The roles and responsibilities for incorporating data into a model and managing it are unclear.
3. A lack of understanding of the benefits of BIM adoption.
4. Lack of awareness and experience in the usage of BIM.
5. Insufficient software and hardware resources for the use of BIM instruments.
6. There is a lack of coordination among project stakeholders in order to use the model in different phases of the project.
7. An appropriate legal framework and resources for incorporating owners' perspectives into design and production are lacking.

According to Johnson *et al*., (2003), numerous studies have identified the following major barriers to BIM adoption:

1. Industry's inability to change existing procedures and learn new technology.
1. There is a lack of clarification about duties, obligations, and the implementation of benefits.

Furthermore, the fragmented nature of the construction industry, which is a project-based industry, as well as variations in market readiness in different countries, lead to BIM's slow adoption (Johnson *et al.*, 2003). Higher project costs, the need for complete preparation, and a number of designers who are resistant to using BIM in their design services are all factors that are preventing BIM adoption (Takim *et al.*, 2013), which also influences the construction stage. According to

Yan and Damian (2008), the cost of human capital and time-consuming training procedures are the key obstacles to implementation.

Furthermore, various disciplines in industry have different expectations of BIM (Johnson *et al.*, 2003). Managers and contractors, for example, should provide a more intelligent Document Management System (DMS) that offers CAD data directly to analyse, modelling, and risk preparation systems, while architecture considers BIM as an extension for 2D CAD. As a result, the product expectations of BIM vary widely. In terms of method, new approaches are required, in which several participants collaborate on a common objective in order to create a shared model. As a result, further coordination and cooperation are needed to disrupt the old models that each discipline employs (Johnson *et al.*, 2003).

Finally, working in BIM has resulted in a change in conventional engagement and working environments due to new positions and responsibilities (Johnson *et al.*, 2003). People must be attentive to use BIM, which requires recognition, interest, and motive, and all three must be acquired in order to use the tool (Ahn and Kim, 2016). To work in a new environment, further knowledge sharing and training is needed. Furthermore, for a large-scale project, some roles such as BIM manager are developed (Johnson *et al.,* 2003).

The management of change that must occur during the transition to BIM implementation (Bryde *et al.,* 2013) is an unending task, involving workers who need improved preparation and participants' dedication to new practices in order to assist all actors in becoming accustomed to this new phase. Furthermore, according to Jannifer (2004), the position of the project manager, as well as their day-to-day activities and the outcomes of these activities following the adoption of BIM on construction projects is still unclear. Furthermore, it is being debated if BIM can be a solution to the problem of the construction industry's disjointed existence; this ensures that knowledge gathered by a project team over the course of the project's life cycle cannot be shared (Singalov and Komig, 2016).

Table 2.2 Challenges affecting the implementation of BIM

Challenges of BIM collaboration		
Barriers	**Category**	Authors
Unclear BIM advantages regarding developing Practice. Unclear task and accountability regarding the use of data into a model and sustaining the Model. Lack of knowledge regarding BIM implementation.	**Knowledge**	Himmati, (2017), Enshasi, (2016), Damian, (2008), Linder and Wald, (2011).
Lack of resources both software and hardware Regarding use of BIM tool. Model integration in different phases of use Software compatibility and updates**.**	**Technology**	Lee,*et al*, (2013), Yan and Damian, (2008), Lapple, (2003)
Unwillingness of industries or organizations in Shifting from current practice and learning new Technology. Absence of clarity about roles, responsibilities and Benefit delivery**.**	**Process**	Hardin, (2015),Azhar, (2011), Salman (2008).

Source; field survey, 2019.

2.8 Success Factors of BIM Collaboration

Due to BIM collaborative barriers, complete adoption of BIM will remain a challenge unless these barriers are resolved quickly. Previous research on BIM performance factors that could improve professional engagement will be highlighted in this chapter, A compassionate work climate and leadership, according to Ozorhon *et al.* (2010), are the most powerful facilitators; "A leader's vision is demonstrated through the lens of a constructive working atmosphere," (Akintoye *et al*., 2012) "a leader's vision is demonstrated through the lens of a supportive working environment."Ozorhon *et al*., (2010); Blayse and Manley, (2004) agree that collaborative working methods will increase levels of information transformation because of the harmonious working environment between project stakeholders to achieve a shared goal. Some success factors that drive BIM implementation has been established based on the literature review, and they are mentioned in table 2.3 below.

Table 2.3 Success factors of BIM collaboration

Success factors of BIM collaboration	Authors
Raising the understanding of BIM; Appropriate training of staff; Coordination among project parties; Upper management support.	Sinclair, (2012)
Government support; Teaching BIM in schools; Staff training; Declining the price of BIM software; Provision of legislation on BIM usage; Mobilizing clients on the importance of BIM; Organization cultural change.	Kiani *et al.*, (2015)
Establishing a collaborative and integrated working methods and teamwork between all designers on a project; Presence of employees with BIM capability;	Tsai *et al*., (2014), Sinclair, ()2012

New procurement routes and forms of contracts aligned to the new working methods; Interoperability of software; Developing BIM standards.	Eadie *et al*., (2013)
Increased client demand; Interoperability of BIM outputs and 3rd party applications; Establishment of guidance and training; Developing BIM orientated standards.	Kiani *et al*., (2015)
Perceived benefits: Internal readiness; External pressure.	

Source; field survey, 2019.

2.9 Measure of Collaboration in Construction Projects

Collaboration is needed in BIM. Various parties share their expertise and skills in a single model. BIM promotes streamlined project execution by providing a platform and tools for collaborative design and project management (Hinmati, 2017). To ensure coordination, mechanisms for cooperation must be in place. For construction management, a number of key performance indicators (KPIs) have been developed. Team performance, coordination, stakeholder management, and human resource management are among them, as are price, time, and productivity (Ku, 2013). Ku (2013) outlined the behaviors that can contribute to good teamwork. Just a few examples include: ingenuity, productivity, co-location, commitment, multidisciplinary work, decision authority, supportive environment, planning, openness, consensus leader selection, aligned people and organization, and aligned process and practices. Hamid and Pardis (2014) developed a framework for determining teamwork that takes into account personal and team attributes, as well as planning, human-human interactions, human–computer interactions, communication networks, and team members' physical locations.

When assessing collaboration, take into account the effect of BIM on construction performance. "Based on a case study, Kassim *et al*. (2015) identified some KPIs focused on the business impact of BIM, such as speed of development, improvement in skills and knowledge, cost reduction, travel, printing, document shipping, and better architecture and deliverables."

The effects of BIM on the construction life cycle in Nigeria, according to the researcher, should be investigated. The impact on production speed, performance, time and completion, change reduction, and cost reduction are just a few of them.

2.10 BIM Activities in Construction Stage

In a conventional procurement process, the construction stage comes after the design stage, but in a Design and Build (D&B) phase, they happen simultaneously. A building's construction stage has more experts than its design stage. During the construction phase, subcontractors such as mechanical, electrical, and plumbing (MEP) are also involved. According to Autodesk (2002), BIM allows for scheduling and work flow preparation during the construction stage, although it also includes cost estimates, virtual construction logistics of cranes, and materials on site during the preliminary pre-construction process.

The following are the most important benefits of the construction phase:

1. The targets and scheduling of construction schemes

2. Scheduling what is constructible

3. Clash detection and reporting; and

4. Quality of projects has been analysed and improved by rescheduling projects to improve value.

The 4th Dimension is particularly important in BIM because it is used in the construction stage to identify and analyse various construction options (LaPointe, 2012). It was created by moving schedule dates from the project plan to the model, reviewing the construction series, detecting clashes, defining construction milestones, and better understanding and relating the project to the client and contractor. By adding schedule data to a 3D building design and adding time as the fourth dimension, a 4D model can be built.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Research Approach

A research approach is a plan and procedure that includes anything from general assumptions to specific data collection, analysis, and interpretation methods. As a consequence, it is decided by the essence of the research issue being discussed (Creswell, 2013). According to Jebreen (2012), research approaches are basically divided into two categories: data collection and data analysis as explained below.

3.2 Data Collection

The analytical data for this study was gathered from a primary source.

3.2.1 Primary data source

The questionnaire was created in such a way that it was able to address the research questions. Before being sent to the field, the questionnaire was scrutinized and validated by the project leader, who concluded that it was worthy of distribution. One hundred and fifteen (115) questionnaires were self-administered to the intended sample of the population, which included architects, quantity surveyors, contractors, and structural engineers in both the public and private sectors, with 85 questionnaires returned and analysed, accounting for 73.9% of the total questionnaires distributed.

3.2.2 Secondary data source

The literature review was compiled using secondary sources, all of which had a strong connection to the research questions.

3.2.3 Instrument of data collection

The study was built with project professionals in mind, such as Architects, Quantity surveyors, Builders, and Structural engineers. Because there are so many different types of survey questions, it's critical to pick the right one for the job to make data collection easier.

3.2.4 Questionnaire design

Based on the literature review, the questionnaire was built predominantly on a Liker's scale format to suit the study, with the majority of questions being closed-ended (or multiple choices). The questionnaire was then scrutinized and checked in order to answer the research questions posed in the study. There were five (5) parts of the questionnaire: Personnel detail, Section A Section B: BIM Implementation Benefits Section C: Implementation issues for BIM Section D: Factors that help people collaborate more effectively, Cooperation measures in BIM implementation (section E).

These questions focused on the respondents' job title, educational level, and years of work experience, as well as organizational details such as sector and employee size. The B Benefits of BIM Implementation section includes questions about variables that are considered benefits as a result of BIM adoption and implementation.

The measure of cooperation in BIM implementation is found in Section E. In sections B and C, respondents select the appropriate option from 1 to5, where"1" indicates strongly disagreed and"5" indicates strongly agreed, and in sections D and E, respondents select the appropriate option from 1 to5, where"1" indicates strongly unimportant and"5" indicates strongly important.

3.2.5 Population of the study

According to a study by Alwashi et'al, (2017) pointed that; there are approximately two thousand five hundred professionals (2500) inside the construction industry in Abuja; the study's target population is comprised of Architects, Quantity Surveyors, Builders, and Structural Engineers in Abuja.

3.2.6 Sample frame

Architects, Quantity Surveyors, Architects, and Structural Engineers are among the professionals in the construction industry in Abuja, Nigeria, where most of the intensive and comprehensive construction activities are carried out.

3.2.7 Sample size

Using the online survey monkey calculator, a sample size of 115 was estimated from a target population of 2500, with an 80 percent confidence level and a 6 percent margin of error.

3.2.8 Sampling technique

Architects, Quantity surveyors, Builders, and Structural engineers in construction companies in both private and public organizations were randomly selected from the 6 area councils based on technical requirements.

3.3 Method of Data Analysis

The frequency of the respondents, as well as the weighted total, RII, and Mean score, were determined and ranked according to their significance.

3.3.1 Relative importance index (RII) with mean score

RII=w/AN(RII1) is a mathematical equation (1)

Where;

W: The respondents' weighting of each element, which ranges from 1 to 5, for example, (w1+w2+w3+w4+w5), where “1” means “strongly disagree” and “5” means “strongly agree.”

A**:** the highest weight (i.e. 5 in this study) and;

N**:** the total number of respondents in the sample.

Statistical mean score;

$X = \sum x / \ N$Equation (2)

Where;

x=The mean score.

x=the summation of the total scores.

N=the total number of scores.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Respondents Information

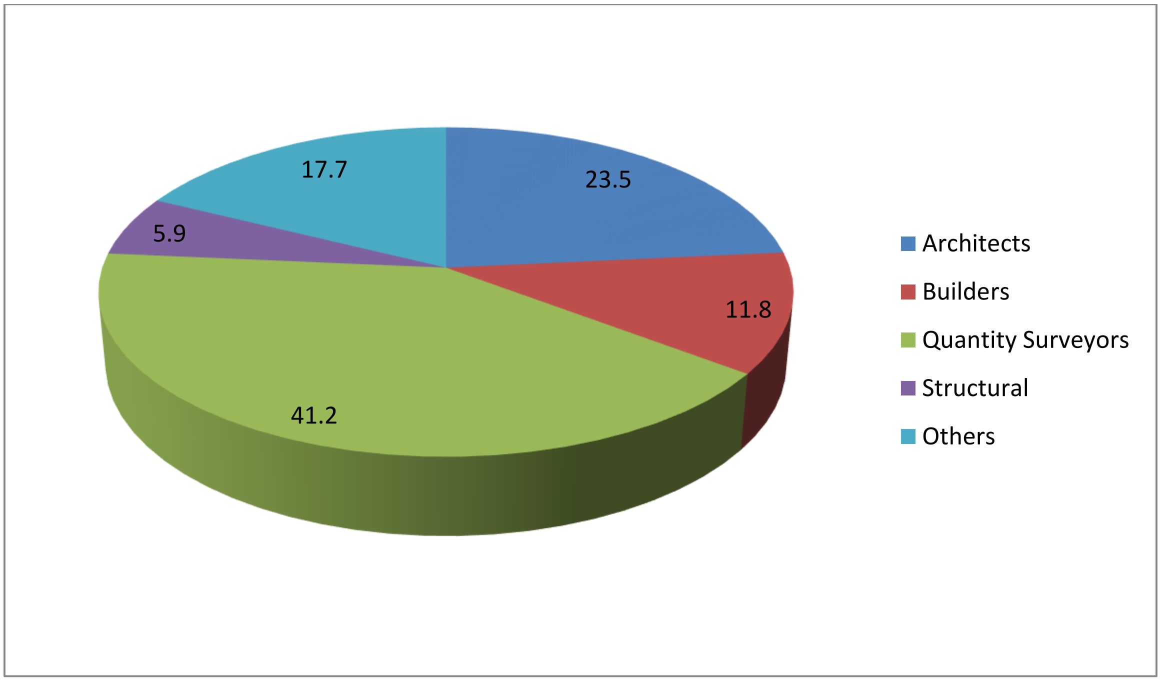

Figure 4.1, working position of respondent

4.1.1 Working position

As shown in Figure 4.1, the data obtained revealed the respondents' positions in their respective organizations. Architects (20) 23.5% structural engineers (5) 5.9% quantity surveyors (35) 41.2% architects (10) 11.8% and others (15) 17.7% completed the questionnaire. This result showed that quantity surveyors had the most responses, followed by structural engineers.

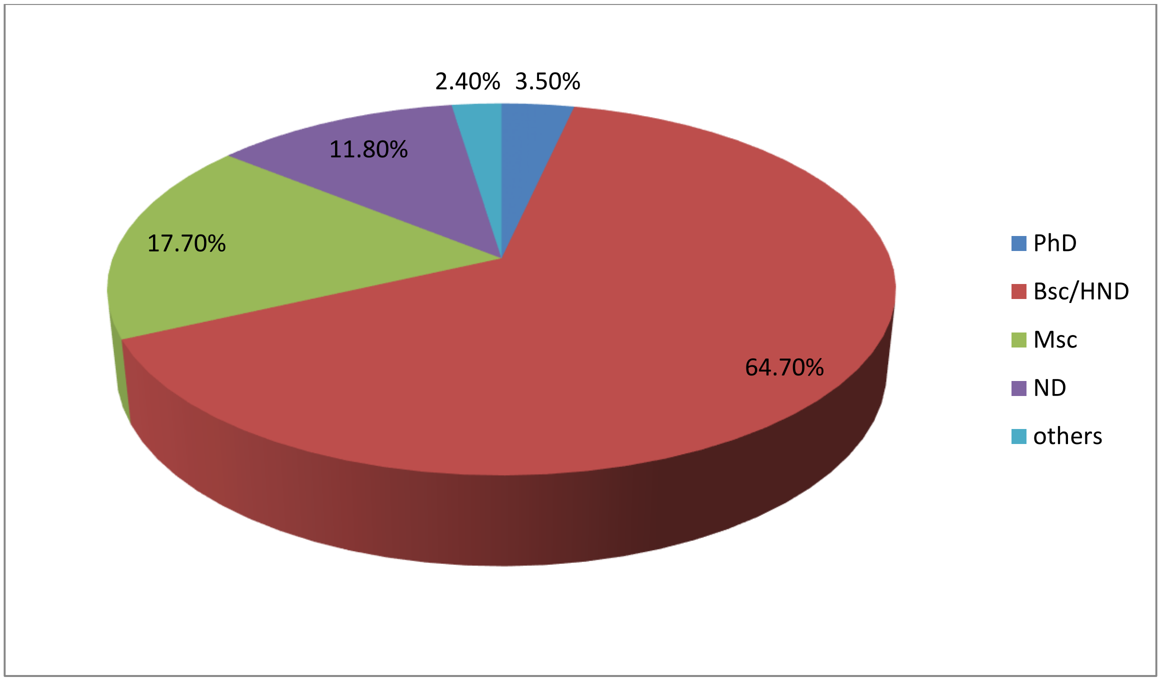

Figure 4.2, Educational Qualification of respondents

4.1.2 Educational qualifications

The majority of respondents' educational level was the HND/BSc (55) 64%, MSC (15) 17.7%, ND (10) 11.8%, PhD (3) 3.5% and others (2) 2.4% as illustrated in Figure 4.2.

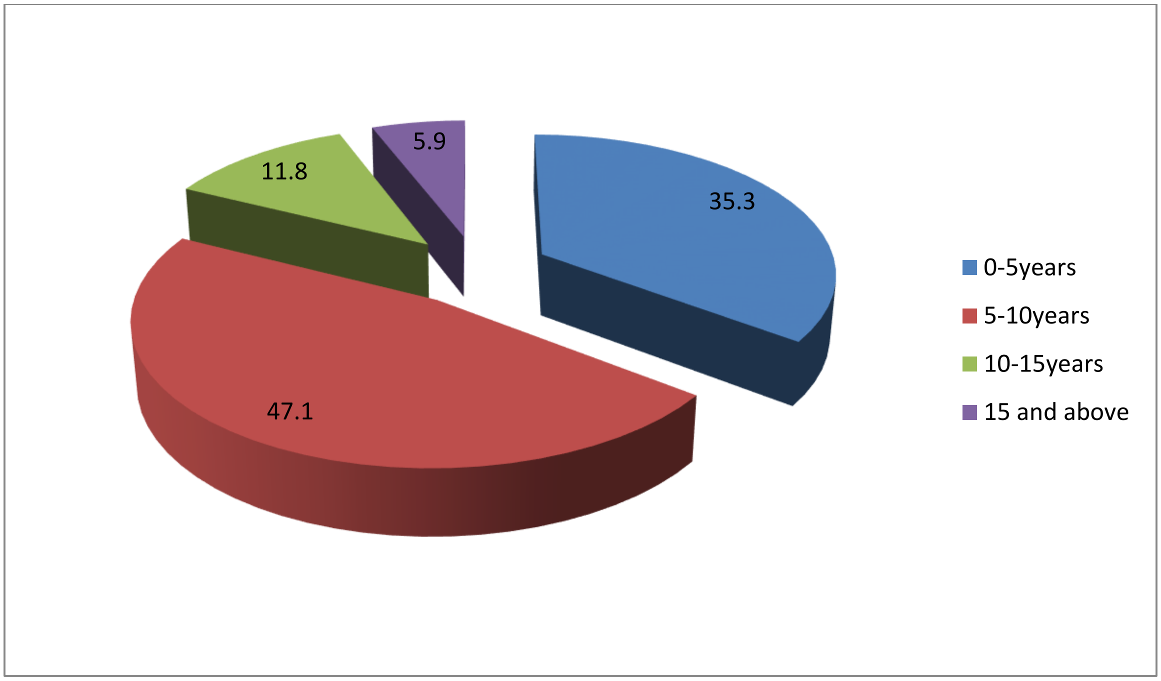

Figure 4.3, Years of working Experience

4.1.3 Years of working experience

Figure 4.3, present the years of working experience of the respondents in there organization, where 30 number of the respondents amounting to 35.3% have an experience of (0–5) years, 40 number of the respondents with 47.1% have an experience of (5-10) years, 10 number respondents with 11.8%has the experience of (10-15) years, and 5 respondents with 5.9%has the working experience of (15) years and above.

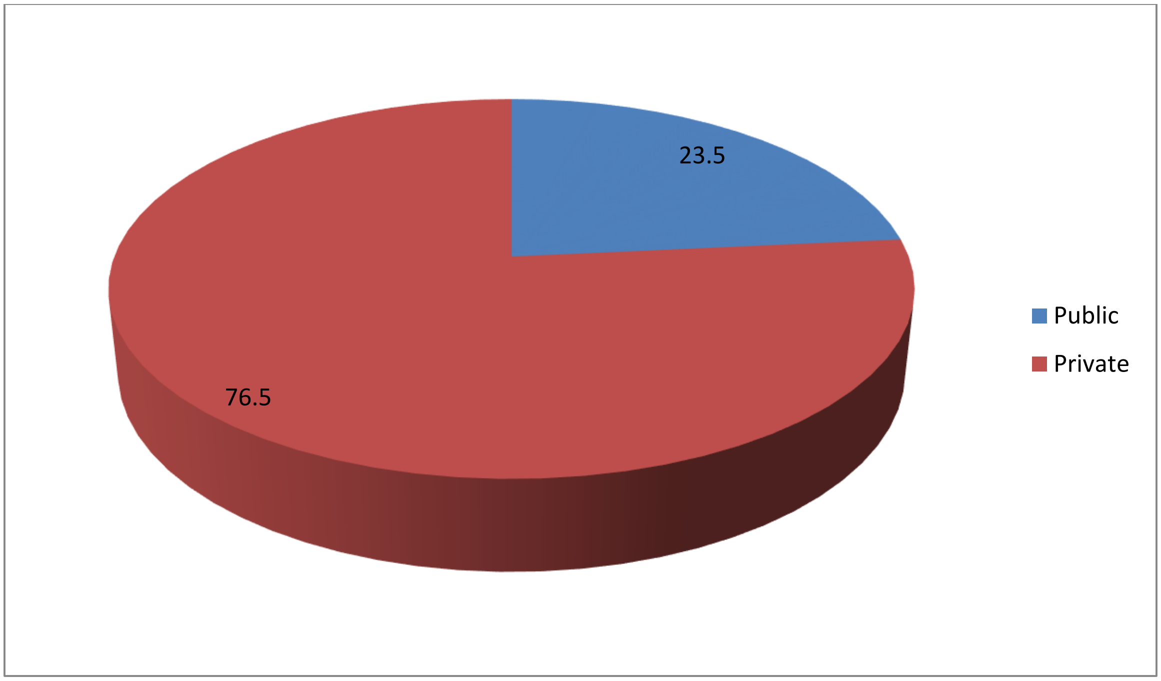

Figure 4.4, Organizational Sector

4.1.4 Organizational sector

Figure 4.4, shows that 65 respondents were working with the private organization which make up 76.5% of the sample population and 20 respondents from the public sector with 23.5% of respondents.

Table 4.1, Number of Employees in the Organizations

Firms	Population	Percentage Rating
Large	50-100	41.2
Medium	30-50	38.8
Government	0-15	20

Source; field survey, 2019.

4.1.5 Numbers of employees

The majority of the respondents (41.2%) work in large firms that has up to 50-100 employees, followed by (38.8%) of respondents working in medium-sized firms with about 30-50 employees. (20%) respondents from Government Ministries with up to 0-15 employees, the respondents were located within Abuja metropolis as indicated in table 4.1.

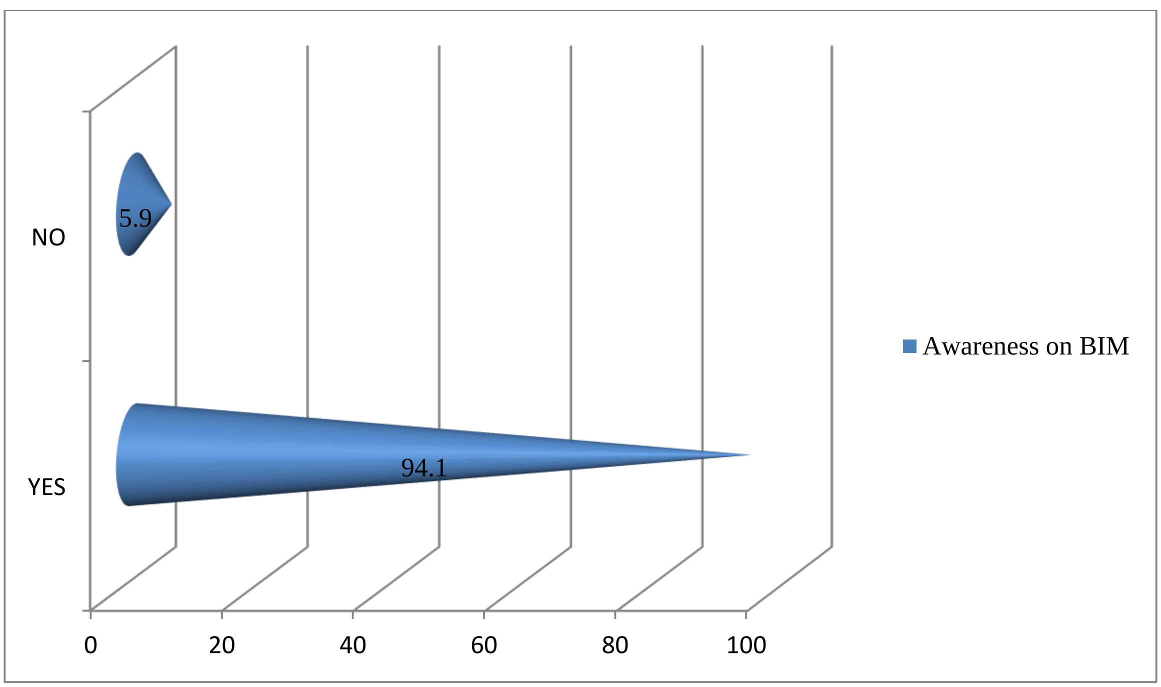

Figure 4.5, Awareness on BIM

4.1.6 Awareness on BIM

Figure 4.5 present 80 numbers of respondents ranging to (94.1%) has awareness on BIM concept and application; on the other hand only 5 of the survey respondent's equivalent to 5.9% have no idea or are unfamiliar with BIM.

4.2 The Benefits of BIM Collaboration

A factor weighted statistical mean (average) should score 4.0 or higher to be considered significant. Using the frequencies command in the formula, the effects of the statistical mean score of both variables were examined for their distribution. The results show that the mean scores of all factors have a significant normal distribution.

The ranking of significant factors was reinforced by this distribution check. Following the statistical mean score analysis for the responses as shown in Table 4.2, the most significant advantage of cooperation indicated as most important is clash identification and reporting, which was placed first in the overall factor ranking with a statistical mean score of (4.764). This finding is close to that of a study done by (Barlish and Sullivan, 2012). This means that identification reduces professional understanding of the need to collaborate and make required adjustments, which reduces repetitive work during construction activities to a large extent.

Time savings and increased quality management are ranked second and third among the advantages of BIM cooperation, with statistical mean scores of (4.705) and (4.647), respectively. This finding is consistent with a study conducted by (Siti-Hamidah, 2013). Every project strives to save time and improve the quality of work. Improved waste management is the fourth most significant element of gain of BIM partnership, with a statistical mean score of (4.564). This finding is consistent with (Hinmatti, 2017). However, risk reduction with statistical mean score of (3.764) was the top ranking advantage of BIM collaboration according to this study.

Table 4.2 Benefit of BIM collaboration

Benefits of collaboration	Weighted Sum	Mean Score	Ranking
Clash detection	405	4.764	1st
Time savings	400	4.705	2nd
Improve quality	395	4.647	3rd
Waste management	388	4.564	4th
Enhance planning, design and costing	375	4.412	5th
Improve collaboration and communication	370	4.353	6th
Cost reduction	365	4.294	7th
Improved facility management	360	4.235	**8th**
Information processing, schedule and budgeting	340	4.000	**9th**
Efficient resource utilization	335	3.941	**10th**

Source: Field Survey, 2019.

4.3 Challenges of BIM Collaboration

The challenges faced by professionals in BIM collaboration in the construction industry are presented in Table 4.3. The findings were statistically evaluated and rated according to the level of agreement by the respondents. This study ranked “lack of BIM professional expert” in BIM processes first in terms of degree of agreement (4.765), This means that a major challenge in the implementation of BIM technology has been put on hold due to a lack of BIM knowledge; this finding is consistent with the work of (Hinmatti, 2017). However, the construction industry's "high cost of BIM" implementation remains a trait, which was rated as the study's second biggest BIM challenge. As a result, the third and fourth variables, "Risk and difficulties associated with the use of BIM" were ranked third and fourth, respectively. The statistical mean score for "the interoperability problem" was (4.647) and (4.447) respectively. This result is consistent with the findings of Yan and Damian, (2008) and Hardin, (2015), which shows that high cost of BIM implementation, risk and lack of professional expertise were the common trait to BIM collaboration.

Table 4.3 Challenges in BIM collaboration

Challenges of BIM collaboration	Weighted Sum	Mean Score	Ranking
Lack of BIM technical expert	405	4.765	1st
High cost of implementation	398	4.682	2nd
Risk and challenges with the BIM model	395	4.647	3rd
Interoperability	378	4.447	4th
Lack of cohesion among participants	375	4.412	5th
Cost of training	373	4.388	6th
Lack of management support	372	4.376	7th
Unwillingness to chance organisation's culture	370	4.353	8th
Lack of understanding of BIM benefit	325	3.824	9th

Source; Field Survey, 2019

4.4 The success Factors of BIM Collaboration

A factor's RII value should be 0.8 or higher, and the weighted statistical mean (average) should be 4.0 or higher to be considered significant, according to previous research. The distribution of each factor's statistical mean score was investigated using the frequencies command in the formula. The results show that the mean of all factors has a significant normal distribution. The most important aspect of partnership, as shown in Table 4.4, is the avoidance of project failure (RII= 0.939 and mean=4.694), which is also ranked first in the overall factor ranking. This is similar to the findings of a study conducted by (Hinmati, 2017). “Encourages team building” is the second most important element, with a relative importance index of (RII=0.929 and mean=4.647). “With (RII=0.922 and mean=4.612) and (RII=0.918 and mean=4.588), respectively, is the third and fourth important factor improving cooperation. Furthermore, the average relative significant index (RII) has a value of 0.824 and a mean of 4.118, suggesting that this is an important collaboration method in BIM implementation.

Table 4.4 Success Factors of BIM Collaboration.

Factors of collaboration	Weighted Sum	RII	Mean Score	Ranking
Encouraging team building.	395	0.929	4.647	2nd
Information Sharing.	375	0.882	4.412	7th
Improved quality of Service.	376	0.885	4.424	6th
Facilitate communication among project members.	370	0.871	4.352	8th
Project completion within time	365	0.59	4.294	10th
Profitable to organization	390	0.918	4.588	4th
Friendship and trust	360	0.847	4.235	11th

Avoidance of project failure	399	0.939	4.694	1st
Sustainable on large projects	392	0.922	4.612	3rd
Reduces bureaucracy	350	0.824	4.118	13th
Cost reduction in construction	377	0.887	4.435	5th
Risk management	369	0.868	4.342	9th
Legal risk liability.	358	0.842	4.212	12th

Source; Field Survey, 2019

4.5 The Key Performance Indicators of Collaboration

Table 4.5 shows the main performance indicators (KPIs) and their relative significance as a metric for evaluating teamwork in a BIM-based construction environment. Reduction in changes, alteration/rework was rated first after the study (RII=0.988 and mean score=4.941), and the result was close to the work of (Shinju et al., 2015). Document shipping is ranked second (RII=0.935, Mean score=4.765). Communication and team results, on the other hand, were ranked third and fourth, respectively, with (RII=0.941 and Mean score=4.706) and (RII=0.939 and Mean score=4.694). However, the average relative important index has a score of (0.788) and a statistical mean score of (3.941), indicating that the rate of growth of construction activities in collaboration is below the level of importance, and therefore it does not have the relative significance in calculating collaboration in the construction industry.

Figure 4.5 the Key Performance Indicators of Collaboration

Key Performance Indicators	Weighted Sum	RII	Mean Score	Ranking
Cost, Time & Quality.	373	0.878	4.388	9th
Team performance	399	0.939	4.694	4th
Communication	400	0.941	4.706	3rd
Human Resource Management	375	0.882	4.412	8th
Productivity	385	0.906	4.529	7th
Speed of Development	335	0.788	3.941	10th
Improvement in Skills and Knowledge	395	0.929	4.647	5th
Better Architectures and Deliverables	393	0.925	4.624	6th
Document Shipping	405	0.953	4.765	2nd
Reduction in Changes/Alterations/Rework	420	0.988	4.941	1st

Source; field survey 2019

4.6 Discussion of Results

The first research question in the study aims to determine the magnitude of cooperation's importance in BIM implementation in the construction industry. The most important benefit of cooperation, as shown in Table 4.2, is clash detection and reporting, which has a statistical mean score of (4.764) and is also ranked first; This is similar to the results of a study done by (Barlish and Sullivan, 2012). This means that professional awareness of the need to interact and make necessary changes is minimized, which helps to dramatically minimize repetitive work during construction activities.

The second and third ranked advantages of BIM collaboration, with statistical mean scores of (4.705) and (4.647), respectively, are time savings and improved quality control. This result is in line with the findings of a report conducted by (Siti-Hamidah, 2013). Waste management is ranked fourth, with a statistical mean score of (4.564), which is consistent with the work of (Hinmatti, 2017). However, the study's top-ranked benefit of BIM collaboration is risk reduction, which received a statistical mean score of (3.765), indicating that the risk reduction benefit was not significant.

The second research question looked into the barriers to collaboration in the construction industry when it came to BIM implementation. Table 4.3 shows the challenges that professionals in the construction industry face when collaborating on BIM models, the data was statistically analysed and categorized based on the respondents' degree of agreement. With a statistical mean score of (4.765), this study ranked “lack of BIM technical expertise” in BIM processes first, indicating that a significant obstacle in the implementation of BIM technology has been paused due to a lack of BIM knowledge. This result is in line with the findings of (Hinmatti, 2017). However, the “high cost of BIM” implementation in the construction industry, which was ranked second among BIM challenges in this study, remains a source of concern. As a consequence, the factors "Risk and challenges in using the BIM model: “the interoperability problem” and “the interoperability problem” were ranked third and fourth, respectively, with statistical mean scores of (4.697) and (4.647) this result is consistent with the findings of a study conducted by (Hardin, 2015). This conclusion is in line with that of (Himmati, 2017). Furthermore, with a value of 0.824 and a mean of 4.118, the average relative significant index (RII) is a valuable tool for collaboration.

"How relevant are key performance indicators in evaluating mutual performance of stakeholders in BIM implementation?" was the fourth research question. "Reduction in changes/alteration/rework" was ranked first (RII=0.988 and mean score=4.941), which was similar to "Reduction in changes/alteration/rework" (RII=0.988 and mean score=4.941) (Shinju et al., 2015). Communication and teamwork, on the other hand, came in third and fourth, with (RII=0.941 and Mean score=4.706) and (RII=0.939 and Mean score=4.694), respectively. Over the course of this investigation, it was discovered that certain problems emerge during the process; the following factors were discovered: BIM technical knowledge is lacking, as is the cost of BIM implementation, as well as the risk and difficulties associated with using the BIM model. To achieve a shared project goal the above challenges must be addressed.

The importance of BIM implementation in terms of teamwork is undeniable; this study identified some primary success factors in the implementation of BIM in the construction industry that have been considered important in the process, such as project failure avoidance, team building, project sustainability, and company profitability.

This result, on the other hand, shows that collaboration among construction professionals on BIM implementation in the construction industry can boost professional engagement and help achieve a common project target.

CHAPTER FIVE

5.0 CONCLUSION, RECOMMENDATION AND AREA OF FURTHER STUDY

5.1 Conclusion

Architects, Quantity Surveyors, Builders, and Structural Engineers are constantly faced with the question of how to promote high technical performance and better collaboration among Architects, Quantity Surveyors, Builders, and Structural Engineers during the implementation of BIM. A layer of uncertainty is added by the fact that, according to this article, the everyday realities of handling construction activities provide the ability to “reduce and prevent project failure, promote team building and engagement, and maximize gains and sustainability on large projects and organizations.” This is especially important during the construction phase of a project to ensure timely completion. As a result, the study's most encouraging finding highlighted the main performance indicator that has a direct relationship with factors unique to achieving good project outcomes through collaborative networks at the construction level, namely "reduction in job changes or alterations during construction, document shipping, team performance, good communication, and productivity". The study discovered that coordination between architects, quantity surveyors, designers, and structural engineers can be strengthened during the implementation of BIM technology during the construction stage of projects to increase project performance and productivity.

5.2 Recommendations

The changing construction industry has shifted its activities to increase efficiency, effectiveness, productivity, and project quality while lowering project costs and timelines, as stated at the outset of this study. Furthermore, the scope of today's building projects necessitates the participation of many specialists at different stages of the project, and this breadth of knowledge is critical for active participation. However, a deliberate technique should be introduced in order to efficiently increase the mandatory collaboration among all professionals in the construction industry.

The following are some of the most important factors to consider in order to improve collaboration among professionals in the construction industry: ‘the management to integrate motivational derivation and help to create an enabling environment for collaboration, transforming management and organization's mind set to accept the new trend of BIM collaboration, prompt updates of resources and software for ease of work, and to encourage cross-sectional information flow to identify and report any clashes.

Finally, an assessment and measurement section should be established, with experts from various disciplines tasked with evaluating professionals' performance in collaborative construction project activities.

Since a lack of technical experts is one of the challenges of BIM collaboration, our universities and other higher learning institutions should introduce BIM technology subjects and courses as soon as possible in order to educate the younger generation on the concept of BIM and enhance collaboration through skills and expertise.

5.3 Area of further study

Collaboration among stakeholders in the pre-construction stages has been examined with respect to preliminary site investigations and building designs, according to a report, and research work on collaboration among team players in the construction industry has been enhanced.

However, it will be interesting to see how construction managers and organizations can change their mind-sets toward active cooperation among stakeholders in the post-construction stages of the construction process, especially in the project's overall maintenance.

More research is also needed on the functions and responsibilities of quantity surveyors in a collaborative setting during the construction project's whole life cycle (WLC) of a project.

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APPENDIX A

FEDERAL UNIVERSITY OF TECHNOLOGY MINNA
SCHOOL OF ENVIRONMENTAL STUDIES
DEPARTMENT OF QUANTITY SURVEYING

QUESTIONNAIRE SURVEY:

TOPIC: - **BUILDING COLLABORATION AMONG PROFESSIONALS ON BUILDING INFORMATION MODELLING IMPLEMENTATION IN ABUJA, NIGERIA.**

DEAR RESPONDENTS,

REQUEST TO COMPLETE QUESTIONNAIRE

I am Nuhu Ibrahim with the registration number MTECH/SET/2017/7162 of the post-graduate school of federal university of technology Minna,

I am writing to solicit information for a research work titled: **BUILDING COLLABORATION AMONG PROFESSIONALS ON BUILDING INFORMATION MODELLING IMPLEMENTATION IN ABUJA, NIGERIA.**

It will be important if vital information are provided with much clarity and sincerely, be rest assured, that all information provided shall be treated confidentially and respondent's reputation shall be preserved in all circumstances.

SURVEY QUESTIONS

SECTION A: Personal information of respondents

Please mark the appropriate answer below

1. Working position:

   (a) Architect (b) Structural engineer (c) Quantity Surveyor (d) Builder (e) others
2. What is your qualification level?

   (a) ND (b) HND/BSC (c) MTech (d) PhD. (e) others
3. Year of experience

   (a) 0 – 5 years (b) 5 – 10 Years (c) 10 – 15 Years (d) 15 years and above
4. Which sector is your organization?

   (a) Public (b) Private
5. Number of organization employees:

   (a) 1- 15 (b) 16 – 30 (c) 31 – 50 (d) 51 – 100 (e) Over 100 employees
6. Are you conversant with building information modelling (BIM)

   (a) Yes (b) No

SECTION (B), Benefits of BIM

1. On the scale 1 to 5 to what extend do you agree with the following factors as benefits of BIM in construction projects.

		1	**2**	**3**	**4**	**5**

	Benefits of BIM	Strongly Agree	Disagree	Neutral	Agree	Strongly agree
	Enhance design, planning and construction of projects					
	Accurate quantity take off					
	Improve collaboration and communication among stakeholders.					
	Clash detection and reporting					
	Time saving and improved quality of project					
	Target and scheduling of construction activities					
	Schedule and work flow coordination.					
	Risk reduction and waste management					
	Improve facility management					
	Cost reduction in construction					
	Efficient resource utilization					
	Good information processing of documents, schedule, budget and project parking.					

SECTION (C) Barriers to BIM adoption

8. On a Scale 1-5 Indicate to what extent do you agree with the following barriers with respect BIM Adoption?

		1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree

	Barriers To BIM Adoption					
	Legal issues					
	Risks and challenges with the use of BIM models					
	Lack of cohesion among project participants					
	Lack of understanding of BIM and its benefits					
	High cost of implementation					
	Cost of training					
	Interoperability					
	Lack of BIM technical experts					
	Lack of management support					
	Unwillingness to change organization culture					

SECTION (D) measure of collaboration in BIM implementation

9. On the scale 1 - 5 mark the level of agreement on the following variables as a measure of collaboration in BIM implementation in construction project.

		1 **Strongly Disagree**	**2** **Disagree**	**3** **Neutral**	**4** **Agree**	**5** **Strongly Agree**

	Key performance indicators					
	Cost of construction					
	Time of delivery					
	Quality and standard of work					
	Team performance					
	Communication flow					
	Human resource management					
	Productivity of workers					
	Speed of development					
	Improvement in skills and knowledge					
	Better Architecture and deliverables					
	Document shipping Reduction in changes/rework					

SECTION (E) Factors of collaboration

10. On the scale 1 - 5 mark the level of importance on the following factors enhancing collaboration in BIM implementation in construction project.

	Factors enhancing collaboration	**1** **Strongly less important**	**2** **Less important**	**3** **Moderate**	**4** **Important**	**5** **Strongly important**
	Encourages Team building					
	Information Sharing					
	Improve quality of service					
	Facilitate communication among project members					
	Project completion within time					
	Future opportunity					
	Profitable to organization					
	Friendship and trust					
	Avoidance of project failure					
	Reduce bureaucracy					
	Sustainable on larger projects					
	Encourages different area of business					
	Reduction of construction cost					
	Risk reduction					
	Legal risk liability					

APPENDIX B

Data Analysis

Factors of Collaboration in BIM	Frequency of Responses										Weighted Sum	RII	Rank
	5	W5	4	W4	3	W3	2	W2	1	W1			
Encourages Team Building	60	300	20	80	5	15	0	0	0	0	395	0.929	2
Information sharing	55	275	15	60	10	30	5	10	0	0	375	0.882	7
Improved quality of service	56	280	14	56	10	30	5	10	0	0	376	0.885	6
facilitate communication among project members	50	250	20	80	10	30	5	10	0	0	370	0.871	8
Project completion within time	45	225	25	100	10	30	5	10	0	0	365	0.859	10
Profitable to organization	65	325	10	40	5	15	5	10	0	0	390	0.918	4
Friendship and trust	40	200	30	120	10	30	5	10	0	0	360	0.847	11
Avoidance of project failure	67	335	10	40	8	24	0	0	0	0	399	0.939	1
Sustainable on large projects	62	310	13	52	10	30	0	0	0	0	392	0.922	3
Reduces bureaucracy	30	150	40	160	10	30	5	10	0	0	350	0.824	13
Cost reduction in construction	57	285	13	52	10	30	5	10	0	0	377	0.887	5
Risk management	49	245	21	84	10	30	5	10	0	0	369	0.868	9
legal risk liability	39	195	30	120	11	33	5	10	0	0	358	0.842	12

Key Performance Indicators	5	W5	4	W4	3	W3	2	W2	1	W1	Weighted Sum	RII	Rank
Cost time of quality	53	265	17	68	10	30	5	10	0	0	373	0.878	9
Team performance	62	310	20	80	3	9	0	0	0	0	399	0.939	4
Communication	60	300	25	100	0	0	0	0	0	0	400	0.941	3
Human resource management	50	250	25	100	5	15	5	10	0	0	375	0.882	8
Productivity	45	225	40	160	0	0	0	0	0	0	385	0.906	7
Speed of development	40	200	20	80	10	30	10	20	5	5	335	0.788	10
Improvement in skills and knowledge	55	275	30	120	0	0	0	0	0	0	395	0.929	5
Better Architecture and Deliverables	66	330	10	40	5	15	4	8	0	0	393	0.925	6
Document shipping	70	350	10	40	5	15	0	0	0	0	405	0.953	2
Reduction in changes	80	400	5	20	0	0	0	0	0	0	420	0.988	1

Table 4.1 Factors of Collaboration.

Factors of collaboration	Frequency of Responses					Weighted Ranking	score	RII
	5	4	3	2	1			
Encourages Team Building	60	20	5	0	0	395	0.929	2
Information sharing	55	15	10	5	0			
Improved quality of service	56	14	10	5	0	375	0.882	7
Facilitate communication among project members.	50	20	10	5	0			
Project completion within time	45	25	10	5	0	376	0.885	6
Profitable to organization	65	10	5	5	0			
Friendship and trust	40	30	10	5	0	370	0.871	8
Avoidance of project failure	67	10	8	0	0			
Sustainable on large projects	62	13	10	0	0	365	0.859	10
Reduces bureaucracy	30	40	10	5	0			
Cost reduction in construction	57	13	10	5	0	390	0.918	4
Risk management	49	21	10	5	0			
legal risk liability	39	30	11	5	0	360	0.847	11
						399	0.939	1

	392	0.922	3
	350	0.824	13
	377	0.887	5
	369	0.868	9
	358	0.842	12

Source; Field Survey, 2019

Figure 4.2 The Key Performance Indicators of Collaboration

Key performance Indicators	Frequency of Respondents					Weighted Ranking	Scores	RII
	5	**4**	**3**	**2**	**1**			
Cost time of quality	53	17	10	5	0	373	0.878	9
Team performance	62	20	3	0	0	399	0.939	4
Communication	60	25	0	0	0	400	0.941	3
Human resource management	50	25	5	5	0	375	0.882	8
Productivity	45	40	0	0	0	385	0.906	7
Speed of development	40	20	10	10	0	335	0.788	10
Improvement in skills and knowledge	55	30	0	0	0	395	0.929	5
Better Architecture and Deliverables	66	10	5	4	0	393	0.925	6
Document shipping	70	10	5	0	0	405	0.953	2
Reduction in changes	80	5	0	0	0	420	0.988	1

Source; Field Survey, 2019

Table 4.1 Benefit of BIM collaboration

Benefits of collaboration	Weighted Sum	Mean Score	Rankig
Clash detection	405	4.764	**1st**
Time savings	400	4.705	**2nd**
Improve quality	395	4.647	**3rd**
Waste management	388	4.564	**4th**
Enhance planning, design and costing	375	4.412	**5th**
Improve collaboration and communication	370	4.353	**6th**
Cost reduction	365	4.294	**7th**
Improved facility management	360	4.235	**8th**
Information processing, schedule and budgeting	340	4.000	**9th**
Efficient resource utilization	335	3.941	**10th**

Source; Field survey, 2019.

Table 4.2 Challenges in IM collaboration

Challenges of BIM collaboration	Weighted Sum	Mean Score	Ranking
Lack of BIM technical expert	405	4.765	1st
High cost of implementation	398	4.682	2nd
Risk and challenges with the BIM model	395	4.647	3rd
Interoperability	378	4.447	4th
Lack of cohesion among participants	375	4.412	5th
Cost of training	373	4.388	6th
Lack of management support		4.376	7th
Unwillingness' to chance organisation's culture			

Lack of understanding of BIM benefit	372		
		4.353	8th
	370		
		3.824	9th
	325		

Source; Field survey, 2019.