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Assessment of Building Information Modeling (BIM) Awareness, Knowledge and Its Adoption in the Ghanaian Construction Industry

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Abstract: Building Information Modeling (BIM) is an intelligent 3D model-based process that gives architectural, engineering, and construction (AEC) professionals the insight and tools to more efficiently plan, design, construct, and manage buildings and infrastructures. The introduction and implementation of BIM has brought changes in the construction's traditional procurement system and this has made its adoption a bit slow and difficult to take off swiftly and more officially. Previous researches have identified gaps in contractual relationships, roles and the resulting risks in BIM implementation. This paper focuses on the adoption of BIM in the Ghanaian Construction Industry thereby highlighting the concept of BIM in enhancing productivity and also determines the level of knowledge and awareness of BIM by industry players and stakeholders as well as establishing the extent of usage of BIM in the Ghanaian construction industry. A descriptive survey research was conducted with both structured and unstructured questionnaire and administered both via e-mail and by sending questionnaire link onto a WhatsApp platform groups of the respondents and out of the 263 respondents that took part in the survey, 78 respondents feedback were incomplete so 185 member respondents results were analyzed in the form of bar charts, column chart and pie chart representing 70.3% response rate. The research survey respondents comprised of Civil Engineers, Construction Project Managers, Architects, Electrical Engineers, Quantity Surveyors, Mechanical Engineers, Contractors and Facility Managers. The survey results revealed that there is a low level of knowledge of Building Information Modeling (BIM) and its concept in the Ghanaian Construction Industry which is also associated with the low level of awareness, utilization and adoption among stakeholders. BIM therefore represents a new paradigm within AEC that encourages integration of the roles of all stakeholders on the effective execution of projects and therefore edge the participation of relevant professional bodies to facilitate its implementation in order to ensure adequate knowledge of BIM towards improving productivity and efficiency in the Construction Industry.

Keywords: Building Information Modeling, Construction Traditional Procurement System, Contractual Relationships, Ghanaian Construction Industry, Descriptive Survey Research, Structured Questionnaire, Respondent Results

1. Introduction

Building Information Modeling (BIM) involves a process that begins with the creation of an intelligent 3D model and enables document management, coordination and simulation during the entire lifecycle of a project thus plan, design, build, operation and maintenance [1]. The 3D process is aimed at achieving savings through collaboration and visualization of building components into an early design process that will dictate changes and modifications to the actual construction process. It is also regarded as a very powerful tool that when used properly will save money, time and simplify the construction process. BIM is therefore regarded as a complex multiphase process that gathers input from team members to model the components and tools that will be used during the construction process to create a unique perspective of the building process [2]. It can also be viewed as a virtual process that encompasses all aspects, disciplines, and systems of a facility within a single, virtual model, allowing all design team members (owners,

architects, engineers, contractors, subcontractors, and suppliers) to collaborate more accurately and efficiently than using traditional processes. As the model is being created, team members are constantly refining and adjusting their portions according to project specifications and design changes to ensure the model is as accurate as possible before the project physically breaks ground [3].

The aims of the research is to ascertain the adoption of BIM in the Ghanaian Construction Industry thereby highlighting on the concept of BIM in enhancing productivity and also determines the level of knowledge and awareness of BIM by industry players as well as establishing the extent of usage of BIM in the Ghanaian construction industry. The respondents were also allowed to share their ample ideas, opinions, knowledge and awareness on the adoption and the use of BIM.

Building information modeling (BIM) is one of the most promising recent developments in the architecture, engineering, and construction (AEC) industry. With BIM technology, an accurate virtual model of a building is digitally constructed and this helps architects, engineers, and constructors to visualize what is to be built in a simulated environment to identify any potential design, construction, or operational issues.

2. Literature Review

2.1. Concept of Building Information Modeling (BIM)

BIM is a new technological system and a paradigm shift

approach of integrated project delivery in which, a single comprehensive repository of the facilities data from conceptual phase to operational and maintenance phase is generated and well-coordinated in a concurrently manner that provides a digital representation of the building process to facilitate exchange and interoperability of information in digital format which simulates a building project from the initiation stage to demolition as well providing a 3D virtual environment with a workflow of integrated information through a software package [4-6]. It is therefore considered as a novel revolutionary achievement in the construction industry that will enhance effective communication and subsequently improves productivity in construction project delivery.

BIM is not a software as has been the common misconception, but rather a Software supporting BIM system providing openness, interoperability, functionality, accuracy of data, expandability, time management, clash detection, cost estimation and facility management [7]. Building Information Modeling (BIM) is an intelligent 3D model-based process that gives architecture, engineering, and construction (AEC) professionals the insight and tools to more efficiently plan, design, construct, and manage buildings and infrastructure. BIM is used to design and document building and infrastructure designs. Every detail of a building is modeled in the BIM and the model can be used for analysis to explore design options and to create visualizations that help stakeholders understand what the building will look like before it's built. The model is then used to generate the design documentation for construction [1].
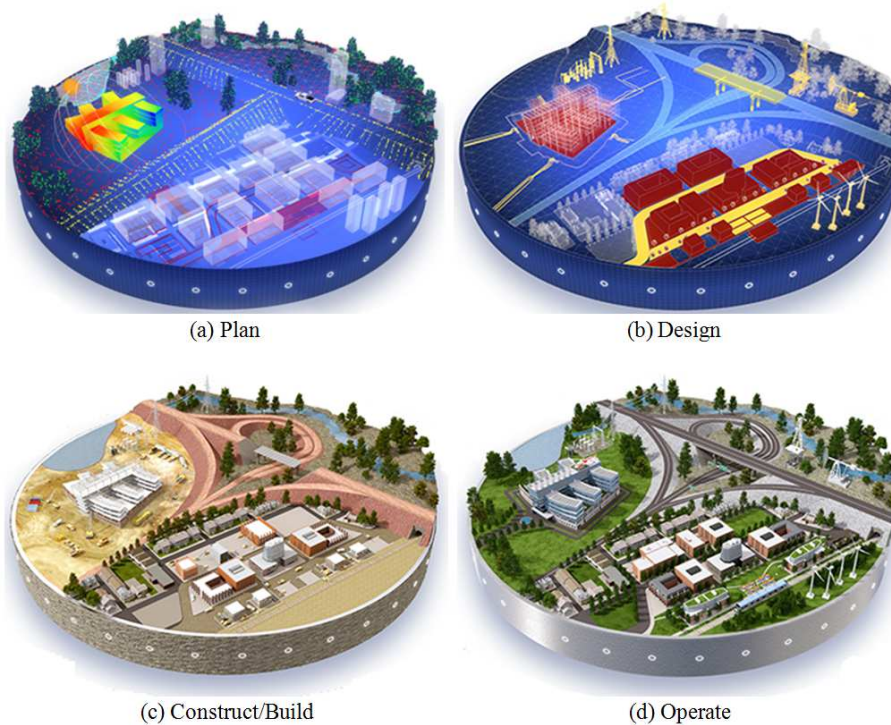

(a) Plan

(b) Design

(c) Construct/Build

(d) Operate

Figure 1. *Process of Building Information Modeling.*

BIM is considered as a major paradigm shift after computer-aided design (CAD) by majority professionals and

academic researchers [8]. Being a new technology, BIM system is a potential legal risk [9], which requires contractual

guidelines because new technologies affect the existing systems and structures, hence demanding for new laws and policy [10] to consolidate interrelationships and holistically, contract management [11]. BIM does not only allows design and construction teams to work more efficiently, but it allows them to capture the data they create during the process to benefit operations and maintenance activities. This is why BIM mandates are increasing across the globe [1].

2.2. Benefits of BIM in Construction

BIM has been an emerging new technological system approach in the AEC industry, there is a lot of confusion about BIM in construction and how it can help contractors. One common misconception is that BIM is merely a technology, or that it only refers to 3D design (though 3D models are indeed

at the core of BIM). BIM is actually a process for creating and managing all of the information about a project, leading to an output known as a Building Information Model, which contains digital descriptions for every aspect of the physical project [12]. The key benefit of BIM is its accurate geometrical representation of the parts of a building in an integrated data environment [13]. While BIM is mostly associated with design and preconstruction, it absolutely benefits every phase of the project life-cycle, even after a building is complete. Building Information Modeling allows projects to be built virtually before they are constructed physically, eliminating many of the inefficiencies and problems that may have pop up during the construction process [12].

The table below highlights the benefits of BIM in construction [12].

Table 1. Benefits of BIM in Construction.

Visualization	A useful manifestation of the BIM process makes the management process more transparent; the three-dimensional (3D) model can easily display what has and has not been obtained in any virtually given area. The weaknesses of the project can be readily noticeable in the BIM model since most of the process revolves on visualization with the 3D model.
Fabrication Drawing	From the 3D BIM model, shop drawings for fabrication of any building component can be easily generated.
Code Checking	To maintain standardization of design, code checking is crucial so as to ascertain compliance with local regulation and international codes of practice. Therefore, design done in BIM can be easily checked for compliance.
Cost Estimation	All components in BIM are developed with inbuilt characteristics of material, cost, volume, etc. therefore, design with BIM will help in generating accurate cost estimate of the project.
Conflicts (Clash) Detection	3D visualization of design will enhance easy detection of interference automatically. For instance, the system will verify that pipes do not intersect with beams, ducts or wall.
Forensic Engineering Analysis	With 3D visualization, it is easy to graphically illustrate potential failures, leaks, evacuation plans etc.
Facilities Management	BIM is considered the best tool for space planning, renovations and maintenance operations.

One key competitive advantage of BIM is its ability to promote greater transparency and collaboration between contractors and suppliers, and thereby reduce waste (procurement, process and material) through all levels of the supply chain. A key driver of the rapid adoption of BIM by clients and industry is that the benefits it creates are shared by the client and the entire supply chain – with downstream benefits to customers who make use of built assets and to society at large [14].

2.3. BIM Applications

BIM is associated with set of processes to produce, communicate and analyze building models. It is seen as an enabler that may help the building industry to improve its productivity [15]. It is considered as a total integration of construction delivery processes, thus if successfully implemented will enhance communication, information flows and collaboration among construction stakeholders. Lack of collaboration has been identified by many writers and commentators as the most serious setback that is affecting productivity in the industry [15, 16].

The BIM application process can be used during design and architecture process creating a clear picture used for better and more integrated designs. The software will be used to foresee problems and coordination between different contractors and as a way to generate construction documents and process that will later be implemented during the physical process. It is ideal when there are many trades executing at the same moment or

when schedules are compressed [2].

2.4. BIM Is Not Only for Architects

Over the years, the industry has commercialized BIM towards architectural related professionals, however, the real purpose and benefits of BIM relate to all construction industry professionals. The 3D representation of the building are now used in roads and utilities too and is geared towards all construction professionals, and they are responsible for understanding the process and participate in providing input to the software [2].

BIM makes a reliable digital representation of the building available for design decision making, high-quality construction document production, construction planning, performance predictions, and cost estimates. Not only that, BIM can also be used by the property owners, once the construction process has ended, to carefully monitor how the building performance and to complete repairs efficiently [2].

The BIM processes cover geometry, space, light, geographic information, quantities, and properties of building components. It also demonstrates the entire building life cycle, including the processes of construction and facility operation [2].

2.5. BIM Risk

BIM risks can be divided into two broad categories: legal (or contractual) and technical. The first risk is the lack of

determination of ownership of the BIM data and the need to protect it through copyright laws and other legal channels. For instance, if the owner is paying for the design, then the owner may feel entitled to own it, but if team members are providing proprietary information for use on the project, their propriety information needs to be protected as well. Thus, there is no simple answer to the question of data ownership; it requires a unique response to every project depending on the participants' needs. The goal is to avoid inhibitions or disincentives that discourage participants from fully realizing the model's potential [17]. To prevent disagreement over copyright issues, the best solution is to set forth in the contract documents ownership rights and responsibilities [18].

Another contractual issue to address is who will control the entry of data into the model and be responsible for any inaccuracies. Taking responsibility for updating building information model data and ensuring its accuracy entails a great deal of risk. Requests for complicated indemnities by BIM users and the offer of limited warranties and disclaimers of liability by designers are essential negotiation points that need to be resolved before BIM technology is used. It also requires more time spent inputting and reviewing BIM data, which is a new cost in the design and project administration process. Although these new costs may be dramatically offset by efficiency and schedule gains, they are still a cost that someone on the project team will incur. Thus, before BIM technology can be fully used, not only must the risks of its use be identified and allocated, but the cost of its implementation must be paid for as well [19].

One of the most effective ways to deal with these risks is to have collaborative, integrated project delivery contracts in which the risks of using BIM are shared among the project participants along with the rewards. Recently, the American Institute of Architects released an exhibit on BIM to help project participants define their BIM development plan for integrated project delivery [20]. This exhibit may assist project participants in defining model management arrangements, as well as authorship, ownership, and level-of-development requirements, at various project phases.

The integrated concept of BIM blurs the level of responsibility so much that risk and liability will likely be enhanced. Consider the scenario where the owner of the building files suit over a perceived design error. The architect, engineers and other contributors of the BIM process look to each other in an effort to try to determine who responsibility for the matter had raised. If disagreement ensues, the lead professional will not only be responsible as a matter of law to the claimant but may have difficulty proving fault with others such as the engineers [18].

2.6. Standard Methods and Procedures' Protocols

When using BIM, a standard protocol is important for the whole BIM process. The protocol should consist of document naming, data file naming, and CAD layer naming, origin, scale, orientation of structure model, etc. Standard procedures should also be defined between different disciplines. All of these are required by effective data sharing

through a common data environment.

The American Institute of Architects has called BIM a "model-based technology linked with a database of project information." This can store complete information about a building in a digital format including things like the quantities and properties of building components. It covers geospatial information and relationships regarding a building, and facilitates the digital exchange and interoperability of the data [20].

2.7. BIM and the Ghanaian Construction Industry

The main contribution of BIM to the Ghanaian Construction Industry will be in enhancing relationships between clients and building professionals as disputes sometimes arise over scope of work, modifications, over-runs and associated costs. Such disputes are more common between building professionals and sponsors of real estate projects. In the public sector, the main challenges regarding efficiency and productivity here are poor budgeting and corruption. In addition, Construction projects in the industry are often involved with inflation of costs. As such, the adoption of BIM will greatly enhance transparency, allowing different stakeholders (bidding contractors, parliament, civil society organizations etc.) to have a better idea of true scope of projects [21].

The low productivity in the Construction Industry is attributed to the inefficiency in production processes that are prevalent in construction projects. Whereas, the Manufacturing Industry boasts higher productivity due to increased efficiency via the implementation of leaner and innovative methods of production in a well-integrated environment. As such, BIM serves as a practical and innovative approach whereby the planning, designing, building and management of infrastructure is done in a coordinated and integrated manner which improves efficiency and reduces waste, and thus, enables the increased productivity to support GDP growth in the country.

2.8. Conflict of the BIM System with the Traditional Procurement System

Deficiencies involved in the traditional procurement methods include, time overrun, material wastage, cost overrun and quality compromise [22]. There is a conflict between BIM system and traditional system [23]; lifecycle collaborative BIM remains hindered by the adversarial nature of the traditional procurement system [9]. Legal issues brought by BIM include: Sharing of copyright data; model management and ownership; BIM standards; processes and responsibilities; standard of care and professional negligence; Intellectual Property Rights; professional liability; claims and disputes; BIM cost compensation; additional project insurance; collaborative working and new roles; software, data security and interoperability; admissibility of electronic-based documents; legal validation of design; legislation and judicial precedence [24-26].

Developing countries such as Ghana are generally

struggling with lack of BIM awareness, lack of standard, little or no government support, unclear legal status of BIM, lack of skills, limited financial, unclear benefits of BIM [27], software, hardware and internet issues [28]. In Ghana, the private sector is gradually leading the adoption of BIM even though is at a slow pace but it is also limited by the Public procurement Act which mainly favors the traditional procurement system. Some professionals are more inclined to BIM more than others, for instance, Architects are taking the lead in BIM, but, Civil Engineers to have a lot to benefit from it, by using it on civil and infrastructure projects [29].

2.9. BIM Future Challenges

The productivity and economic benefits of BIM to the AEC industry are widely acknowledged and increasingly well understood. Furthermore, the technology to implement BIM is readily available and rapidly maturing. Yet BIM adoption has been much slower than anticipated [30]. There are two main reasons, technical and managerial. The technical reasons can be broadly classified into three categories [31].

1. The need for well-defined transactional construction process models to eliminate data interoperability issues.
2. The requirement that digital design data be computable
3. The need for well-developed practical strategies for the purposeful exchange and integration of meaningful information among the BIM components.

The management issues cluster around the implementation and the usage of BIM. Right now, there is no clear consensus on how to implement or use BIM. Unlike many other construction practices, there is no single BIM document providing instruction on its application and use [32]. And also little progress has been made in establishing model BIM contract documents [33]. There is therefore the need to standardize the BIM process and to define guidelines for its implementation.

To optimize BIM performance, either companies or vendors, or both, will have to find a way to lessen the learning curve of BIM trainees. Software vendors have a larger hurdle of producing a quality product that customers will find reliable and manageable and that will meet the expectations set by the advertisements. Additionally, the industry will have to develop acceptable processes and policies that promote BIM use and govern today's issues of ownership and risk management [33].

In the past, facilities managers have been included in the building planning process in a very limited way, implementing maintenance strategies based on the as-built condition at the time the owner takes possession. In the future, BIM modeling may allow a visual nature for all stakeholders to get important information, including tenants, service agents, and maintenance personnel, before the building is completed. Finding the right time to include these people will undoubtedly be a challenge for owners.

3. Methodology

A descriptive survey research was conducted with the use of both structured and unstructured questionnaires which was administered randomly to a sample of stakeholders within various sectors of the Ghanaian Construction Industry via email and by sending questionnaire link onto their WhatsApp group platforms for them to respond. They included Civil Engineers, Construction Project Managers, Architects, Quantity Surveyors, Mechanical Engineers, Electrical Engineers, Contractors, and Facility Managers.

3.1. Questionnaire Structure

The questionnaire structure of this survey was divided into four parts. The first section aims to collect the background information or the profile analysis of the respondents, e.g. their educational qualification, work experience and professional background. The second section includes the respondents' level of awareness and usage of BIM. The third section includes the respondents' level of BIM concept, knowledge and its adoption and the last part provides opportunity for the respondents to share their ideas and opinions openly without restricting them to only closed options in responding to questionnaire.

3.2. Questionnaire Design

The research questionnaire used consist of both structured and unstructured questionnaires, the structured questionnaire was used to identify the respondents' profile analysis, awareness of BIM, the extent of usage of BIM and the knowledge or concept of BIM.

Out of the 263 respondents that took part in the survey, 78 respondents feedback were incomplete so 185 member respondents results were analyzed in the form of bar charts, column chart and pie chart representing 70.3% response rate and out of the 185 respondents, only 92 of them were aware of BIM representing 49.7% of the entire sample and 93 of them were not aware of BIM representing 50.3%.

4. Results Analysis and Discussions

The survey results were analyzed using Statistical Package of Social Studies (SPSS) software. This software is one of the management tools that help in analyzing data and then comes out with a more credible and meaningful results and interpretations.

4.1. Respondents' Profile Analysis

Table 2. *(Respondents Area of Specialization or Profession).*

Numbers	Specialization/profession	No. of respondents	Percentage %
1	Quantity Surveyors	30	16.2
2	Civil Engineers	17	9.2
3	Architects	34	18.4
4	Contractors	23	12.4
5	Construction Project Managers	40	21.6
6	Mechanical Engineers	9	4.9
7	Facility Managers	20	10.8
8	Electrical Engineers	12	6.5
	TOTAL	185	100

Table 2 and figure 2 describe the distribution of respondents based on their area of specialization or profession. 16.2% of the respondents are Quantity Surveyors, 9.2% are Civil Engineers, 18.4% are Architects, 12.4% are Contractors, 21.6% are Construction Project Managers, 4.9% are Mechanical Engineers, 10.8% are Facility Managers and 6.5% of the respondents are Electrical Engineers. It can therefore be deduced that majority of the Respondents that took part in the research survey are in the portfolio as Construction Project Managers representing 21.6% of the total respondents.
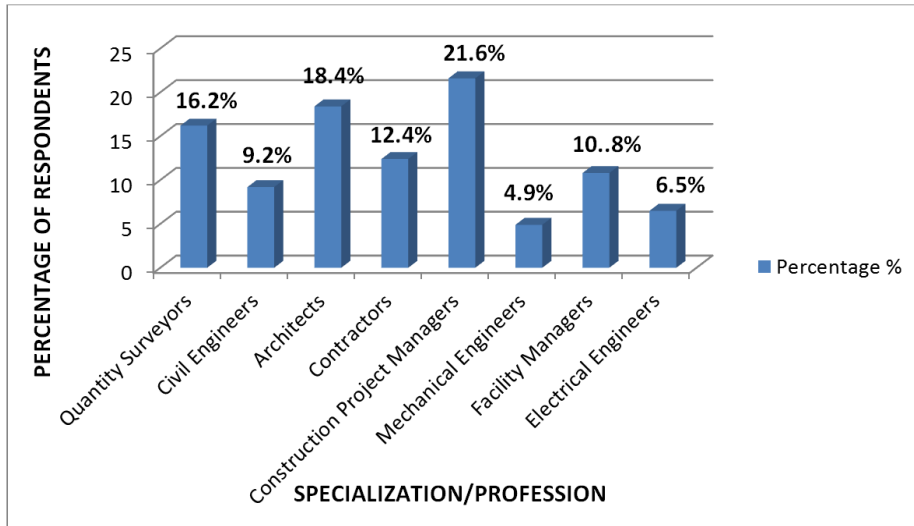

Figure 2. Percentage Area of Specialization of Respondents.

Table 3. Years of Work Experience of the Respondent.

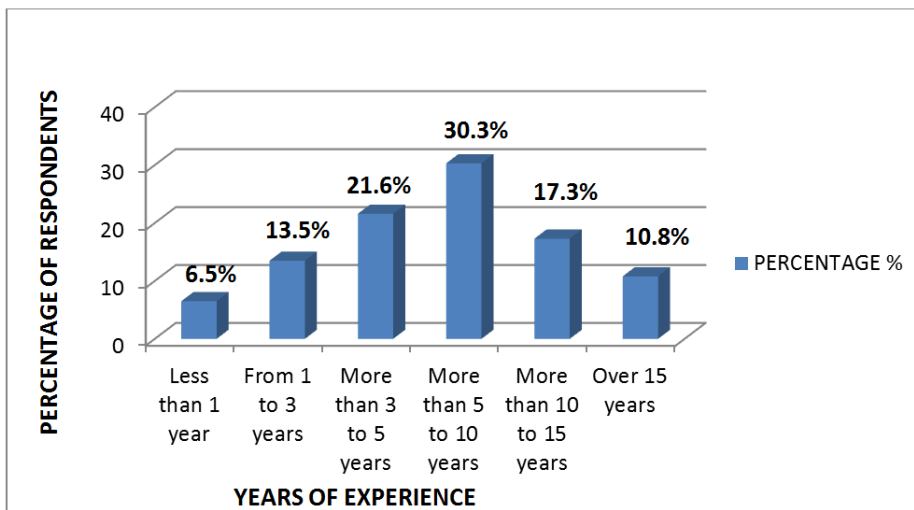| NUMBERS	YEARS OF EXPERIENCE	NO. OF RESPONDENTS	PERCENTAGE (%)
1	Less than 1 year	12	6.5
2	From 1 to 3 years	25	13.5
3	More than 3 to 5 years	40	21.6
4	More than 5 to 10 years	56	30.3
5	More than 10 to 15 year	32	17.3
6	Over 15 years	20	10.8
	TOTAL	185	100

Figure 3. Percentage years of working experience of Respondents.

According to table 3 and figure 3, 6.5% of the respondents have less than 1 year working experience, 13.5% also have from 1 to 3 years working experience, 21.6% also have more than 3 to 5 years working experience, 30.3% also have more than 5 to 10 years working experience, 17.3% also have more than 10 to 15 years working experience and 10.8% of the total respondents also have over 15 years working experience. It can therefore be deduced that majority of the

respondents fall within more than 5 to 10 years working experience, representing 30.3% of the total respondents. In accordance with this, it can be inferred that, majority of the respondents who took part in the survey therefore have ample knowledge in the field of construction industry which make the respondents reliable and credible sources of information which is required to satisfy the research goal.

Table 4. Qualification of Respondents.

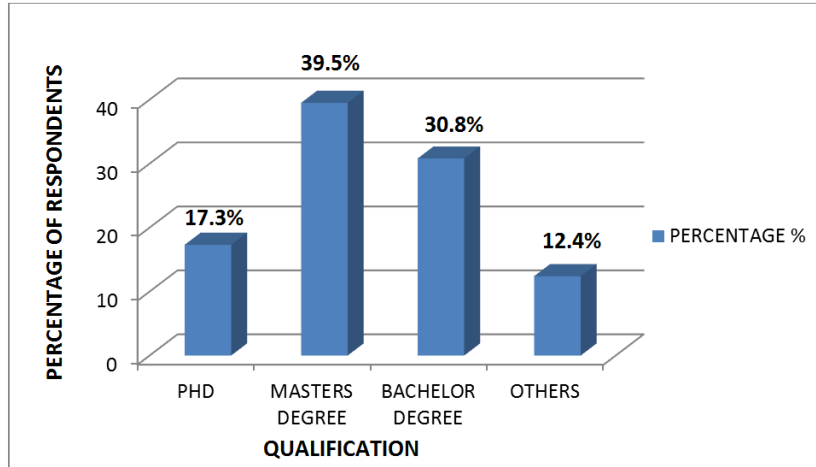| Numbers	Qualification	No. of respondents	Percentage (%)
1	PHD	32	17.3
2	Master's Degree	73	39.5
3	Bachelor Degree	57	30.8
4	Others	23	12.4
	TOTAL	185	100

Figure 4. Percentage Educational Qualification of Respondents.

From table 4 and figure 4 above, 17.3% of the respondents have attain PHD qualification, 39.5% of the respondents have Master's Degree qualification, 30.8% also have Bachelor Degree qualification and the remaining 12.4% represent Other qualifications. It can therefore be deduced from the table and figure above that majority of the respondents have attain Master's degree qualification which represents 39.5% of the total respondents. It can therefore be revealed that the majority of the respondents have the needed qualification and therefore have ample knowledge in the construction industry.

4.2. Level of BIM Awareness and Usage

Table 5. Number of years of BIM Awareness by respondents.

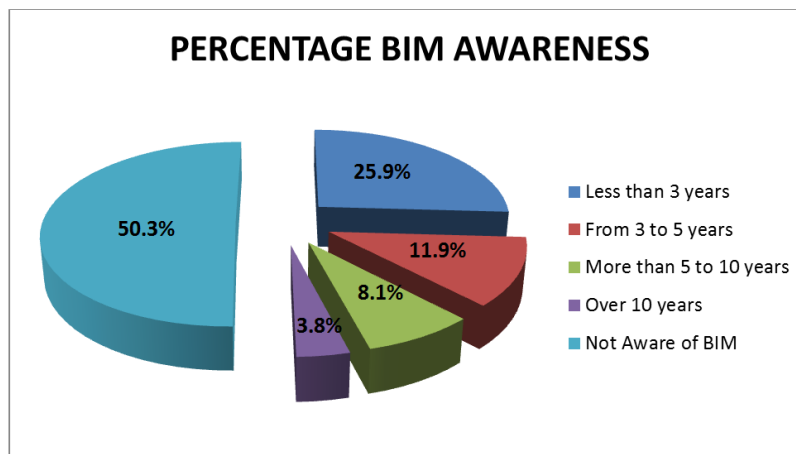| Numbers	Years of BIM awareness	No. of respondents	Percentage (%)
1	Less than 3 years	48	25.9
2	From 3 to 5 years	22	11.9
3	More than 5 to 10 years	15	8.1
4	Over 10 years	7	3.8
5	Not Aware of BIM	93	50.3
	TOTAL	185	100

Figure 5. Percentage BIM Awareness by the Respondents.

Table 5 and figure 5 describe the distribution of respondents based on their years of BIM awareness. 25.9% of the respondents had been aware of BIM for less than 3 years, 11.9% had also been aware of BIM from 3 to 5 years, 8.1% had also been aware of BIM for more than 5 to 10 years, 3.8% had also been aware of BIM for over 10 years and 50.3% were not

aware of BIM. The research survey therefore revealed that a total of 92 respondents out of the overall total of respondents 185 are aware of BIM representing 49.7% of the entire respondents and 93 of the respondents too were not aware of BIM representing 50.3% which forms about a little more than half of the entire respondents. So averagely the awareness of BIM in the Ghanaian Construction Industry is not all that promising and more awareness needs to be created.

The survey results of the respondents were further analyzed on the basis of BIM awareness and also not aware under their respective area of profession or specialization. The table 6 and figure 6 below display an overview of the results after the analysis.

Table 6. Respondents BIM Awareness and No Awareness by Area of Profession or Specialization.

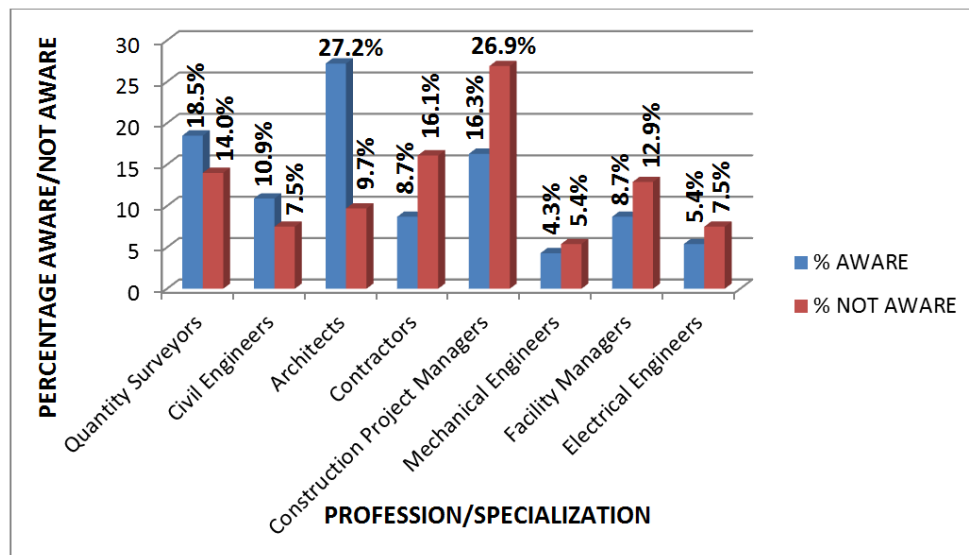| Numbers	BIM awareness by profession/specialization	Number of respondents	Aware	Not aware	% aware	% not aware
1	Quantity Surveyors	30	17	13	18.5	14.0
2	Civil Engineers	17	10	7	10.9	7.5
3	Architects	34	25	9	27.2	9.7
4	Contractors	23	8	15	8.7	16.1
5	Construction Project Managers	40	15	25	16.3	26.9
6	Mechanical Engineers	9	4	5	4.3	5.4
7	Facility Managers	20	8	12	8.7	12.9
8	Electrical Engineers	12	5	7	5.4	7.5
	TOTAL	185	92	93	100	100

Figure 6. Percentage BIM Awareness and No Awareness of Respondents by Area of Profession or Specialization.

Table 6 and figure 6 describe the distribution of respondents BIM Awareness and also those NOT Aware based on their area of profession or specialization. The survey analysis revealed that, under the profession or specialization of the respondents that were Quantity Surveyors, 18.5% were Aware of BIM while 14.0% were Not Aware of BIM. 10.9% under the profession of Civil Engineer were aware of BIM while 7.5% were not aware. 27.2% of the Architects were aware of BIM while 9.7% were not aware, 8.7% of the Contractors were aware of BIM while 16.1% were not aware, 16.3% of the Construction Project Managers were aware of BIM while 26.9% were not aware, 4.3% of the Mechanical Engineer were aware of BIM while 5.4% were not aware, 8.7% of the Facility Managers were aware of BIM while 12.9% were not aware and 5.4% of the Electrical Engineers were aware of BIM while 7.5% were also not aware. It can therefore be deduced that the Architects are most category of specialization that are aware of BIM representing 27.2%. This is followed by the Quantity

Surveyors representing 18.5%. It was also deduced that Construction Project Managers were the most group of the respondents that were not aware of BIM representing 26.9%. This therefore warrant for more awareness creation of BIM in the Ghanaian Construction Industry.

The survey results of the 92 respondents who were aware of BIM were further analyzed to know their extent of usage of BIM in their everyday performance activities. The table 7 and figure 7 below display an overview of the results after the analysis.

Table 7. Number of years of BIM usage by the respondents that are aware of BIM.

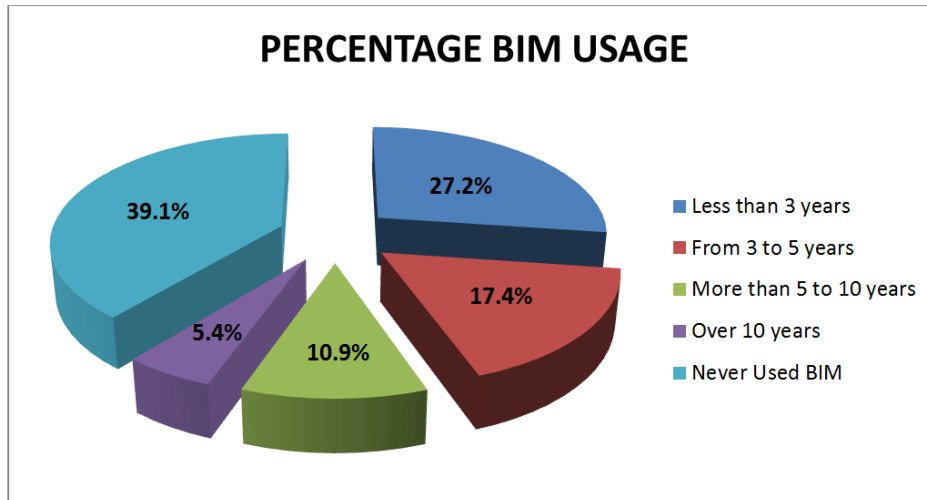| Numbers	Years of Bim usage	No. of respondents	Percentage (%)
1	Less than 3 years	25	27.2
2	From 3 to 5 years	16	17.4
3	More than 5 to 10 years	10	10.9
4	Over 10 years	5	5.4
5	Never Used BIM	36	39.1
	TOTAL	92	100

Figure 7. Percentage years of BIM usage by the respondents that was aware of BIM.

Table 7 and figure 7 show the distribution of respondents based on their years of BIM usage. 27.2% of the respondents had used BIM for less than 3 years, 17.4% had also used BIM from 3 to 5 years, 10.9% had also used BIM for more than 5 to 10 years, 5.4% had also used BIM for over 10 years and 39.1% had never used BIM. The research survey therefore revealed that out of the overall total of 92 respondents who were aware of BIM, a total of 56 respondents had used BIM representing 60.9% of the respondents that were aware of BIM and 36 of the respondents too had not use BIM before representing 39.1%. Deduction from this can therefore mean that even though there is a substantial usage of BIM but more needs to be done to optimize the efficiency and productivity of BIM usage in the Ghanaian Construction Industry.

The survey results of the 56 respondents who had used BIM were further analyzed to know their distinctive Roles of BIM in their everyday performance activities. The table and figure below display an overview of the results after the analysis.

Table 8. BIM Roles of the Respondents.

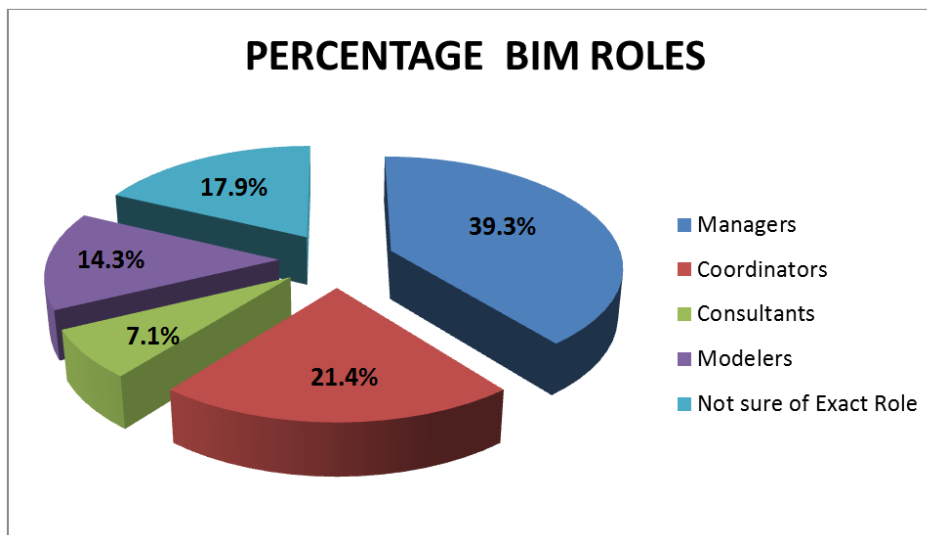| Numbers	BIM roles	No. of respondents	Percentage (%)
1	Managers	22	39.3
2	Coordinators	12	21.4
3	Consultants	4	7.1
4	Modelers	8	14.3
5	Not Sure of Exact Role	10	17.9
	TOTAL	56	100

Figure 8. Percentage Respondents BIM Roles.

Table 8 and figure 8 show the distribution of respondents based on their BIM Roles. 39.3% of the respondents were BIM Managers, 21.4% were also BIM Coordinators, 7.1% were also BIM Consultants, 14.3% were also BIM Modelers and 17.9% could not identify their exact roles played in BIM. It can therefore be deduced that majority of the respondents who had used BIM were in the portfolio of BIM managers representing 39.3%.

4.3. Level of BIM Concept, Knowledge and Adoption

A Misleading definition and description of the concept of BIM was deliberately provided for the respondents who claim to be aware of BIM to ascertain their better understanding of it whether they agree, disagree or not sure about it. The table and figure bellow show the distribution of respondents based on the misleading description of the concept of BIM that was provided in the questionnaire.

Table 9. Misleading Definition and Description of BIM Concept by the Respondents.

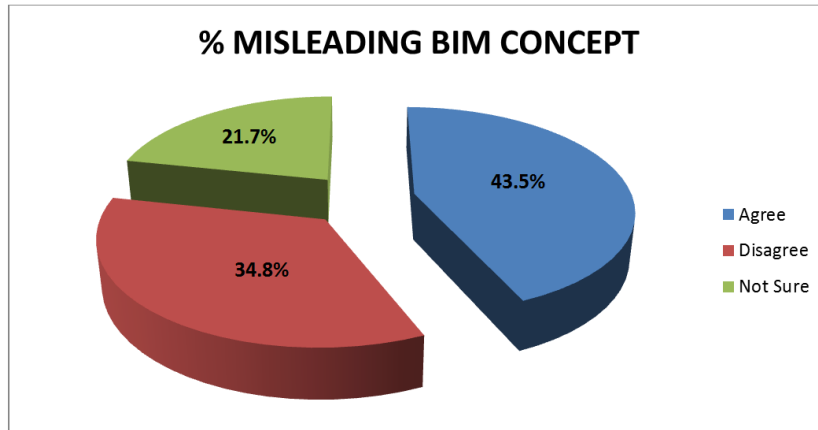| Numbers	Misleading definition of Bim concept	Number of respondents	Percentage (%)
1	Agree	40	43.5
2	Disagree	32	34.8
3	Not sure	20	21.7
	TOTAL	92	100

Figure 9. Percentage Misleading Definition and Description of BIM Concept by the Respondents.

Table 9 and figure 9 show the distribution of respondents based on the deliberate misleading definition and description of BIM Concept provided in the questionnaire for the respondents that claim to be aware of BIM to share their understanding of whether they agree, disagree or not sure about it. 43.5% of the respondents agreed to the misleading concept of BIM, 34.8% of the respondents also disagree to the misleading concept of BIM and 21.7% of the remaining respondents were also not sure of the misleading description of BIM concept provided in the questionnaire. This result therefore indicates that, there is lack of understanding of the concept of BIM amongst respondents who claimed to be aware of it, and as a matter of fact indicates a low level of the knowledge of BIM concept in the Ghanaian Construction Industry.

Under the BIM concept, respondents were also asked to share their knowledge and ideas on BIM dimension, it was revealed that majority of the respondents mainly use BIM for 3D modeling representing 48.2%. 16.1% of the respondents also used 5D (Cost), 12.5% 4D (Time), 10.9% 6D (Operation), 6.9% 7D (maintenance), and 5.4% used 8D (Safety).

It was also revealed that the most common software often utilized by the respondents is AutoCAD Architecture, Revit Architecture and ArchiCAD. However there was low level of utilization of other tools due to no or little knowledge on how to make use of them.

The survey results of the 56 respondents who were aware of BIM and as well had made use of BIM were further analyzed to ascertain about the stages or phases of BIM they were involved in. The table and figure bellow show the distribution of respondents based on their stages of BIM they were involved in.
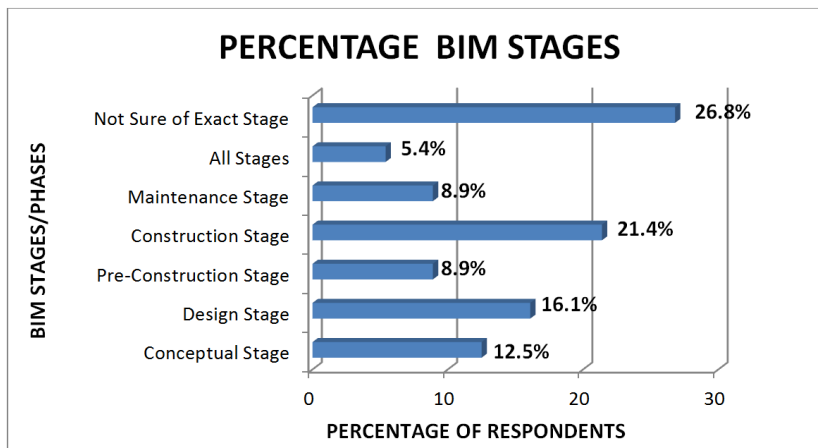

Figure 10. Percentage BIM Stages or Phases involved by the Respondents using BIM.

Table 10. BIM Stages or Phases involved by the Respondents using BIM.

Numbers	BIM stages/phases	No. of respondents	Percentage %
1	Conceptual Stage	7	12.5
2	Design Stage	9	16.1
3	Pre-Construction Stage	5	8.9
4	Construction Stage	12	21.4
5	Maintenance Stage	5	8.9
6	All Stages	3	5.4
7	Not Sure of Exact Stage	15	26.8
	TOTAL	56	100

Table 10 and figure 10 show the distribution of respondents based on their BIM Stages or Phases involved by the respondents who had used BIM. 26.8% of the respondents were not sure of the exact BIM stage they were involved in, 5.4% were also involved in All BIM stages, 8.9% were also involved in the Maintenance stage of BIM, 21.4% were also involved in the Construction stage of BIM, 8.9% were also involved in the Pre-construction stage of BIM, 16.1% were also involved in the Design stage of BIM and 12.5% of the respondents were also involved in the Conceptual stage of BIM. It can therefore be deduced that majority of the respondents who had used BIM did not know the exact stage of BIM they were operating in which therefore confirm that the respondents had little knowledge about BIM.

Respondents were also task to rank the various purposes of the utilization of BIM using the ordinance scale from 1 to 5. The table below shows the distribution of the BIM utilization purposes by the respondents.

Table 11. Purpose of Utilization of BIM by Respondents.

PURPOSE OF BIM UTILIZATION	NO. OF RESPONDENTS IN ORDINACE SCALE					TOTAL	RELATIVE INDEX (RI)	RANK
	1	2	3	4	5			
3D Modeling/Presentation	10	7	4	14	21	56	0.82	1
Construction Drawings	33	0	9	4	10	56	0.54	2
Engineering Analysis	38	7	5	0	8	56	0.49	3
Cost Estimation (Budget)	25	18	0	9	4	56	0.43	4
Clash Detection	56	0	0	0	0	56	0.20	5
Increased Productivity	56	0	0	0	0	56	0.20	5
Program Scheduling	16	0	0	0	0	56	0.20	5
Facility Management	56	0	0	0	0	56	0.20	5
Code Checking	56	0	0	0	0	56	0.20	5

The results revealed that, the most common purpose of utilization of BIM by the respondents is for 3D Modeling/Presentation which is ranked 1st with an RI score of 0.82, this therefore indicates that BIM is only popularly used for Presentation purposes. The 2nd most ranked purpose of BIM utilization is for Construction drawings with an RI score of 0.54. Engineering analysis was ranked 3rd on the purpose of BIM utilization. The 4th most utilization purpose of BIM was for Budgeting or Cost Estimation and the remaining purposes were ranked 5th. The fact that other utilization purposes were below the 0.60 RI score indicates that, there is low level of knowledge of the benefits of utilization of BIM amongst stakeholders in the Ghanaian Construction Industry.

Respondents also share information and ideas on the reason for slow adoption of BIM in the construction industry. Respondents were asked about the reasons for slow adoption of BIM and also not able to adopt the new technological approach of BIM. 18.5% reported on lack of training, 5.4% said there was no client requirement, 8.7% lack of standards & guidelines, 10.9% said that BIM implementation process was too expensive, 16.3% cited lack of policy, 8.7% were satisfied with the already existing system, 4.3% said change resistant attitude and 27.2% did not understand BIM. This result therefore revealed that the failure in adoption of BIM is much contributed by lack of better information, knowledge and understanding of BIM in the construction industry.

The figure below shows the distribution on the slow adoption of BIM.
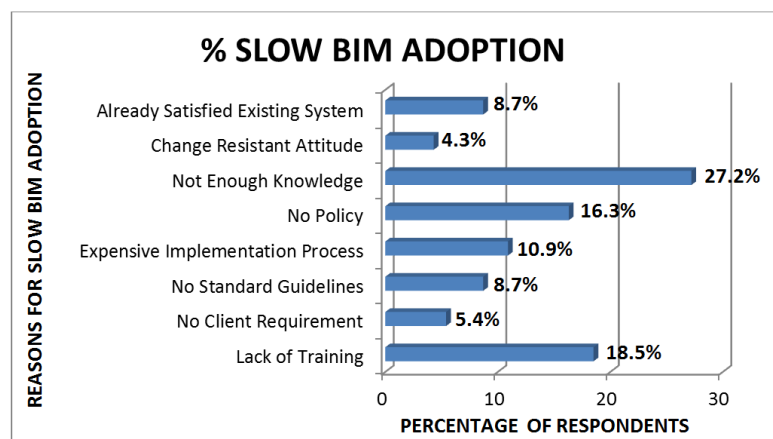
Figure 11. (Percentage of Slow BIM Adoption by the Respondents).

In comparison with a similar study conducted between June and August 2014 in the Nigeria Construction Industry also shows that there is little awareness, low level of utilization and also slows adoption rate by the stakeholders and key players in the industry as revealed in the Ghanaian Construction Industry too. This therefore confirms that the integration and implementation of BIM in Africa is a bit challenging and therefore requires much attention in order for it to be incorporated into the systems of the African Construction Industry. This low level of awareness, utilization and adoption is attributed to the fact that, BIM is yet to be fully integrated into the educational curricula of Academic Institutions. When this is done will provide the necessary pivotal contribution step towards increased knowledge and awareness, this will also ensure that Graduates have the background knowledge of the concept and implementation of BIM in the construction industry.

4.4. Situation of BIM Adoption in the Ghanaian Construction Industry

The opinions and ideas given by the respondents concerning the adoption of BIM in the Ghanaian Construction Industry shows that the adoption is still low and also in a slow pace, this is because there is little or low knowledge and shallow understanding of BIM and its concept. Other factors that also impedes BIM adoption apart from the ones elaborated in figure 11 includes failure to include BIM in the Education curriculum, complexity of BIM, lack of leadership, inadequate sensitization, size of projects dictating adoption, lack of case studies and lack of BIM championing. In addition, most contractors are also unwilling to adopt the new emerging system, client's failure to require BIM, inflexible employers, unfavorable procurement rules, rigid traditional procurement system and lack of government mandate are other reasons for low adoption level.

In spite of all these, the respondents also believed that BIM has influenced on contract management by making it easier to deal with it. BIM facilitates collaboration, improved quality, business benefit, positive return of investment (ROI), easier decision making, clash detection, early problem detection in professional relationships. It also makes it easier for parties to appreciate design components, reduces adversarial relationships. It also eliminates inconsistencies and abortive works, Bills of quantities are more accurately done, it gives transparency, empowers clients to appreciate real-time 3D visualization. It thus enables risk management through early identification and mitigation.

5. Conclusion

BIM represents a new paradigm within AEC, one that encourages integration of the roles of all stakeholders on a project. This integration has the potential to bring about greater efficiency and harmony among players who all too often in the past saw themselves as adversaries. As the use of BIM accelerates, collaboration within project teams increases, which will lead to improved profitability, reduced costs, better time management, and improved customer–client relationships. Teams implementing BIM should be very careful about the legal pitfalls, which include data ownership and associated proprietary issues and risk sharing. Such issues must be addressed up front in the contract documents.

Industry groups are trying to develop one standardized BIM model that can be used to integrate all different types of modeling systems. By so doing, they will facilitate the coordination and communication in the design-construction-operation team on one single platform. The purpose of this movement is to create a single data center, with multiple CAD and specs depending on the discipline that you are working for. All data will then be put together allowing it to be used for take-offs, analysis, coordination and important project milestones. This effort will help standardize the process and will establish a base that can be used during the bidding process so everyone can be judged using some standard guidelines. The future of BIM is both exciting and challenging. It is hoped that the increasing use of BIM will enhance collaboration and reduce fragmentation in the AEC industry and eventually lead to improved performance and reduced project costs.

One of the challenges in the construction industry is lack of effective collaboration which has contributed to poor quality delivery, time, and cost overruns in the lifecycle of a project. The BIM system gives the solution to these challenges caused by the Traditional procurement system however lacks a legal framework for BIM implementation, due to its collaborative nature that is changing relationships, roles, and responsibilities. The Ghanaian construction industry lacks the guidelines on how to handle these changes, how to use or apply BIM, how to handle legal issues as well as how to handle contract management issues.

Building information modeling is therefore an emerging and innovative way to virtually design and manage projects. Predictability of building performance and operation is greatly improved by adopting BIM.

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