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Appraisal of The Use of Building Information Modelling (BIM) in the Construction Project Planning in Lagos State, Nigeria

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ABSTRACT

Sustainability is a critical issue in global urbanisation which has a huge impact on the construction environment. The quest for sustainable processes is changing the way construction is been managed globally. The search for better effective tools in construction project management has brought about the use of Building Information Modelling (BIM) in construction project planning. The role of BIM is like that of the project manager, who coordinates the management of construction projects. This study investigated the level of the use of BIM as a construction project planning tool and the factors responsible for its use in Lagos State, Nigeria towards finding ways of enhancing effective and sustainable construction project planning techniques in Nigeria. The study also examined the processes of construction project management and how BIM fits into the process. The study adopted a pragmatic research technique that uses both qualitative and quantitative research approaches. Qualitative (secondary) data were extracted from literature and analysed by content analysis. While quantitative (primary) data were gathered with a structured questionnaire. The primary data were collected from 132 construction professionals in the study area. The data collected was to evaluate their level of awareness and use of BIM as a planning tool during the construction stage of projects. The result was presented using descriptive approach with the aid of charts and tables. The study outcome shows that the use of BIM has mostly been applied in design, drafting and management. The study also identified three main factors that influence the use of BIM in the study area. The factors are: the high cost of BIM software; the lack of cooperative use of BIM by all professionals involved in a construction project; and the low existing level of technological know-how in the construction industry which does not enable professionals to get the full value of BIM. The study recommends that investment and training in the construction industry in the study should be focused more on the implementation of cutting-edge technology in construction processes to better harness the technical and the long-term cost benefits of BIM.

Keywords: Building Information Modelling (BIM), pr oject planning, sustainability, Lagos State Nigeria.

1. INTRODUCTION

Building Information Modelling Technology (BIM) and sustainability are current trends in building construction. The basic concept of sustainability is managing the natural or environmental resources presently available with the development of the future in mind, trying to prevent things like economic recession, environmental pollution, poverty, or worse total lack of natural resources (Lafarge, 2019). BIM refers to a form of modelling technology which makes use of computers to achieve holistic information management of a project. BIM focuses on production information, effective communication and design analysis (BIM Handbook, 2008). The origin of BIM can be traced back to the 1970s in Georgia Institute of Technology where the idea was developed. It quickly grew into an acceptable concept when professionals using BIM for design and construction management got high commendable results. One of the software at that time was ArchiCAD made by Graphisoft back in 1986. ArchiCAD was an introduction into the virtual building interface, which was made of 3-dimensional (3D) components of the given project (Dey, 2010). However, BIM got its major popularity from the Autodesk release of the "Building Information Modelling" (Autodesk, 2013). Now, BIM has been used in various ways, achieving remarkable possibilities in building construction and is seen as an effective tool for sustainable construction. BIM has significantly influenced the standards for construction management in current times, setting new skill requirement for project managers (Baoping, 2011). It is on this basis that this study aimed at investigating the level of the use of BIM as a construction project planning tool and identifying the factors responsible for its use in Lagos State, Nigeria towards finding ways of enhancing effective and sustainable construction project planning techniques in Nigeria. This study is a source of empirical data to the wider band of knowledge. Its findings will be useful indicators to foster better integration of BIM in construction, as it is a key tool in achieving sustainable construction projects.

2. LITERATURE REVIEW

BIM would be best appreciated in the construction and project management field where it is most likely to have long term applications, beginning with the design stage to the construction stage and to after the construction stage. This is when the building is being used, which is referred to as maintenance stage.

2.1 BIM as a Project Management Tool.

In building projects, there are various issues the project manager faces and BIM can play an essential role in addressing these issues. The issue of constructability can be handled by introducing BIM from the initial stages of design down to the construction process, as BIM can help teammates review the issues related to constructability with visual information, making it easier to make further investigation and make different information-based simulation to find solutions to issues before moving to site. Lahdou & Zetterman (2011) identifies the advantage of BIM tool in project analysis amongst the project managers, designers and engineers in making well-informed decisions by linking appropriate tools to the BIM to evaluate proposed energy consumption during and after construction. It also serves as basis for making good decisions concerning orientation, material, mass, etc. One of the most occurrent problem in construction is the geometric design inconsistencies in the plans of the different disciplines involved. This causes an overlap and clash in use, services or construction method in the different drawings. BIM can be used for resolving these clashes by bringing the plans together to detect them in a process called clash detection. BIM facilitates collaboration throughout the entire project lifecycle through a more effective communication chain. Online communication eliminated that traditional line of communication, giving rise to a means of communication that requires less manpower. Rather there is a shift from an individual party record of data work method to a merged database work method (see figure 1).

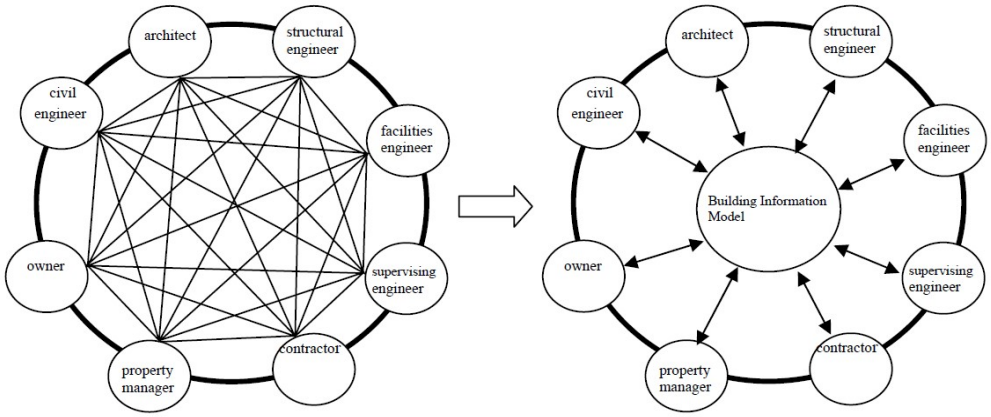

Figure 1: The Role of Building Information Models in the Communication Chain

Data provided from consultants from the different discipline and stockholders on the project is fed into the model and requires proper management. This aids better cooperation among teammates which is an important factor in successful BIM execution. Collaborative work and good teamwork were also amongst the non-technical benefits of BIM identified by Rokooei (2017). Integrated project delivery (IPD) is one of the most significant contributions of BIM (Fajana, 2017). The American Institute of Architects (AIA) refers to IPD as: "a project delivery approach that merges people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to optimize project results, increase value to the owner, reduce waste and maximize efficiency through all phases of design, fabrication and construction". The major objective of IPD is to get the most value out of any project. By uniting the interest of all the parties involved, design and planning decisions are taken as a team thereby reducing instances of non-satisfactory work that will have to be corrected and a more effective approach to management based on shared information (Fajana, 2017).

2.2 BIM solutions in project planning

Project planning is a very important phase in project management where essential information data is made to achieve satisfactory completion of any project. The essential data made includes every action required to describe, develop, merge and sort out all necessary plans. In the project planning stage, three tools are very important which are, budgets, schedules and communication plan, as shown in figure 2.

Figure 1: stages in project management

This paper focused on BIM solutions for schedules. Scheduling is a very important process in a construction project. It can determine how successful the project would be and it is needed for all parties involved to know the location and exact time each task is carried out (Malacarine, Giovanni, Carmen, Michael & Dominik, 2018). The conventional scheduling method, however, depends on human estimated schedules without a complete visualization of all unforeseen effects of made decisions before the real construction. For example, the use of Gantt charts, when created manually are inadequate in visualizing a project schedule (Microsoft visco, 2010). In the traditional way of creating plans, the building model and schedule plans are created and managed separately. But in modern times, 4D BIM offers a platform that merges the two. Project managers can now plan with automated data, being able to see relationships and use that to manage the process, hence make better decisions based on more reliable information and more effective communication, causing lesser disputes between parties.

2.2.1 BIM 4D Technology

4-dimensional (4D) building information models are 3-dimensional (3D) building information models with an added dimension, which is time (4th dimension). 4D models coordinate planning data like the start and end date of a building component and their criticality or slacks, making 4D simulation, storyboards and animation possible with accurate information. This creates the possibility of 4D scheduling. 4D scheduling has to do with the linking of geometric and design components in a building model to scheduling data, creating the possibility of making a video simulation of the construction process that helps the construction team make better analysis and decisions on the project. Different software providers have made 4D tools. For example, Naviswork's Timeliner® (Autodesk), 4D BIM like Vico® Software (Trimble), Synchro® Scheduler (Synchro Software) and Innovaya Visual 4D® simulation (Innovaya). While Using 4D BIM, a very important process is the linking of data from the building components and the project plan in a common or single model. Autodesk (2007) identified two ways of linking this data. The first is by manually inputting data like schedule date from the project plan to the project model.

This is the most commonly used method because it requires less skill. The second is to programmatically link the schedule and the model. This requires more skill, but it saves time and helps for better evaluation of the different construction sequence options. This link can either be done as a direct link between the model file format and the schedule file format. For example, a link between Revit and Microsoft project or exporting the building model into a specialized 4D visualization environment that is already linked to the schedule plan from Microsoft project or primavera@ technology. Also, in recent technology, existing BIM models have options of a plugin to help link the data from the project plan (schedule) to the building model (Malacarine et al., 2018). An example is a tool available in Autodesk consulting. It uses it two directional links between the Revit model and Microsoft project to keep the project updated when changes are made in either program. It has a Revit function that exports applicable building component to a Microsoft file pre-sorted by level and category (for example doors, roof, ceiling, and so on) for rapid project scheduling and resource tasking (Autodesk, 2007).

Another part of the 4D scheduling technology is 4D visualization technology. Autodesk (2007) in their article on BIM and project planning featured Visual Simulation by Innovaya. Visual Simulation is a 4D planning and constructability analysis tool. It allows integration of BIM from Revit with a schedule data from Microsoft project or equivalent. Visual simulation works with the Revit API (application programming interface) to export the building model into to Innovaya file format. It creates an environment for both 3D and 4D models navigation. Schedule plans can be created directly from the visual simulation platform by using the Revit Phases to generate sequenced task based on hierarchy building components.

When there is a need for further detailed planning, the software has a link to Microsoft Project and Primavera that provides a synchronising, import and export functions (Autodesk, 2007). The 4D visual environment enables the user to make better planning decisions as users can explore various scheduling possibilities by changing the date of a task in the Gantt chart and seeing a visual simulation of the ripple effect. A study by Ustinovicuis, Arūnas, Jovita, Mantas, Oksana & Robertas (2018) focused on BIM technology in project planning. Their result showed that a design software functions best when the BIM package has more tools and could be used for many tasks without exporting the information to another setting. The analysis of the design software research revealed that in the building process stages building design and project delivery, BIM programs have the widest spectrum of tools that ensure fluent design actions during the stages. It was determined that a proper investment planning using BIM tools requires all the standard documents that would be directly connected to the project to facilitate a thorough project analysis (Greenwood, Lockley, Malsane & Matthews, 2010).

2.3 Challenges of BIM in construction

There are a lot of challenges professionals have faced incorporating this software on a project. Eadie, Browne, Odeyinka, McKeown & McNiff (2013) identified the challenge of the cost of BIM software and cost of BIM training for staff. Since BIM is a new technology, the experienced older professionals have a lot of catching up to do and this doesn't come cheap. It also involves a huge capital investment which most developing countries might be struggling with. Another challenge is the natural resistance from humans to change (McAdam, 2010). People find it hard embracing a new way of doing things. But the technological world doesn't sit around waiting for acceptance, it keeps innovating and by the time these resistant professionals witness the benefits, there is a big knowledge gap and only a few can really close it up. This leaves the industry with two categories of professionals; the inexperienced professionals that are BIM literate or the experienced professionals that are majorly BIM illiterate. This relates to what Arayici (2011) meant when stating that lack of understanding about BIM among professionals is a challenge faced in the construction industry.

Operability of BIM among the professionals involved in a construction project is also a challenge Eastman, Teicholz, Sacks & Liston (2011) identified in their research. When an architect decides to run a project with the use of BIM, there would be problems if the engineer, contractor or any consultant involved cannot use BIM. It makes the effect counterproductive as BIM wouldn't be used to its full potential. Other challenges noted by researchers like Gray, Teo, Chi & Cheung (2013) and Sawhney & Singhal (2013) is the fact that BIM isn't adequately infused into the current state of procurement processes which makes the room for disruptive possibilities. Gu, Singh, Taylor, London & Brankovic (2009) in their research identified the lack of standard BIM contract documents as a challenge in the use of BIM. Most projects in developing countries like Nigeria are rushed and not a lot of provision is made for the adequate amount of time that BIM requires to set up a project. BIM requires the design and construction team to think holistically and thoroughly from the first day of the design process and this most times results in a long time dedicated to the design stage and planning. This is the only unpleasant part because the longer design stage is covered up by precise and satisfying construction and pre-construction stage. However, the initial time demand is still seen as a challenge (Golparvar-fard, 2013).

3. METHODOLOGY

This research is based on the pragmatic philosophy. It makes use of questionnaires as its primary source of data and extensive literature study as its secondary source of data. Extensive literature study is used as bases to identify the use of BIM in sustainable construction and to outline the possible factors responsible for the level of BIM integration on building projects generally. Based on the identified factors, a questionnaire was developed to identify the level of use of BIM tools for project management and the factors responsible for its level of use in the construction industry in Lagos State, Nigeria. These questionnaires were administered among a randomly selected sample group, comprising of practising professionals in the construction industry in the study area. These professionals include contractors (main and sub), consultants (architect, project managers and engineers). Since the exact population of architects, surveyors and engineers is hard to ascertain, the Cochran equation for the unknown population was used to calculate the sample size. The equation is $N_o=z^2pq/e^2$ (where N_0= sample size, Z^2 = the abscissa of the normal curve that cuts off an area at the tail, e= the desired level of precision, p= the estimated proportion of an attribute that is present in the population, 0.2-0.3 for small, 0.5 for medium and 0.8 for infinity /large effect and q =1-p)

N_0= (1.962) x (0.2) x (1-0.2)/ $(0.05)^2$ = 245.8624, approximated to 246 Respondents

4. RESULT, ANALYSIS AND DISCUSSION

4.1 Response Rate and Format

A total of 246 copies of the questionnaires were administrated. However, 148 copies of the questionnaires were retrieved which represents approximately 60% response rate. This is more than 50% of the respondent, thus considered reasonable. Out of 100% respondents (from the 60% valid), 31% were architects, 18% consultant engineers, 24% contractors and 27% project managers. The scale of measurement used in the design for the questionnaire was a 5-point Likert scale. This Likert scale is a survey scale that ranges from one extreme attitude of agreement to another, with the inclusion of a neutral midpoint. Respondents evaluated factors were based on N, R, S, O and VO which stands for Never, Rarely, Sometimes, Often and Very Often. Evaluation also base on SA, AG, N, D and SD meaning Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree was used.

4.2 Knowledge of BIM and BIM Tools

Result in Figure 3 shows, a 100% awareness level of BIM among all professionals in the AEC industry in Lagos State, Nigeria. This is not surprising as BIM is even being introduced to them right from school.

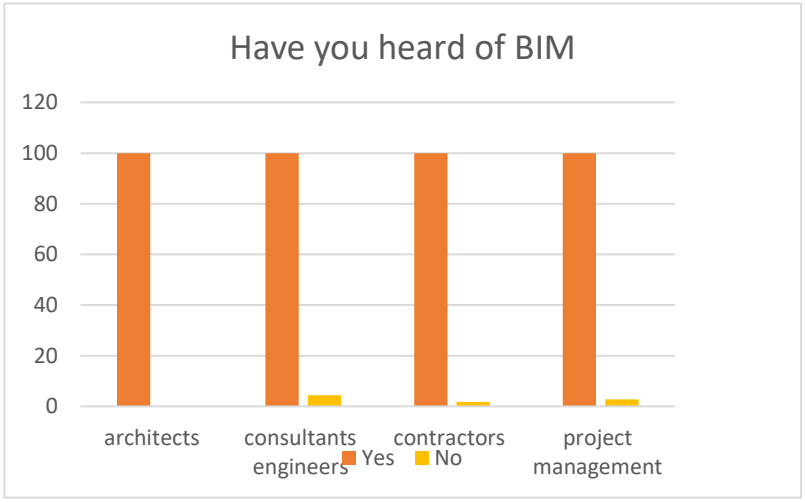

Figure 3: Summarises the findings of this study that has to do with the awareness level of BIM among AEC professionals
Source: Fieldwork

However, when asked their skill level on selected BIM software, the result shows that it is limited to only a few software. The software mostly used is Revit with 100% usage and sketch-up with 70% usage as shown in figure 4.

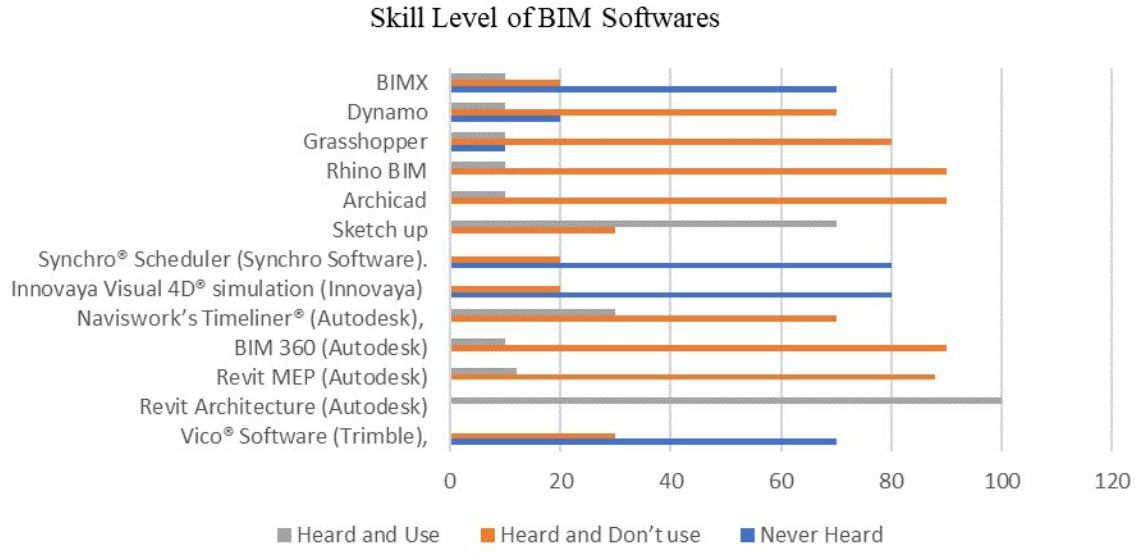

Figure 4: Showing indicated level of use of BIM software
Source: Fieldwork

The low level of use of more detailed analytical software shows the professionals seem to be lacking skill rather than knowledge of these BIM tools. For example, 90% have heard about BIM 360 and don't use it, but only 10% have never heard about it. 70% have heard of Dynamo, but don't use it. However, when it comes to BIM software that mostly facilitates 4D technology, professionals indicate a high level of illiteracy.

For example, 4D enabling tools like, Innovayo visual 4D simulation has 80% of professionals that have never heard about it, same with synchro scheduler. The results also indicated that BIM is not fully integrated into the construction process in study population.

4.3 The Use of BIM

Table 1 shows the use of BIM across all the professionals. BIM is mostly used for design 83%, drafting 90% and 3D visualization 80%. This is however expected because of their indicated skill level as shown in figure 5. This result implies that project managers do not make use of BIM tools for managing the project.

Table 1: Shows the result from respondents on their use of BIM tools

Use of BIM	N	R	S	O	VO
Design	0	0	9	8	83
Drafting	0	0	0	10	90
Cost estimation	50	20	20	10	0
Planning	40	10	10	10	30
3D visualization	0	10	10	0	80
4D visualization	60	10	0	10	20
Energy analysis	50	20	20	10	0
Information management.	50	0	30	0	20

Source: Fieldwork

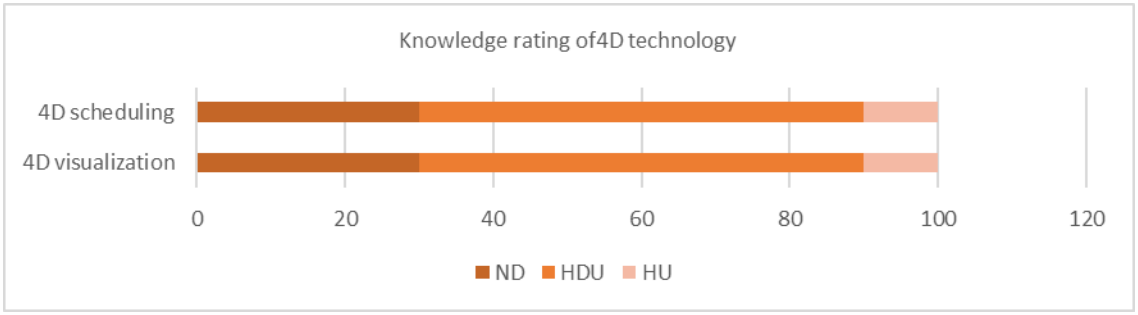

Figure 2: Showing indicated Knowledge level for 4D technology
Source: Fieldwork

They still use less automated computer-aided scheduling tools, manual planning projection that is fully based on experience (that isn't totally reliable) and manually crosscheck site progress with the schedule. The literature review spoke about BIM having a great impact on the project management process of a construction site. 100% of professionals agree with that. However, the results shown in figure 5 shows that most (60%) of the professionals, including the project managers, don't use BIM tools that enable better project management like 4D scheduling and 4D visualization. But they have knowledge of the tool.

4.4 Perception of General Factors Limiting the Level of Use of BIM

the results show that BIM is not fully embraced as a project planning tool rather it is still limited to the design stage. There are two main challenges identified in this study as shown in table 2.

Table 2: Data response on factors limiting the use of BIM

challenges	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. BIM softwares are too expensive	10	0	20	10	60
2. The training is too expensive	10	0	30	20	40
3. Requires a lot of time at the initial setup stage of the model	10	20	10	20	40
4. BIM interface is not easy to understand	20	30	30	20	0
5. BIM doesn't offer me anything new in my project	60	20	10	0	10
6. I am highly experienced in construction, and too busy to learn the new BIM technology	40	20	40	0	0
7. I handle mostly small and medium-scale projects and BIM consumes too much time, it isn't profitable	50	10	10	30	0
8. Professionals from other disciplines don't use BIM which makes it a counterproductive approach.	10	10	10	20	50
9. The technology level of the construction industry in my state doesn't better support some BIM feature. (like BIM enabled prefabricated components)	10	10	0	40	40
10. I lose information in my model when transferring from one format to another	10	20	30	10	20

Source: Fieldwork

First is the high cost of BIM software, which 60% strongly agree and 10% agree. Considering the current economy of Nigeria, a huge capital investment is best avoided. This place a limitation on the type of firms that run original versions of Revit. Some professionals use unlicensed versions because of the cost and unfortunately, this version has a lot of limitations and exploring the true potential of the software isn't possible. Half (50%) strongly agree and 20% agree to the fact that not having all professional from the different disciplines use BIM on a given construction project is a challenge (making it the second biggest challenge). This makes the work done by few professionals on BIM counterproductive. This is also evident in the results in table 1, where for example engineers and architects use the BIM tool for design and drafting, but the contractor and project manager do not use BIM. Thus, forcing the project to still run through the conventional construction management process that is prone to a lot of material waste and delay. Generally, as a developing country, Nigeria still has a lot of catching up to do in terms of technology and this also affects the construction industry. 40% of professionals strongly agree and 40% agree to the fact that the current technology level of the construction industry in Lagos does not support some benefits of the BIM technology like BIM enabled prefabricated building components.

4.5 Discussion

The result of this study shows that AEC professionals in Lagos mostly don't use BIM as a planning tool. They limit it to just the design stage of the project and identified three major reasons why. The first is because BIM software is too expensive to purchase. This result agrees with Eadie et al., (2013) opinion of cost being a significant challenge with the use of BIM. The second is the lack of cooperative use of BIM by all professionals in the project team. This result is in line with Eastman et al., (2011) statement of operability of BIM among professionals being a challenge in the use of BIM. Gu et al., (2009) identified a possible solution when he stated the need for Standard BIM contract documents for construction projects. The third and major challenge is the technology level available in Lagos State. This factor can be referred to as a location-based factor, as it is not noted as a significant challenge in previous research..

5. CONCLUSION AND RECOMMENDATIONS

This study investigated the level of the use of BIM as a construction project planning tool and the factors responsible for its use in Lagos State, Nigeria towards finding ways of enhancing effective and sustainable construction project planning techniques in Nigeria. From the findings of the study, three main factors that influence the use of BIM in Lagos State are the high cost of BIM software, the lack of cooperative use of BIM by all professionals involved in a construction project and the low existing level of technological know-how in the construction industry which does not enable professionals to get the full value of BIM. Based on the findings the following recommendations are made: Firstly, trainings and investments in the construction industry in Lagos State by the private or public sector should focus on learning and implementation of evolving technology in respect to construction processes in order to enable the construction industry to better benefit from BIM. Secondly, a standard BIM contract document should be made for construction project to ensure cooperative use of BIM by all professionals that make up a project team

Area for Further Research: Further work on this topic can include proposal development for mini BIM packages, such as data plans which enable the use of original versions of BIM tools in a smaller scale and at a cheaper cost.

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