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Bim Adoption in Architectural Practice in Ghana: A Study of Current Status and Future Prospects.

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A B S T R A C T

The concept of Building Information Modelling (BIM) has revolutionized the Architecture, Engineering, and Construction (AEC) industry and countries such as the UK, USA, China, Germany, etc. which have adopted BIM have benefited from its merits which include an increase in productivity, reduction in errors, time efficiency, cost reduction, etc. However, in developing countries like Ghana, BIM awareness is low resulting in a low level of BIM adoption within Ghana's AEC industry. This paper aims to assess the adoption of BIM in architectural practice in Ghana in order to come up with measures to encourage the mainstream adoption of BIM in Ghana. Semi-structured open-ended interviews were conducted to collect data. From the analysis, it was established that the adoption of BIM by Ghanaian architects is low. Some of the barriers to the low level of BIM adoption were discussed which included the lack of BIM experts within the industry, lack of financial means and resources to adopt BIM, and low level of BIM awareness within the industry. Some measures to encourage the mainstream adoption of BIM were also discussed which included the active involvement of the government of Ghana and GIA (Ghana Institute of Architects) as the main "pushers" of BIM adoption in the country through consensus and legislation, the addition of BIM education to the curriculum of architecture schools in Ghana and the establishment of a BIM Centre to train professionals and students in the AEC Industry of Ghana on how to adopt and use BIM in their workflow.

Keywords: Building Information Modelling, AEC Industry, BIM adoption, Architectural practice, Computer-Aided Design

1. Introduction

BIM adoption has seen an immense adoption in the AEC industry in the past five (5) years according to McGraw-Hill (2012). Using BIM technology comes with several advantages which include an increase in productivity, reduction in errors, time efficiency, cost reduction, etc. Also, the technology benefits all project team members and enables a more seamless and carefully planned building process through integrated project delivery (IPD) (Ahzar et al., 2012; Autodesk, 2010).

According to McGraw-Hill (2009), about half of the architecture sector in the United States use BIM, and its acceptability is projected to grow as the benefits of using it become clear. Researchers expected that BIM would have reached an echelon in North America by 2008, even though the adoption rate at the time was only 28%. Around 71 percent of architects, engineers, contractors, and owners were using BIM in some form or another in 2012 (McGraw-Hill Construction Report,2012). In the United States, BIM utilization increased by 47 percent from 2008 to 2012 (McGraw-Hill construction study, 2012). This supports the findings of the (National BIM Report,2014), which shows that most structures are being constructed using BIM technology, which allows for improved engagement and information exchanges about a project.

BIM has gained traction in most developed countries in the last five years as a result of its promising future (Woo, J. H. (2006).). Numerous studies have admitted that the adoption of BIM has not progressed as quickly as expected (Eastman et al., 2011; Azhar et al., 2008; Howell & Batcherler, 2005; Fisher & Kunz, 2004). Knowledge and know-how for its acceptance and execution, on the other hand, are widely available and developing . However, major studies show that a deficiency in several skilled personnel in the BIM field has been a significant factor impeding BIM's successful use and implementation (Wong et al., 2011; Gu & London, 2010; Hartmann & Fischer, 2008).

As technology is heavily impacting today's modern world, there is the need for professionals in the architecture industry to also incorporate advanced technologies into their workflows and BIM is one of the current technological advancements that could revolutionize the architecture industry in Ghana. The level of BIM adoption by AEC professionals within Ghana is very low. Only a few professionals use it mainly for 3D modeling and presentations and this is a setback because it is not utilized to its fullest potential. There is therefore the need for BIM adoption and implementation within Ghana's AEC industry to maximize productivity and reduce cost etc.

Even though some architects believed that the BIM concept was highly restricting because it reversed their natural order of design, its usage has increased over time because the benefits outweigh the drawbacks...

1.1 Concept of Building Information Modelling

Ashurst, A. (2014) defines BIM as a smart 3D model-based method that offers professionals of the AEC industry with the knowledge and tools they require to plan, design, construct, and manage buildings and infrastructure more efficiently.

According to Kiviniemi, A. (2013). BIM is not a software, contrary to popular belief, but rather a software-supporting system that provides interoperability, data accuracy, time management, cost estimation, clash detection, and facility management.

AutoCAD is a drafting tool that describes project components geometrically while Building Information Modelling identifies each component of the building by its purpose and data assigned to it (Philip, 2012). Any geometry, for example, a rectangle drawn to represent a room or a house in Autocad provides no detail about intended use Nonetheless, a BIM software specifies the intended usage of each item; otherwise, industry-standard dimensions and materials will be assigned automatically Salmon, J.L. (2009). BIM differs from traditional 2D CAD in that 2D CAD represents a structure utilizing discrete views such as plans, components, and elevations. When a change is made in one view, all of the other views must be evaluated and amended as well, which is a time-consuming process and susceptible to errors (Jongeling (2016). BIM, on the other hand, specifies structures in terms of spaces, walls, beams, and columns, etc. with 3-dimensional data which is parametrically altered unlike in traditional CAD where drawings are confined to 2D geometries such as lines, arcs, and circles, etc Alshawi, M. (2007). A building information model is capable of storing all data related to a building, including its functional attributes and physical attributes. For example, information on the unit's supplier, operating and maintenance practices, flow rates, and clearance criteria would be included in a BIM for air conditioning.

Within a single 3D model, BIM allowed the collaboration of multiple design professionals to plan, design, and construct a project (Smith, M. (2013).In a virtual model, this entails incorporating all of the data needed to carry out each particular task. Nothing in the BIM model should be subjective to complete all planned activities and analyses .

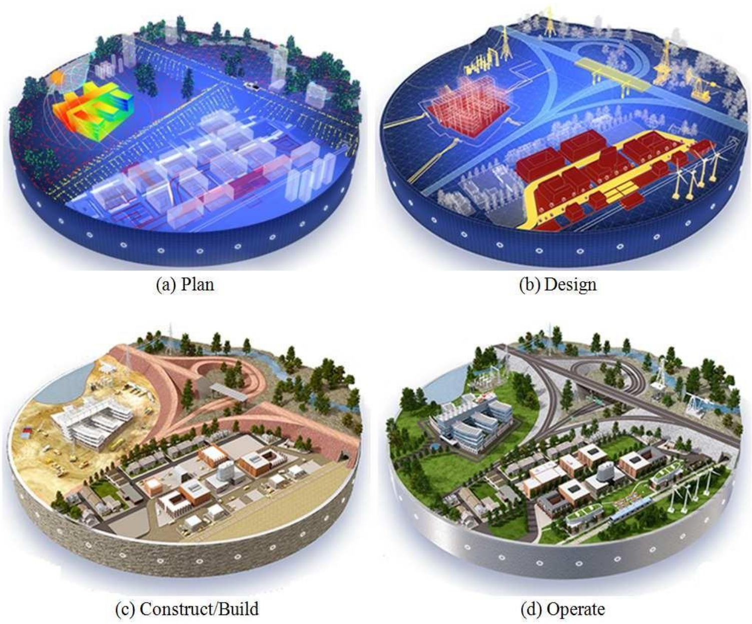

Figure 1. 1 Process of Building Information Modelling (Appiah, 2020)

1.2 BIM Maturity Levels

The BIM maturity level is from 0 to 3 and beyond, describing a network designed to share data digitally. In other terms, it describes the methods for exchanging digital information. The various layers of BIM can be used at any point during the project cycle (NBS National BIM Report, 2017).

BIM Level o

In the maturity levels, BIM level 0 is the lowest. The drawings are unintelligent, uncontrolled CAD projects that are usually two-dimensional and are typically characterized as a pre-BIM state. There is no teamwork because things are not linked and exchanged. Level 0 involves only 2D drafting for the production of drawings, and this fosters no collaboration. A great number of professionals in the industry are ahead of this level (NBS National BIM Report, 2017).

BIM Level 1

level 1 BIM is a degree of development when information is shared in part via a Common Data Environment (CDE). Not only are drawings and models shared, but also timetables and specifications. Because not everyone on the project team is exchanging models at this level, it's frequently referred to as lonely BIM, Stanley and Thurnell (2014).There is a digital site or platform that contains all of the project's data. The CDE serves as the foundation for facilitating, managing, and disseminating data and project information among multidisciplinary teams in a controlled manner throughout the project life cycle. By delivering coordinated data, using shared information speeds up projects and minimizes costs (Stanley and Thurnell (2014).).

BIM Level 2

This level is characterized by collaborative working, which necessitates the sharing of information as a project-specific activity that must be shared between multiple systems and project stakeholders (Stanley and Thurnell (2014). This level can alternatively be described as a managed 3D environment with associated data that was built using models from different disciplines. The different models can be combined to form a centralized model that retains its identity and integrity (Stanley and Thurnell (2014).

BIM Level 3

BIM Jongeling

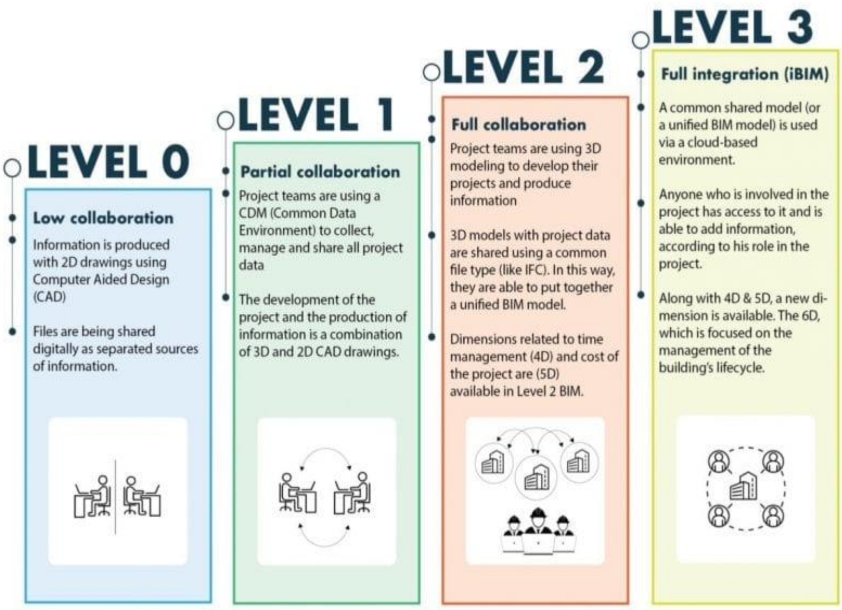

Figure 1.2 Levels of BIM Maturity (Acca Softwrae, 2021)

1.3 Benefits of BIM

BIM is time-efficient. This is due to the decrease of repetitive work, as well as the elimination of mistakes and early detection of omissions (Eastman, 2008).

Furthermore, any changes made in the design are instantly updated in the project model; BIM resolves most design inconsistencies and errors allowing for the creation of accurate and effectively planned projects (McGraw-Hill, 2009; Porwal et al., 2013).

Additionally, because BIM can enumerate material quantities, it is possible to estimate project costs early on. This aids in the quantitative and qualitative verification of design parameters as early as the project's planning phase (Eastman, 2008; Ahzar et. al., 2012).

1.4 BIM Adoption by the AEC Industry

The current condition of the AEC industry and its readiness to adopt BIM vary greatly. Because of this, different techniques to encourage BIM adoption may be required in different regions.

BIM adoption varies among companies due to regional, cultural, and organizational differences. During the initial phase of BIM adoption (early 2000s to mid-2010s), significant insights and proposals were shared in the literature (Volk et al., 2014). Understanding BIM implementation issues and promoting adoption has been a focus for academics, considering the various factors influencing adoption at national and organizational levels. The study of BIM adoption is valuable as it examines both global issues and cultural factors that contribute to its success (Volk et al., 2014).

BIM adoption has been studied in various countries. In the United Kingdom, a three-step roadmap known as the governance approach in BIM management was developed to enhance BIM adoption. Researchers (Rezgui et al., 2013) investigated this approach. A survey conducted by (Khosrowshahi et al.,

2012) analyzed the effects of BIM on daily activities in the UK. They found that collaborative atmosphere and efficient management processes were advantageous for BIM adoption.

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Liu, Z. (2010) and Stanley and Thurnell (2014)) examined BIM adoption in Sweden and both concluded that it is still in its early stages. In Australia, studies by Won, J., Lee, G., Dossick, C., and Messner, J. (2013).have focused on BIM adoption. These studies indicate that Australian market leaders have a and that the industry's adoption of BIM is limited, as the AEC sector has only implemented BIM methodology and technology to a restricted extent.

Moreover, some participants had difficulty understanding the concept of BIM, including its distinction from standard CAD tools and its cost implications. Other studies by Arayici, Y et al.(2011) suggest that barriers to BIM implementation vary across countries, indicating the significant role of cultural influences in achieving successful BIM implementation. According to the two studies, BIM can greatly assist in sustainable construction, information management, and integrated project delivery (IPD). Woo, J., Wilsmann, J. and Kang, D. (2010) conducted a study at the organizational level, analyzing qualitative and quantitative data from 26 BIM user firms. They found that the implementation tactics for BIM varied across different project processes. Additionally, they noted that as firms gain more project experience, their approach to BIM implementation evolves. Firms that align with the implementation strategy plan and are willing to share BIM files throughout the project process are considered the opposite of firms in the early stages of BIM implementation .

To achieve successful BIM implementation, AEC companies need to enhance their operations across all construction phases. This involves acquiring new software skills, adjusting workflows, training employees, delegating tasks, and redefining building modeling approaches (Bernstein and Pittman, 2004). Therefore, the industry would greatly benefit from a clear guideline that outlines an effective BIM strategy and organizational approach (Bernstein and Pittman, 2004)..

1.5 Barriers to BIM Adoption

BIM adoption faces challenges in education and training from two sources: tertiary education curriculum and post-tertiary education. When a company aims to incorporate BIM into its operations, a common requirement is to train employees in this new technology Smith, D. (2007).However, the education curriculum in Ghana's higher education system has yet to adequately address the need for BIM education. This scarcity of properly trained professionals has hindered the adoption and implementation of BIM . Additionally, another recurring problem is the fair distribution of contributions and risk allocation among parties involved.

Publications like Richard and Jason's ConsensusDOCS 301 BIM Addendum, 2010, are available in developed countries to address specific rights and obligations and facilitate the integration of BIM in building projects. However, these rules and guidelines are usually limited to their respective countries and may not be applicable elsewhere. The lack of a clear legal framework associated with BIM is another obstacle highlighted by several researchers (Bernstein et al., 2005). The wide variety of design software options makes it challenging to create an interoperable model that can seamlessly interact with different applications. Interoperability, as defined by McCartney (2010), refers to a BIM package's ability to access and modify BIM models from other software without losing any stored data. Despite established standards like the IFC (Industry Foundation Class) for BIM models , and software companies' efforts to enhance compatibility between various BIM applications, data interoperability remains a significant barrier to BIM adoption (Young et al., 2009).

In addition to the aforementioned study, numerous other research efforts have explored the obstacles to BIM adoption worldwide. A study conducted by Stanley and Thurnell (2014)in New Zealand examined the situation of cost consultants and their familiarity with BIM. The main barriers to BIM adoption among cost consultants, as identified in this survey, include the time required for learning, implementation costs, insufficient comprehension of the model, negative attitudes of consultants, and resistance to change.

2. Materials and Method

This paper utilized a qualitative research approach involving interviews to investigate the adoption of BIM in architectural practice in Ghana. The aim was to gather detailed and comprehensive feedback from respondents in order to address research questions and achieve study goals and objectives.

Research Tactics

This study's research approach includes data sources, determining the population and sample size, data collection method, and data analysis.

Sources of Data

This study gathered information from primary and secondary sources. Primary data was collected from architects in Ghana, while secondary data was obtained through a literature review. The literature review served as a reference and offered existing information on the subject.

Population Size, Target Group, and Sample Size Determination

Data acquisition was performed using purposive and snowball sampling methods. Purposive sampling involves intentionally selecting specific subjects to be included in the study, and it was employed to identify key respondents from the Ghanaian Architecture Industry. This approach is suitable when the population size is unknown or cannot be individually recognized (Kumar, 1999). The researcher aimed to gather feedback from a specific group of respondents who possessed relevant experience with the use of BIM, having been involved in projects to some extent.

In Kumasi, a list of licensed architects was obtained and snowball sampling was used to identify active architects and those involved in ongoing projects. A representative sample of 30 architects was selected from the Kumasi metropolitan area to represent Ghana using the snowball sampling technique.

In this research, the population of interest is the architects in Ghana. The primary objective of the study is to examine the utilization of BIM in architectural practice specifically within Ghana.

Data Collection Method

Primary data for the research was collected through semi-structured open-ended interviews. These interviews enabled individuals to share their knowledge and perspectives on a specific issue. Both in-person and phone interviews were conducted.

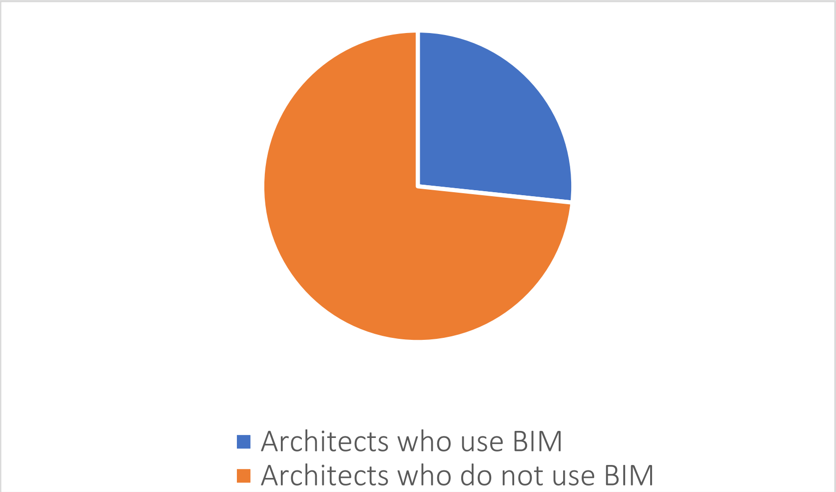
Analysis of Primary Data

The interviews were recorded and transcribed for analysis. Qualitative data analysis involves various methods, each with its own purpose, strengths, and weaknesses. The six commonly used methods for analyzing qualitative data are thematic analysis, discourse analysis, narrative analysis, grounded theory, qualitative content analysis, and interpretive phenomenological analysis.

Thematic analysis was chosen as the most effective approach to analyze the qualitative data in order to achieve the research's goals, objectives, and questions. This method identifies patterns of meaning in a collection of data, such as interviews or focus group transcripts. It involves categorizing data into themes or commonalities, allowing the researcher to make sense of the content and derive meaning from it.

3. Results and Discussion

Out of the 30 architects that were interviewed, 8 of them use BIM whereas 22 do not use BIM.



Architects Understanding of BIM

The findings from 8 BIM users indicated a strong comprehension of BIM, and their definition of BIM aligned with existing literature in the field.Two respondents (n=2) clarified that BIM is a technology that enhances the efficiency of planning, executing, and managing projects for AEC professionals. This aligns with Ashurst, A. (2014) definition, which describes Building Information Modeling (BIM) as a smart 3D model-based approach that equips AEC professionals with the necessary knowledge and tools for more efficient planning, designing, constructing, and managing of buildings and infrastructure.

According to a respondent, BIM represents a progression from 2D line drafting by incorporating extra features that offer designers the flexibility to make changes to the design without the need to redraw it in all views. The respondent further explained that BIM intelligence enables data exchange among the design team, and the same model can be shared with other professionals.

Additionally, another participant concisely described BIM as the utilization of a 3D model that incorporates data accessible to various stakeholders involved in a project.

Two BIM users limited BIM's definition to its software aspect, considering BIM as synonymous with software tools like Revit and Archicad. However, various literature sources present a different viewpoint Kiviniemi, A. (2013) argues that BIM should not be considered a software itself, as commonly believed, but rather a software-supported system that enables interoperability, accurate data management, time tracking, cost estimation, clash detection, and facility management.

All 8 participants who use BIM were familiar with 3D BIM. Among these users, 4 had knowledge of 4D BIM and agreed that it involves incorporating time-related information into a 3D model. Additionally, 3 out of the 8 BIM users were aware of the fifth dimension (5D BIM), which involves adding cost data to the BIM model. One respondent possessed knowledge of 6D BIM, stating that it facilitates the analysis of a building's energy consumption during the early stages of design for architects and designers.

The Findings from 22 architects who are not familiar with BIM indicate a lack of substantial knowledge about it. Six respondents were unaware of BIM, suggesting a low level of awareness within Ghana's architecture industry. Additionally, 16 respondents had heard of BIM but lacked a comprehensive understanding of its concept, which can be attributed to limited awareness and training within the industry. These factors significantly impede the adoption and implementation of BIM.

Benefits of BIM to Architects

8 respondents who use BIM were all of opinions that BIM comes with a lot of advantages and that influenced their decision to choose BIM. Respondents shared similar views on the benefits of BIM.

Some of the respondents (n=5) stated that BIM has made work faster because of the coordination of the drawings. They explained that when a change is made in one view, the changes are automatically reflected in all other views of the projects. A respondent mentioned that the BIM process creates accurate models that can be visualized in a 3D workspace even before the project breaks ground physically. The respondent further added that since the entire BIM workflow is time-efficient, it has boosted his productivity, and now he can work on multiple projects almost at the same time.

The State of BIM Adoption by Architects

Concerning the adoption of BIM by architects in Ghana, investigations were made to assess the current state of BIM adoption by architects in Ghana and it was discovered that the level of BIM adoption is low.

8 out of 30 sampled respondents were identified as BIM users and are involved in BIM one way or the other. During the interviews, it was discovered that 2 of the respondents in this category have their exposure to BIM limited to only BIM applications which implies that they essentially use it only for 3D modeling without collaboration with other professionals or systems and this is confirmed by existing literature. According to (Stanley and Thurnell (2014), the level of BIM adoption by AEC professionals within Ghana is very low. Only a few professionals use it mainly for 3D modeling and presentations and this is a setback because it is not utilized to its fullest potential.

Additionally, only 3 respondents stated that their BIM workflow encompasses data exchange between other professionals and this implies that their BIM maturity level is 2. BIM maturity level 2 involves collaborative working and requires an information exchange process that is specific to that project and coordinated between various systems and project participants. Stanley and Thurnell (2014).further explains that in Level 2 all, parties use their 3D CAD models, and are not necessarily working on a single, shared model. The collaboration comes in the form of how the information is exchanged between different parties.

Results also revealed that 22 respondents were not involved in BIM, although some of them admitted to having heard of BIM but are still not up to speed with its concepts and principles. Ultimately, this put these respondents in BIM maturity level 0 which is defined by Stanley and Thurnell (2014) as a level of no collaboration which involves only 2D CAD drafting, using products such as AutoCAD which is used to create 2D drawings which can be shared via paper and/or electronic means or a mixture of both. All the respondents who were not involved in BIM stated their design workflow included AutoCAD for 2D drafting and documentation and this was supported by Stanley and Thurnell (2014).

From the interviews, it was also discovered that none of the respondents are involved in any kind of BIM training in their respective offices and this is a major setback because, for the mainstream adoption of BIM to be improved, training and education on BIM should be encouraged.

9 out of 22 respondents who do not use BIM said they have plans to adopt BIM shortly after more knowledge acquisition and skill training in the BIM field. 6 respondents expressed more interest and were willing to add to their existing knowledge on BIM and 7 respondents said their decision not to use BIM is their personal preference but will be open to new developments in the future.

Barriers to BIM Adoption by Architects in Ghana

Questions were asked to find out the barriers to the adoption of BIM by architects in Ghana. Some of the respondents stated that a low level of BIM awareness is a factor that hinders the adoption of BIM. Respondents further explained that BIM has gained roots in developing countries but in developing countries like Ghana, BIM adoption is low because of low public sensitization and awareness.

Some of the respondents said the lack of BIM training and education is a major barrier to BIM adoption. The respondents explained that BIM has become a technical aspect in the industry and requires training to fully grasp the concept and operations to practically implement and this supported Kiviniemi,

A. (2013) who states that the adoption and deployment of BIM have been hampered by a scarcity of properly trained professionals. Respondents also mentioned that the non-existence of BIM education in the architecture curriculum of architecture schools preferably in the first year. A respondent stated that integrating BIM education in the curriculum will improve awareness among students who will learn BIM at an early stage and subsequently apply it in future practice.

Some of the respondents (n=4) were of the view that since BIM is a technological advancement in the way buildings is designed, the older group of architects who lack the technological edge and know-how may find it a hassle to easily adapt to this new trend as compared to the younger group of architects who can easily adapt to new trends and technology.

Measures to Encourage the Mainstream Adoption of BIM by Architects

All respondents thought that to encourage the mainstream adoption of BIM by architects in Ghana, there should be a nationwide sensitization and awareness creation to expose architects to BIM and its concept. Some of the respondents mentioned that seminars and workshops on BIM could be organized to teach architects the core principles of BIM. Respondents also stated that architects can acquire essential skills through BIM training and education. Respondents were also of the view that BIM education should be integrated into the curriculum of architecture schools in Ghana to enable the emerging generation of architects to become exposed to BIM at the tertiary level which they can apply subsequently in their future architectural practice.

On the global scale, a respondent suggested that BIM software developers can promote the adoption of BIM through advertisements aimed at exposing the AEC industry to the concept of BIM. The respondent added in Ghana, the GIA and other stakeholders having known the significance of BIM could petition the Government of Ghana to invest in BIM. This would cover the cost involved in training, logistics, and software packages.

All respondents were of the opinion that the government of Ghana, the Ghana Institute of Architects (GIA), and tertiary institutions (specifically architecture schools) in Ghana should be the main promoters of BIM adoption in Ghana.

4. Conclusion

Based on the findings of the research, the following conclusions were made

Firstly, most architects are not using BIM to its fullest potential in the Ghanaian architecture industry.

Secondly, the barriers to the adoption of BIM within Ghanaian architecture include the lack of BIM experts and trained personnel, low level of BIM awareness and knowledge, poor technology edge on the part of some architects, and the lack of financial resources.

Lastly, the measures to encourage the mainstream adoption of BIM by architects in Ghana include the addition of BIM education to the tertiary curriculum in architecture schools, organizing seminars and workshops on BIM to train and educate unexposed architects, more awareness creation and public sensitization on BIM, Active involvement of the government of Ghana and GIA (Ghana Institute of Architects) as the main “pushers” of BIM adoption in the country through consensus and legislation

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