A Survey on the Status of Building Information Modeling's (BIM) Adoption and Implementation in Public Sector Construction Projects in Nigeria [1]

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ABSTRACT

The purpose of this study was to investigate the use, adoption, and implementation of BIM in public-sector construction projects. BIM and related technologies are required to improve construction projects. The study looked at the adoption and implementation of BIM in public sector construction projects in Port-Harcourt, Rivers State, Nigeria. The study used a survey research design method of investigation, and a convenient/purposeful sampling strategy was used to select a sample size of 317 from a population of 394. The data collection and measurement instrument consiseds of a questionnaire based on the Likert scale, as well as semi-structured interviews and personal observations. The Cronbach's alpha test was used to assess the survey's reliability. Statistical tools were used to display the results, which included frequency distributions, figures, and charts (IBM SPSS Statistics version 25).

According to the study's findings, BIM adoption and implementation rates in public sector construction projects are low. This is due to the fact that 41.63 percent of the 263 respondents had not deployed BIM, 33.91 percent were about to use or apply BIM, and 24.46 percent had already used or applied BIM. Approximately 63.09 percent of those polled had heard of BIM in the past, while 36.91 percent had never heard of it. According to the findings of this study, raising awareness among construction project stakeholders is necessary to effect a paradigm shift in accepting change and deploying the much-needed enthusiasm for adopting BIM and its procedures, as well as obtaining competent BIM professionals (literate).

Keywords: Adoption, building information modeling, construction projects, implementation, public sector, Port-Harcourt, Rivers State.

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INTRODUCTION

When BIM is considered, as Azhar (2011) explains, it provides the ability to meet certain objectives by simulating a construction project in a virtual environment. With this technology in place, it is expected that an accurate virtual model of a project will emerge, giving rise to what is known as a building information model. Once the project is completed, the BIM will display the geometric data and required data for supporting the design, procurement, fabrication, and construction of all project-related activities. BIM is defined as a tool for creating and managing building data through the use of computer-aided design (CAD) and information and communication technology (ICT) (Aladag, Demirdögen, & Isik, 2016). According to Gardezi, Shafiq, Nurudinn, Farhan, and Umar (2014), BIM is a digital model that incorporates the physical and functional characteristics of a proposed project in a digitally modelable form. The entire concept of BIM is to pre-stage the facility in a virtual format, well ahead of physical building construction, in order to prevent problems that could occur and impact the finished facility before it is even built. In terms of BIM applications, numerous different application options can be used in a wide range of project situations, allowing for the effective use of constructability analysis, scheduling, cost estimation, and sequencing (Gerges, Austin, Mayouf, Ahiakwo, Jaeger, Saad & El Gohary, 2017). Because it represents a major paradigm shift in the field of ICT, it has the potential to be integrated as a critical component for procurement into the construction project life cycle.

For the quality of the design document, the BIM user can increase coordination and improve communication among all involved parties, including but not limited to the design document, disciplines, and all project participants, reducing the number of errors and omissions. Furthermore, because all design documents have been thoroughly annotated with necessary design information, the improved design process ensures a more informed design environment and helps save resources on project implementation (not just materials, money, or time) (Migilinskas, Popov, Juocevicius & Ustinovichius, 2013). A BIM is a three-dimensional representation of space that includes various material property attributes as well as potential actors who can exchange and modify information. There was a time in the life cycle of a building when the goal of BIM usage was to show how the construction process would look. However, with the introduction of 3D digital models, the goal of BIM usage has shifted to being a tool to assist organisations in improving performance across all phases of the building life cycle (Aladag, Demirdögen, & Isik, 2016).

BIM has only recently emerged as a result of recent advances in information technology procedures. BIM was created to address the issue of low productivity in the building design and construction industry. The solution is viewed as a next-generation solution for expediting the process, with the expectation that it will simplify the delivery process of structures, manage and access building and facility information. Despite extensive research into the development of BIM, the adoption rate has been slower than expected. There are numerous contributing variables at work here and identifying them all is difficult. Although adoption barriers have been widely acknowledged, there is an urgent need to learn more about how they affect adoption and how they interact when considered together" (Walasek & Barszcz, 2017).

LITERATURE REVIEW

Though the concept of BIM began and evolved at Georgia Tech in the late 1970s, it has grown tremendously over the last few decades. The increased focus on construction businesses and construction teams that have discovered the value of adopting BIM is resulting in more efficient construction projects. In 2002, virtual design, construction, and facilities management were referred to collectively as BIM for the first time (Rokooei, 2015). ICT has arrived in the construction industry, bringing with it a slew of new challenges for consultants. The proliferation of interoperability platforms necessitates the use of model-based modelling in partner cooperation and collaboration. This collective model will better inform and modify the entire construction process to help improve buildings, reduce costs, shorten construction time, and increase productivity (Abdulmumin, Idi, Ibrahim & Muhammad, 2020). According to Lu et al. (2019), the growth of BIM in the business, building, design, policy, research, and management worlds has aided the global architectural, engineering and construction (AEC) industry. This is regarded as a strategic development, with governments all over the world looking to mandate its use in government projects.

The construction industry has traditionally used BIM for visualisation and organisation, but the goal of adopting BIM today is to increase overall project efficiency from start to finish (Aladag et al., 2016). Chuck Eastman, a BIM leader based at Georgia Tech, describes BIM as "a digital representation of the building mechanism used to promote information sharing and interoperability" (Lu et al., 2019). Large-scale projects, such as the completed London 2012 Olympic 6,000-seat velodrome and the 48-story Leadenhall Building known as The Cheesegrater, have all used BIM in way that Bryde, Broquetas, and Volm (2013) described. BIM is typically used for individual components of both small and large-scale projects. Another example is the recently opened new bus station in Slough, UK, where the modular stairs used in the design and construction were BIM designed and installed.

Although BIM is composed of software, it is also a method and software. BIM requires workflows and project management practises that rely on three-dimensional intelligent models (Azhar, 2011). BIM is a new term in the construction industry that promotes the inclusion of all project participants. It has the potential to increase productivity and cohesion among team members who have previously perceived themselves as adversaries (Azhar, 2011). BIM supports the modern project delivery method of integrated project delivery, which focuses on the human, system, and business structures and procedures that are used throughout a project's life cycle. According to Migilinskas et al., (2013), BIM has become the critical information modelling principle in the building industry. A third point worth mentioning is that firms have been working hard for several years to ensure that three-dimensional BIM with many dimensions is created to serve the construction sector (Okorie, 2021).

BIM's Application on Construction Projects

BIM can be represented as a virtual process, in which all elements, disciplines, and structures of a facility are combined to allow everyone on the design team to communicate more correctly and effectively (Azhar, 2011; Okorie, 2021). BIM encompasses several applications such as design collaboration, simulation of energy efficiency, scheduling and quantity take-off, conflict detection, and 3D visualisation. BIM is advantageous for the following reasons:

3D Coordination

According to Gong et al. (2019), engineering, procurement and construction (EPC) projects have high complexity and various cooperation challenges. BIM has shown the ability to increase collaboration between many fields, such as architectural design, mechanical, electrical, and plumbing, and project management. A BIM-based visual conference helps in multiple decision-making, scheme selection, and technical discussions. However, cooperation based on BIM networks, such as improving design and administration of resources, is also possible. During the planning and design stages, visualising the project in 3D is an essential part of BIM. BIM models have been deployed to efficiently convey vital information among construction specialists. In contrast, paper-based designs are difficult to integrate and coordinate. BIM helps to Design and combine 3D parts in the software to form a single model that presents different viewpoints of the model (Ismail, Drogemuller, Beazley & Owen, 2016).

Planning and Monitoring of Construction Processes

4D BIM is based on incorporating the timetable into the virtual architecture (Amade et al, 2018). The Critical Path Method (CPM) is commonly used in the creation of 4D BIMs. CPM activities are defined by their dependencies and lengths. Activities serve as either a predecessor or a successor to another activity, depending on the planned order of execution. According to Eastman, Teicholz, Sacks, and Liston (2011), 4D CAD construction planning entails linking the construction plan to the 3D artefacts in the design, allowing the construction to be simulated and displayed at any time. This visualisation depicts how the building is intended to look, as well as the various drawbacks and potential for change (site, crew and equipment, space conflicts, safety problems, and so forth). According to Gong et al. (2019), conventional construction planning frequently employs the CPM to plan out and manage the construction process. Other activity-based scheduling systems, such as the CPM, produce a tight building schedule. The construction schedule information can be expressed as on-site construction process patterns using 4D BIM in scheduling and planning in accordance with the IFC standard. Furthermore, it was claimed that modelling and simulation methods can be used in 4D BIM information systems or environments to visualise and evaluate construction schedules by incorporating a "set of entities" that collaborate to achieve a goal.

According to Han and Golparvar-Fard (2015), the availability of reality capture technologies has increased interest in improving the construction of visual sensing data. Two basic types of visual sensing data collection predominate in progress tracking. They also stated that the laser scanning method is currently the most popular way to obtain 3D reality. The accuracy of high-end laser scanners ranges from 3 to 6 mm. As building applications evolve, so does the use of progress monitoring functions in laser-scanned models. A laser scanner's point clouds are frequently blended into an integrated model. Progress deviations are identified by comparing a combined 3D as-built model to the Plan BIM. The proliferation of point-and-shoot and time-lapse cameras, as well as smartphones, has greatly increased the number of photos taken on construction sites, as well as as-built construction process records in digital format (Han & Golparvar-Fard, 2015).

Visualization

BIM implementation has several benefits, according to Zahrizan, Ali, Haron, Marshall-Ponting, and Hamid (2014). Creating a three-dimensional model helps everyone involved in construction projects obtain a better idea of what they are constructing. In addition, they mentioned that mechanical, electrical, and plumbing (MEP) designers have to use collision detectors, which need time without visualisation tools. Visualization can be thought of as visual mental pictures that are utilised to create, perceive, and modify spatial information. Information analysis is most useful in extracting data insights. BIM amplifies the perspective of the construction plan, as stated by Gong et al. (2019). They also described 4D visualisations as "simple representations of project production and can be used by a wider variety of project participants." Overlaying 2D plan drawings to visualise the location of the system components in 3D space is historically how collision detection is conducted. Using 3D parametric modelling, however, this activity may be completed in a short period of time and is more effective compared to the traditional way. BIM's visual design allows all stakeholders to obtain critical information, including residents, service agents, and maintenance workers. BIM visualisation may be used to cooperate, communicate, and represent data.

Prefabrication

According to Abbasnejad and Moud (2013), the design proficiency of the BIM model means that prefabrication is more likely to work. As a result, construction can be carried out off-site, which is cost-effective and controlled, and built efficiently. With BIM, the greatest chance to increase construction practises is prefabrication, as stated by Jackson (2010). A well-coordinated BIM model lets each project region be reviewed and optimised separately. Prefabrication procedures for delivering project components may be explored by the contractor, particularly those that are repeated. Prefabrication produces better quality and reduced prices. Although Azhar (2011) reaffirmed that prefabrication capabilities would be widely employed to cut costs and improve quality of work, it was projected that the industry's adoption of prefabrication would expand over time. They (Eastman et al., 2011) highlighted that BIM platforms must allow parametric and flexible parts and relationships as well as handle and import building model data from BIM building design platforms. In addition, good model visualisation and export data information should also be provided in accessible formats for machine manufacture.

Cost Estimation

According to Diaz (2016), project managers should have numerous take-offs in order to collect data and to know a range of options over the life of the project. Due to the database-to-BIM model intersection, the exact calculation can be completed significantly faster. Additionally, procurement-wise, these take-off items are conveniently utilised. BIM will make it easier for a quantity surveyor to compute project costs and materials in a quicker period, resulting in a potential 80% reduction. BIM's capacity to supply information on length, width, and volume, as well as information about the material of doors, windows, and finishes, is one of the primary advantages mentioned by Franco, Mahdi, and Abaza (2015). Each item can be given a cost, which may then be used to calculate a rough approximation of the material costs (Abbasnejad & Moud, 2013). This offers a simple way to do design value engineering. Recall, though, that project price would also require the cost estimator/expertise engineer's.

Collaboration and Team Cohesion

Fragmentation is inherent to the construction industry's structure and customer base. Industry practise is to unite interdisciplinary workers on a project which requires a great lot of teamwork and collaboration (Ren, 2011). BIM in construction projects is highly dependent on cooperation and team cohesiveness (Rokooei, 2015). Experts from various projects come together to form a unified approach. Team building and cohesion are produced. In order to build a successful relationship, everyone must work together in accordance with the BIM principle. BIM is helping firms in the AEC sector form new business partnerships. BIMs claim to promote integration, interoperability, and cooperation (Ren, 2011).

Record Model

Construction managers might provide a BIM document to the building owner (Hergunsel, 2011). As-built subcontractors are included in the model, each object property can be included in the model's linkages. Facility department can use centralised databases to find details rapidly. After the scheme is completed, building managers will be able to give clients with a BIM record. The section incorporates the assimilated subcontractors. Moreover, object properties might include relationships to submissions, procedures, and preservation, while also specifying guarantees. A service desk should support the data bank for simple information discovery. The successful model is often used for additional lighting, hazard power, way out, fire alarm, fire extinguishers, smoke detectors, and sprinkler categories.

Operations and Maintenance

One of the fundamental incentives for the usage of BIM, as Jackson (2010) claims, is the project's "cradle to grave" duty for maintaining and operating the project after completion. At the time the building engineer takes control of the project, the "as-designed" record of the constructed project is up-to-date and accurate. Not only that, it is able to tie project information to equipment and maintenance manuals used by plant staff.

Clash and design error detection/investigation

"Clash detection" is like a "spellcheck" for construction components. Unexpected material or system interference in a 3D project model is successfully discovered, inspected, and alerted (Jackson, 2010). Conflict arises when pieces of distinct models occupy the same region, encounter conflicting parameters, or display an inaccurate sequential construction process time series (Lu et al., 2019). However, this feature is designed to pay special attention, as it has widespread use and immediate effects. BIM models are designed on a scale and almost always in 3D space, so all important structures may be evaluated for interference, check that no steel columns, ducts, or walls connect with the pipe process (Azhar, Nadeem, Mok & Leung, 2008).

The vast majority of difficulties are found when the contractor receives design sketches and everyone is there and working. In order to deliver a permanent solution, decisions and delays must be minimised. BIM allows one to identify problems before construction and to remedy them prior to construction.

BIM's status in terms of its implementation and adoption on construction projects.

Despite the low rate of BIM adoption among major large-scale Chinese contractors in 2012 (Li, Ng, Tong, Skitmore, Zhang, & Jin 2017), a 2014 survey conducted by the Shanghai Construction Trade Association (SCTA) and Luban Consulting discovered that 67 percent of construction firms nationwide had begun BIM practices, and more than 10% of customers had used BIM in more than half of their projects by the end of 2014. Increased BIM adoption in China's AEC industries could be a result of recent government regulations and industry standards. According to Li et al, (2017), China's recent BIM-related government policy movements have made significant strides in announcing the vision for digitization, publishing the first edition of the BIM standard in 2012, outlining strategic goals and a detailed timeline for BIM implementation in 2013, and proposing the use of BIM throughout the project life cycle.

Mehran (2016) states that the Dubai Municipality (DM) is the first body in the UAE to oversee BIM adoption. In May 2014, the municipality mandated the use of BIM in structures with more than 40 stories or 300,000 square feet, as well as government programmes. Despite the fact that the BIM design is not new, it dates all the way back to the 1970s in the aerospace and manufacturing industries. On the other hand, BIM began to appear in UAE construction projects in the mid-2000s. Though BIM technologies have been used in a variety of countries since the early 1980s, according to Gamil and Rahman (2019), some countries have yet to consider or understand the significant benefits of incorporating BIM into project delivery and execution, and the interference of socio-technical issues that undermine BIM implementation exacerbates existing issues. Yemen is one of the countries that has yet to establish or initiate a policy or programme promoting the use of BIM in construction projects due to a variety of barriers and impediments (Gamil & Rahman, 2019).

While Appiah (2020) argued that developing countries such as Ghana face a number of challenges, including a lack of awareness of BIM, a lack of standards, little or no government support, an unclear legal status for BIM, a lack of expertise, limited financial resources, unclear BIM benefits, and software, hardware, and internet issues, to name a few. He also stated that the private sector in Ghana is steadily leading the way in terms of BIM adoption, albeit slowly, as a result of the Public Procurement Act, which favours the traditional procurement system. Architects, for example, are more likely than other professionals to use BIM for civil and infrastructure projects. According to Mosse, Kabubo, and Njuguna (2020), Kenya's goal is to achieve newly industrialised middle-income status by 2030. This can be accomplished through the implementation of programmes and practises that promote long-term resource management. In Kenya, ICT innovation fosters accountability, assisting in the fight against corruption. Unfortunately, cartels are corrupt. They reported that government entities such as the Nairobi City County (NCC) are falling behind the curve in terms of ICT adoption, despite the fact that they have adopted 2D drawings and digital approvals but not BIM. In Kenya, the private sector is driving BIM adoption, although slowly. Along with the difficulties, there is a lack of comprehension and no implementation strategy for building sector leaders (Okorie, 2021).

Akerele and Etiene (2016) conducted a study in Nigeria to determine the level of awareness of BIM use among professionals in the Nigerian building construction industry across the design, construction, and post-construction stages of a project. The findings indicated that professionals in the Nigerian construction business have a limited understanding of how to effectively use BIM. In a similar report, Abdulmumin et al. (2020) examined the level of knowledge of BIM tools and the extent to which these tools are employed by construction consultants in Abuja, Nigeria. The study discovered a lack of BIM understanding, which contributed to the slow adoption of BIM. Another analysis of BIM awareness in the Nigerian construction industry, more precisely in Kaduna State, Northwest Nigeria (Ryal-Net & Kaduma, 2015), revealed that stakeholders in the Nigerian construction industry have a low level of BIM knowledge. As a result, it is critical for Nigeria's construction industry, which has been dubbed a "sleeping giant" and accused of lacking production capacity due to inefficiency and poor service delivery, among other issues, to leverage the widely lauded benefits of BIM and achieve the continuous improvement expected by its core players (Abubakar et al., 2014; Kori & Kiviniemi, 2015). Despite its obvious benefits, little information about its implementation in the Nigerian construction industry has been released.

RESEARCH METHODOLOGY

A descriptive survey design was used in the research. Descriptive survey research design, as seen by Sekeran (2010), is a sort of design used to acquire information on the current status of the phenomena in order to explain "what existing." descriptive research design was employed to facilitate gathering, summarising, presenting, and interpreting material for clarity reasons. In the case of circumstances when the borders between the subject of study and the background are unclear, and where inquiry involves “how” and “why” of present occurrences the investigator cannot influence. This study was tailored to get the most useful information on the use of BIM in Nigeria. The study's primary focus was on public sector workers in Port-Harcourt, Rivers State, Nigeria consisting of construction project managers, architects, quantity surveyors, engineers, and project supervisors in the research area have been studied.

Research samples must satisfy two main criteria according to Somekh and Lewin (2004). What is your first question? And, who would you like to learn about? Krejcie and Morgan's sample size determination approach was utilised to choose respondents from the survey, utilising these suggestions (Krejcie & Morgan, 1970). This was preferable since it lets the researcher identify responders who possess the requisite expertise of the issue in question. Additionally, given the nature of the sector, the study included experts who had the knowledge and competence to engage in the study on the basis of their class and experience. Five (5) construction businesses headquartered in Port Harcourt, Rivers State, with a population of 394 practitioners were hired for the study. The population was used to satisfy the demands of the Krejcie and Morgan approaches arriving at a sample size of 317 respondents.

Data collection was done via questionnaires. The Likert scale was employed to measure respondents' views as advised by Kothari (2004). The questionnaire was divided into two sections: in the first section, demographic characteristics of the target group were collected, i.e. age, industrial experience, education level, etc., while the primary questions raised in the study question were identified in the second area. The content of the questionnaire was determined by the investigator seeking the opinions of experts in the field of study, in particular some senior academics and professors at the university. Validity refers to the degree to which data analysis and data collection procedures are reliable, truthful and impartial (Saunders, Thornhill & Lewis, 2009). It is important to ensure that it has some validity before using a research tool. Cronbach's alpha was used to verify the reliability of the instrument on the basis of the reliability of the internal accuracy of the test instruments. Cronbach's alpha was created for the key themes in the questionnaire, which formed the test scale for the reliability of the questionnaire.

The data used both primary and secondary sources. The primary data consisted of open-ended and closed-ended questionnaires. Secondary data was acquired from scholarly journals and research papers. Work satisfaction can be measured by surveying or interviewing the population as specified by Somekh and Lewin. On the whole, questionnaires are used for work satisfaction research. To aid in making clear recommendations, answers were provided that were more structured. Descriptive and inferential statistics were generated using the IBM Statistical Package for Social Sciences (SPSS) version 25.0. Frequency distribution and descriptive statistics were adopted in evaluating and analyzing the data collected.

RESULTS AND FINDINGS

The participants in the study are 394 construction workers from Port-Harcourt, Rivers State-based construction enterprises. Using the Krejcie and Morgan sampling methods, a sample size of 317 was obtained from the construction firms. A total of 265 questionnaires were retrieved, while about 233 of them were found useable for further analysis.

The Cronbach alpha test was used to examine the test's capacity to yield consistent and stable measurements over time. From the highlights of the different construct categories' internal consistency through IBM SPSS Statistics version 25, high alpha frequency of 0.892 indicates that the measured item is a latent concept (Sekeran, 2010). Cronbach's alpha values vary from 0 to 1, with 0 being the weakest and 1 being the greatest. Alpha values for this range are as follows: $0.9 \geq 0.9$ exceptional; $0.9 > 0.8$ good; $0.8 > 0.7$ acceptable; $0.7 > 0.6$ dubious; $0.6 > 0.5$ terrible; $0.5 < 0.5$ bad. The data for this study were found to be reliable judging from the outcomes of the Cronbach's alpha coefficient values of 0.892.

The questionnaire initially covered the characteristics of the respondents in relation to their field, years of industry experience, qualifications, project type, and knowledge of BIM principles, as applicable to the industry. Figure 1 shows that 48 (20.60%) of respondents were architects, whereas 53 (22.75%) were builders, 42 (18.03%) were project managers, 35 (15.02%) were engineers, 34 (14.59%) were quantity surveyors, and 21 (9.01%) of the respondents are "others."

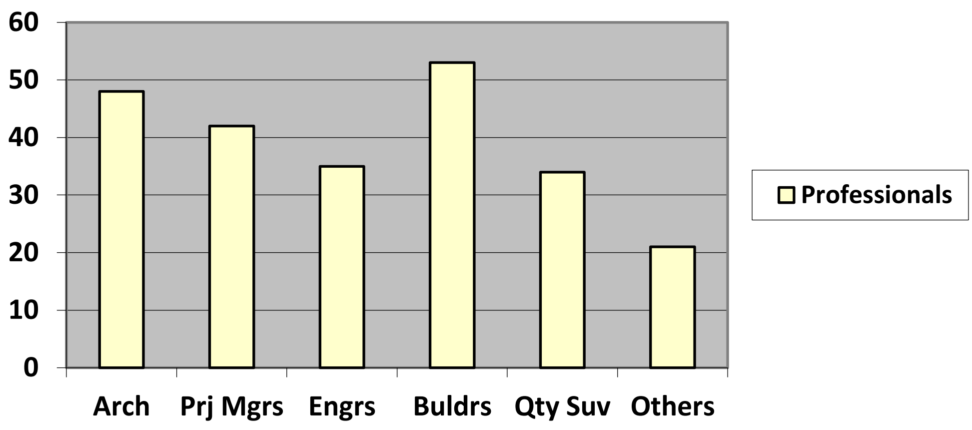

Figure 1: Professional's discipline

Figure 2 depicts the experiences of industry respondents. Twenty-eight percent of respondents spent between one and five years in the industry, while a quarter of respondents spent between six and ten years in the sector.

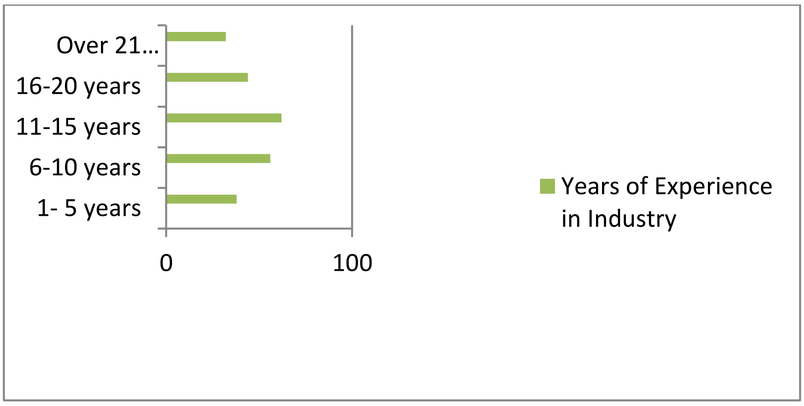

Figure 2: Respondent's years of experience in the industry

Based on the following graph, over two hundred (87.55%) of the professionals held B.Sc./B.Tech./B.Eng degrees. While (10.3%) has an MBA/M.Tech/M.Sc as qualification. And (2.15%) held a Ph.D as an academic qualification.

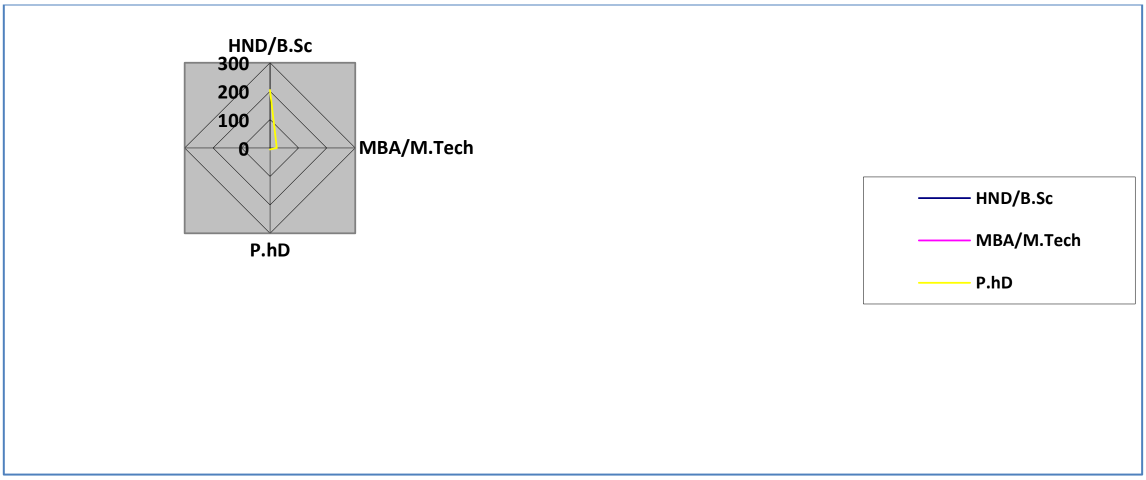

Figure 3: Respondent's academic qualification

In Figure 4, the construction sector is the context for considering how knowledge of BIM applies to the industry. A total of 147 (63.09%) of the population have heard of BIM, whereas only 86 (36.91%) of the population have not heard of it.

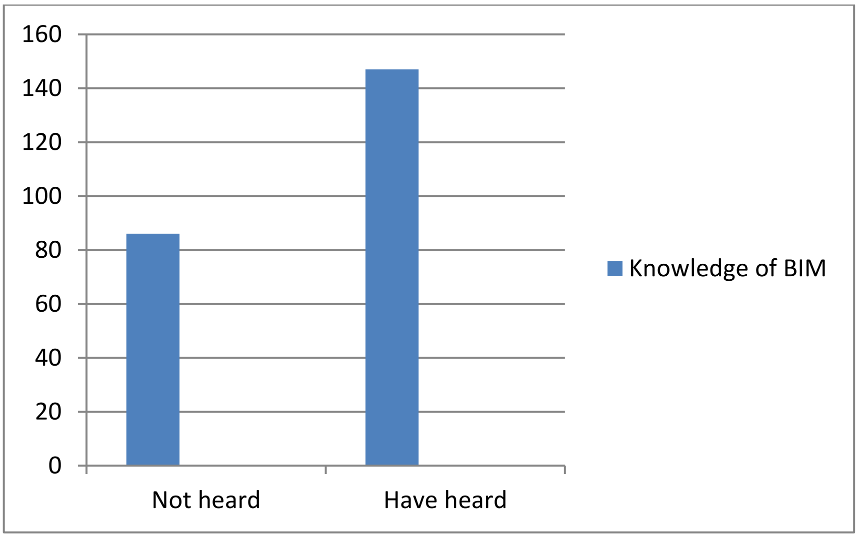

Figure 4: Knowledge of BIM

The diagram below illustrates the global implementation of BIM inside the organisation shown in Figure 5. The percentage of companies that have not used BIM recently is around 97 (41.63%), with the percentage of companies about to apply BIM being 79 (33.91%), and the percentage of companies who have been using BIM in the past is approximately 57 (24.46%).

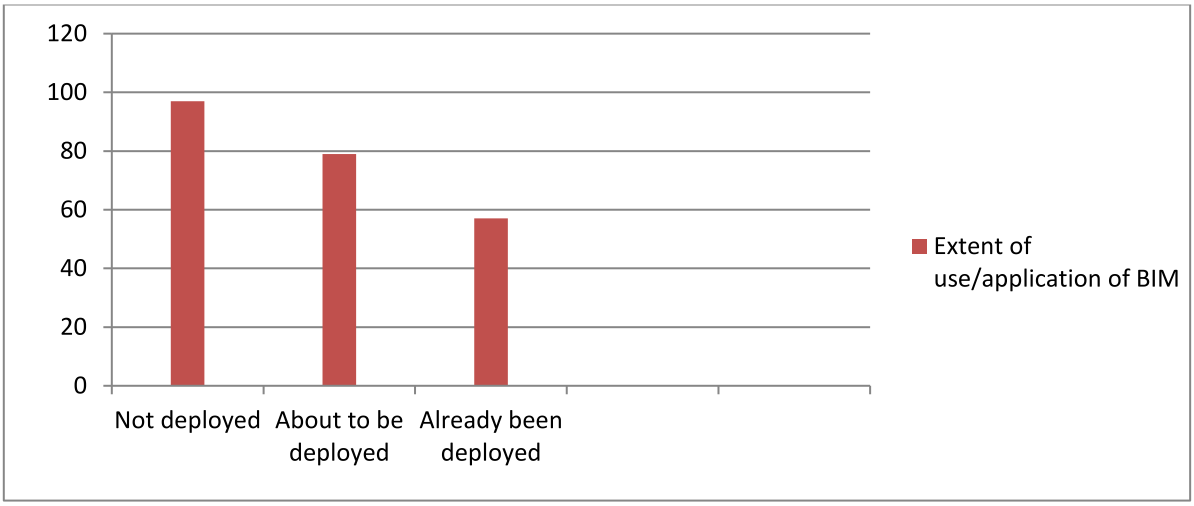

Figure 5: Extent of use/application of BIM

Discussion of findings

Cronbach's alpha was used to determine the accuracy of each BIM question item and its application to the adoption and execution of BIM in building projects. The Cronbach alpha coefficient was an important tool for determining the reliability and validity of the data. The internal consistency of various types of objects related to the adoption and execution of public sector construction projects resulted in a total of 0.892. As a result of this exercise, there is a strong indication that the instrument is accurate, as well as a good confirmation of internal consistency. In summary, this is consistent with Guar and Guar (2009) and Pallant (2005)'s recommendation of a Cronbach's Alpha Reliability Ratio of 0.6 to 0.7 as a suitable upper limit for further research.

According to the responses, 147 (63.09 percent) of the participants have heard of BIM in the past, whereas 86 (36.91 percent) have not. Though the researchers discovered that the effects of BIM are extensive, they attribute this to a lack of understanding of what BIM actually accomplishes. One possibility is that many respondents have not heard of BIM because they were unaware that it is a project management tool designed to help ensure that previous errors created during the life of the previous project do not reappear on the intended project. As a result, BIM is an extremely important project management tool, and immediate action should be taken to inform project managers and others about it. The lack of distinct characteristics in the work produced can be attributed to the lack of Nigerian BIM literature. Regarding the previous level of BIM-related activity deployment, 41.63 percent of respondents have not currently implemented BIM, while a third of respondents (33.91 percent) plan to deploy BIM in the near future, and nearly a quarter of respondents (24.46 percent) have already deployed BIM in the past. These findings support the notion that the majority of respondents did not use BIM in their project delivery procedures. It is also important to note that the majority of survey respondents were unaware that they were unintentionally using BIM. However, because they are using alternative methods to manage some of their project management issues, they may be unaware of the extent to which they are using BIM. Other possible explanations for the low level of BIM deployment in public sector building projects include statements by Abubakar et al. (2014), Kori and Kiviniemi (2015), who claim that Nigeria's construction industry, dubbed a "sleeping giant," lacks the capacity to create due to inefficiency and poor service delivery. While it is true that this assumption had no impact on the construction industry because the majority of projects had short timelines and associated constraints, this conclusion was unexpected because projects are rarely continuous and frequently have blockages.

CONCLUSION AND RECOMMENDATIONS

The overall goal of the study was to analyse the acceptance and implementation of BIM in the construction projects of the Nigerian public sector. This study explicitly identified the status of BIM, based on whether it is being used or implemented in public sector construction projects. Finally, the study presented credible solutions that will aid the overall adoption and implementation of BIM in public sector construction projects in Port Harcourt, Rivers state, Nigeria. To ascertain the progress of BIM adoption and implementation in public sector building projects in Port Harcourt, Rivers State, the study began by identifying which projects were currently under development in the city. Out of the two hundred thirty three (233) responses on whether the respondents have deployed BIM in the delivery of their construction projects, 41.63 percent stated that they have not implemented it in the past, while 33.91 percent said that they will be deploying it soon, while 24.46 percent stated that they have already been implementing it. To find out if the survey respondents had any understanding of BIM, the study aimed to uncover their findings. The study indicated that 63.09% of respondents had heard of BIM in the past, whereas 36.91% had not.

There is a requirement for a concentrated effort to develop information that is made available through BIM awareness-raising among building project stakeholders in the Nigerian construction industry. BIM is a life-saving programme, and so a large amount of data needs to be produced through many avenues, such as workshops, conferences, and association meetings, in order to enhance BIM awareness and encourage acceptance of the important shift that BIM has brought about. To successfully deploy BIM-based building projects, the efficient utilisation of BIM equipment is required. Because it's been shown to foster the return of the spirit of building, including BIM and its techniques should be given proper care and emphasis in order to encourage and embrace BIM adoption. Finally, it is imperative to ensure that experienced BIM (literate) professionals are able to contribute to the expansion of Nigeria's construction industry by ensuring that professionals employ contemporary BIM tools and techniques to compete in the construction market.

REFERENCES

Abbasnejad, B. & Moud, H. I. (2013). BIM and basic challenges associated with its definitions, interpretations and expectations. *International Journal of Engineering Research and Applications (IJERA), 3*(2), 287-294. www.ijera.com.

Abdulmumin, U.S., Idi, M. A., Ibrahim, I. M. & Muhammad, A. A. (2020). Awareness level of building information modeling tools to construction consultants in Abuja, Nigeria. *International Journal of Latest Technology in Engineering, Management & Applied Science*. *9*(I), 72-77.

Abubakar, M., Ibrahim, Y. M., Kado, D. & Bala, K. (2014). Contractor's perception of the factors affecting building information modelling (BIM) adoption in the Nigerian construction industry. Computing in Civil and Building Engineering ©ASCE 2014, 167-178.

Akerele, A. O. & Etiene, M. (2016). Assessment of the level of awareness and limitations on the use of building information modeling in Lagos State. *International Journal of Scientific and Research Publications, 6* (2), 229-234. www.ijsrp.org.

Aladag, H., Demirdögen, G. & Isık, Z. (2016). Building information modeling (BIM) use in Turkish construction industry. *Procedia Engineering*, *161* (2016), 174 – 179. doi: 10.1016/j.proeng.2016.08.520.

Amade, B., Onwuka, U.S., Oguzie, J.O.C., Umoh, E.D. & Uduma, P.N. (2018). Building information modelling and its application in building construction projects. *PM World Journal*, *7*(12), 1-21. (December).

Appiah, B. L. (2020). Assessment of building information modeling (BIM) awareness, knowledge and its adoption in the Ghanaian construction industry. *Journal of Civil, Construction and Environmental Engineering*, *5* (6), 138-150. doi: 10.11648/j.jccee.20200506.11.

Azhar, S., Nadeem, A., Mok, J. Y. N. & Leung, B. H. Y. (2008). Building information modeling (BIM): a new paradigm for visual interactive modeling and simulation for construction projects. *First International Conference on Construction in Developing Countries (ICCIDC–I) "Advancing and Integrating Construction Education, Research & Practice" August 4-5, 2008, Karachi, Pakistan.*

Azhar, S. (2011). Building information modelling (BIM): Trends, benefits, risks, and challenges for the AEC industry. *Leadership and Management in Engineering, 11*(3), 241-252.

Bryde, D., Broquetas, M. & Volm, J. M. (2013). The project benefits of Building Information Modelling (BIM). *International Journal of Project Management, 31*, 971–980. www.elsevier.com/locate/ijproman. http://dx.doi.org/10.1016/j.ijproman.2012.12.001

Diaz, P. M. (2016). Analysis of benefits, advantages and challenges of building information modelling in construction industry. *Journal of Advances in Civil Engineering*, *2*(2), 1-11. http://dx.doi.org/10.18831/djcivil.org/2016021001.

Eastman, C., Teicholz, P., Sacks, R. & Liston, K. (2011). BIM handbook: a guide to building information modeling for owners, managers, designers, engineers, and contractors. 2nd Edition: John Wiley & Sons, Inc. Hoboken, New Jersey.

Gamil, Y. & Rahman, I.A.R. (2019). Awareness and challenges of building information modeling (BIM) implementation in the Yemen construction industry. *Journal of*

Engineering, Design and Technology, 1-9© Emerald Publishing Limited. DOI 10.1108/JEDT-03-2019-0063.

Gardezi, S.S.S., Shafiq, N., Nurudinn, M.F., Farhan, S.A. & Umar, U.A. (2014). Challenges for implementation of building information modeling (BIM) in Malaysian construction industry. *Applied Mechanics and Materials, 567*, 559-564. doi:10.4028/ www.scientific.net/AMM.567.559.

Gerges, M., Austin, S., Mayouf, M., Ahiakwo, O., Jaeger, M., & Saad, A. (2017). An investigation into the implementation of building information modeling in the Middle East. *Journal of Information Technology in Construction (ITcon), 22*(2), 1–15. Retrieved from http://www.itcon.org/2017/1.

Gong, P., Zeng, N., Ye, K. & König, M. (2019). An empirical study on the acceptance of 4D BIM in EPC projects in China. *Sustainability*, *11*, 1316, 1-19. Doi:10.3390/su11051316. www.mdpi.com/journal/sustainability

Hannele, K., Reijo, M., Tarja, M., Sami, P., Jenni, K. & Teija, R. (2012). Expanding uses of building information modeling in life-cycle construction projects. *Work 41 (2012)*, 114-119 DOI: 10.3233/WOR-2012-0144-114. IOS Press.

Han, K. K. & Golparvar-Fard, M. (2015). Appearance-based material classification for monitoring of operation-level construction progress using 4D BIM and site photologs. *Journal of Automation in Construction*, 1-23. http://dx.doi.org/10.1016/j.autcon.2015.02.007

Hergunsel, M. F. (2011). Benefits of building information modeling for construction managers and BIM based scheduling. A Master's Thesis of the Worcester Polytechnic Institute.

Jackson, B. J. (2010). Construction management jump start. 2nd Edition: Wiley Publishing, Inc. Indianapolis, Indiana.

Kori, S.A. & Kiviniemi, A. (2015). Toward adoption of BIM in the Nigerian AEC industry; context framing, data collecting and paradigm for interpretation. 9th BIM Academic Symposium & Job Task Analysis Review, NIBS-Washington DC, USA, 7-8 April.

Kothari, C. K. (2004). *Research methodology: methods and techniques*. (2nd revised ed.). New Delhi, India: New Age International Publishers.

Krejcie, R.V. & Morgan, D.W. (1970). Determining sample size for research activities. *Educational and Psychological Measurement, 30*, 607-610.

Li, J., Greenwood, D. & Kassem, M. (2019). Blockchain in the built environment and construction industry: A systematic review, conceptual models and practical use cases. *Automation in Construction*, *102*, 288-307. https://doi.org/10.1016/j.autcon.2019.02.005.

Li, H., Ng, T., Tong, S., Skitmore, M., Zhang, X. & Jin, Z. (2017). Barriers to building information modelling in the Chinese construction industry. Proceedings of the Institution of Civil Engineers: Municipal Engineer, 170(2), pp. 105-115. https://eprints.qut.edu.au/106988/.

Lu, W., Lai, C.C. & Tse, T. (2019). *BIM and big data for construction cost management*. 2 Park Square, Milton Park, Abingdon, Oxon New York, NY 10017: Routledge 711 Third Avenue.

Mehran, D. (2016). Exploring the adoption of BIM in the UAE construction industry for AEC firms. *Procedia Engineering*, *145*, 1110–1118. doi: 10.1016/j.proeng.2016.04.144. Available online at www.sciencedirect.com.

Migilinskas, D., Popov, V., Juocevicius, V. & Ustinovichius, L. (2013). The benefits, obstacles and problems of practical BIM implementation. *Procedia Engineering*, *57*, 767–774. doi:10.1016/j.proeng.2013.04.097.

Mosse, H. N., Kabubo, C. & Njuguna, M. (2020). Underlying factors guiding Building Information Modelling (BIM) adoption in Nairobi, Kenya. *Journal of Sustainable Research in Engineering*, *6*(2), 36-46. http://sri.jkuat.ac.ke/ojs/index.php/sri.

Okorie, E. C. (2021). An investigation into the adoption of building information modeling in Nigeria's public sector construction projects. A Master's Thesis of the Federal University of Technology, Owerri, Nigeria.

Pallant, J. (2005) "SPSS Survival Manual: A Step by Step Guide to Data Analysis using SPSS". *Published by Allen & Unwin, and Printed by Ligare, Sydney. www.allenandunwin.com/spss.htm*.

Ren, Y. (2011). Building information modeling integrated with electronic commerce material procurement and supplier performance management system. Master's thesis of the University of Maryland, College Park.

Rokooei, S. (2015). Building information modeling in project management: necessities, challenges and outcomes. *Procedia - Social and Behavioral Sciences, 210*, 87 – 95. Doi: 10.1016/j.sbspro.2015.11.332.

Ryal-Net, M.B. & Kaduma, L. A. (2015). Assessment of building information modeling (BIM) knowledge in the Nigerian construction industry. *International Journal of Civil & Environmental Engineering, 15* (6), 60-69.

Saunders, M., Thornhill, A. & Lewis, P. (2009). *Research methods for business students*. (5th ed.). England: Pearson Education Limited.

Sekaran, U. (2010). Research methods for business: A skill building approach (5th ed). New Jersey: John Wiley and Sons.

Somekh, B. & Lewin, C. (2004). *Research methods in the social sciences*. London: SAGE Publications Inc.

Walasek, D. & Barszcz, A. (2017). Analysis of the adoption rate of Building Information Modeling [BIM] and its Return on Investment [ROI]. *Procedia Engineering, 172,* 1227–1234. doi: 10.1016/j.proeng.2017.02.144.

Zahrizan, Z., Ali, N. A., Haron, A. T., Marshall-Ponting, A. & Hamid, Z. A. (2014). Exploring the barriers and driving factors in implementing building information modelling (BIM) in the Malaysian construction industry: a preliminary study. *Journal – The Institution of Engineers, Malaysia, 75*(1), 1-10.

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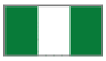

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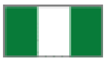

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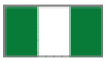

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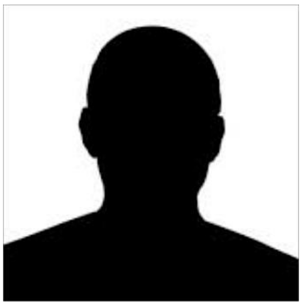

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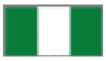

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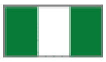

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