Application of BIM Implementation Process in the Operation and Maintenance of Information Management System in Building Facilities

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The appalling state of building facilities in Nigeria, poses a great concern to stakeholders. This stems from lack of adequate information management in the operation and maintenance of building facilities. Therefore, the study is aimed at assessing the application of BIM implementation process in the operation and maintenance of information management system in building facilities. The study made use of a quantitative research approach, making the population for the study to encompass facility management practitioners (Onsite Facility Engineers, Onsite Facility Technicians, Facility Management Professionals [IFMA] and Facility Management Company owners) who are fully registered with International Facility Management Association (IFMA) in Abuja-Nigeria. The sample size for the study is 184 and the respondents were selected by a systematic random sampling method with a close ended questionnaire used for the data collection. The questionnaire is administered via Google forms; and questionnaires shared through the google form link were answered and the results were collected through google response tools, and 121 copies of the questionnaire were duly filled, returned and used for data analysis. The result shows that the implementation of BIM in operation and maintenance of facilities is very low as manual and stand-alone computer system are still predominant in most of the operations carried out by the practitioners and the stakeholders. The study further revealed that Improvement in asset information management that lead to increased efficiency of facility assets is significantly affect by the operational system. The result also shows that Facility managers are traditionally included late in the building lifecycle and posed a high challenge to most practitioners and this has made the application of BIM in operation and maintenance of information management in facility management very negligible, as such the paper suggest that BIM usage in the O&M of buildings should be encouraged and imbibed right from the planning and designing stages of building facilities. Facility managers/professional should also be included right from the inception of a building life cycle to the end of the building.

Keywords: BIM, Information, Facilities, Operation, Maintenance, and Management

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INTRODUCTION

Building facility management comprises of strategic management and governance of the resources and services necessary for a building to function effectively (Bascoul *et al*., 2018). The life cycle of structure, in the management phase of any facility is the last, but by far the longest, phase in a building's life cycle (Nordstrand, 2019). Various nature of information handling is one of the greatest problems of technological advancement facing the practice (Hardin, 2011; Teicholz, 2013). According to Cotts *et al*. (2015), problem often starts at project completion and handover of building documentation and these usually exacerbated later in the facility management phase due to insufficient routines. However, Chien *et al*. (2017) stated that the information handling problem is considered to take much time from the important preventive work, which results in resource waste, reduced employee productivity and impaired tenant service. Building Information Modelling (BIM) is considered by many to offer a solution to the problematic information handling within facility management (Hardin, 2011; Eastman *et al*., 2011). BIM offers the opportunity to streamline the information handling during a building life cycle and thereby improves the building information quality in the facility management phase (Gustav, 2014). Hardin (2010) argued that BIM is not just an information modelling software using three-dimensional intelligent models, but also, it is a tool for making significant changes in the workflow and project delivery processes. Ani *et al. (*2015) posed that BIM is a concept that advances product delivery, which includes quality, reliability, timelessness, and consistency of the process.

However, in Nigeria, poor Operation and Maintenance (O&M) of the building facilities is notable (Nigeria Observer News [NON], 2017). NON (2017) further stated that several studies have been conducted to find out a way to alleviate these problems that include irregularities pertaining to finances, underperforming management departments, poor and outdated records, and lack of maintenance, and cleaning up culture among many others. All of these, according to NON (2017), lead to hitches and hindrances in the operation and maintenance of the building facilities in Nigeria. Olokpo (2018) observed that the run-down syndrome which is an attribute of building facilities in Nigeria, due to poor or lack of maintenance of building facilities has been at the heels of economic development in the country.

Harpa and Freja (2016) reiterated that a lots of processes results in delays, wastages, high costs, poor decisions, and deficiencies in performances that lead

to poor maintenance of facilities and further dilapidation of facility components. Kiran (2020) stated that facility managers spent many hours on finding accurate data like drawings, material specifications, and datasheets during the periods when maintenance service is performed. According to Smith and Tardif (2012), most information created during the design and construction process that is of value to facility managers can only be found elsewhere and in scattered sources.

Therefore, to enhance the level of O&M of buildings facilities in Nigeria, new techniques are inevitably required. Azhar *et al.* (2012) asserted that BIM can be a useful tool during all stages of a building's lifecycle. In a related development, Ani *et al*. (2015) emphasised that it is tools that improve product delivery, which includes quality, reliability, timelessness, and consistency of the process. Although past efforts focused on BIM in the design and construction phase (Azhar *et al.,* 2012; Ioannis *et al*., 2020). Hence, there is a need to assess the application of BIM implementation process in the operation and maintenance of information management system in facility management with the major objective to identify novel ways to use BIM during the building operation phase, to support O&M of building facilities in Nigeria.

LITERATURE REVIEW

Operation and Maintenance Culture in Management of Building Facilities

Facilities maintenance according to Owolabi *et al.* (2014), is an important aspect of building management that is often neglected knowing fully that such maintenance assists retention of the economic life of the facilities. Guzman and Ulloa (2020) observed some shortcomings in facilities like peeling of wall surfaces, rising dampness in substructure, floor slab failure, doors, and windows defect, leaking roof, foundation failure, and sagging of beam. Mohammed and Za (2017) stated that maintenance culture requires the correct diagnosis of defects, immediate remedial measures, sound technical knowledge of material usage, management resources as well as the formulation and implementation of integrated plans and policies to sustain utility. The absence of these qualities has led to the decay of the nation's physical, social, aesthetic, and economic environment (Kunya, 2012). Most facility owners concentrate on the award of contracts for new infrastructures, giving near-to-nothing attention to the O&M of existing ones (Motamedi *et al*., 2014). Adequate O&M of the existing stock of infrastructural facilities and services is another way of keeping the sustainability of structure (Ojara, 2013).

According to Kunya (2012), it is a common knowledge that the deplorable state of building facilities in Nigeria poses a great concern to stakeholders. The present status of most buildings, airports, hospitals, schools, roads and so on around Abuja-Nigeria, give an indication that the society lacks an agent that would have helped manage, ensure effective and efficient functioning of the facilities as well as foster national development. James (2020) established that the flaws in the Nigerian Aviation sector were attributed to a lack of maintenance culture and the training of professionals in the industry. Teicholz (2013) stated that the Facilities Management (FM) practice is characterized by its reactive approach and that the lack of proactive management, that is based on planning, anticipation, and dealing with issues before they become problems, leads to inefficient use of resources. However, the problem of maintaining building facilities has become an important agenda for the country and mounts pressure on the building owners in the aspect of managing its assets and facilities (Dabara *et al.,* 2015). No matter how simple or how complex a facility may be, without a defined order of maintenance management the facilities shall sooner or later not only become non-functional but may in addition constitute a hazard for its users (Abdullah *et al.,* 2012).

Facility Management Information System (FMIS)

An information system is an integrated set of components for collecting, storing, and processing data and for delivering information, cards, and digital products (James, 2020). Business firms and other organisations rely on information systems to carry out and manage their operations, interact with their customers and suppliers, and compete in the marketplace (Nahimah, 2018). An information system is a dynamic area or field that monitors changes, perhaps the most important driving force induced by the development of computers (AfërdÖta, 2014). Systèmes (2014) added that it is a system that works and has to do with information. The lack of information on products and components in terms of usage and cost can lead to difficulties in focusing the role of FM and establishing the supply chain within it. Difficulties in monitoring and tracking financial information can also prevent efficient budget control, accurate estimation of work, and contract and purchase management.

Facilities O&M Information Asset Management

According to Hardin (2010), the most frequent and challenging issue in FM, is the concerns of the attributes of information handling. William *et al.* (2012), explain a worst-case scenario where boxes filled with unsorted building information are handed over to owners. Such often highly unstructured information handling during the handover process usually continues even later in the facility management phase, which results in an unwieldy information basis that hampers the O&M managers' daily work (Tijani *et al*., 2016). According to Zuraihana *et al*. (2016), the current practices imply inefficient use of resources, and the severe localized information leads to time-consuming search processes. Every industry is now faced with understanding on how to leverage information as an asset and the FM industry is no exception in these regard (Chuck *et al.,* 2013).

There is a frequent wide range of difficulties relative to O&M (Marquez & Gupta, 2015). Marquez and Gupta (2015) further attribute the difficulty in O&M to the lack of adequate models that could improve the

understanding of the underlying dimensions of Maintenance. Tijani *et al.* (2016) added that maintenance is composed of a set of activities for which is very difficult to find procedures and information support systems in one place to ease the improvement process. Hence, one of the key challenges in projects is always the need to have sufficient information on products readily available for any maintenance operation, such as specifications, previous maintenance work and a list of specialist professionals to conduct work. Hipkin and De Cock (2010) ranked the barriers to the implementation of O&M systems. The ranking of the barriers faced by O&M managers, supervisors, and operators are lack of plant and process knowledge, lack of historical data, lack of time to complete the analysis required, and lack of top management support (Akcamete *et al*., 2010).

Building Information Modelling (BIM)

An increasingly discussed solution to the information handling problem within FM is "Building Information Modelling (BIM)" (Eastman *et al.,* 2011). According to Abdullahi (2018), BIM is basically a 3D representation of the physical and functional characteristics of a building throughout its life cycle. Eastman *et al*. (2011) further attested that BIM is constructed from the intelligent digital assembly of building components with embedded knowledge of parametric object attributes and characteristics. Moreso, Kymmell (2018) explained BIM tool or product that can generate intelligent digital models connected with other project management tools that facilitate design optimization, constructability, and information collaboration for all stakeholders for a better project output.

Consequently, O&M require the integration of various types of information and knowledge created by different members of the team and phases in a facility life cycle (Ibrahim & Abdulkareem, 2018). O&M in FM activities covers the longest life span of facilities and involves multiple stakeholders that may be replaced over time (Nummelin *et al.,* 2013). Therefore, O&M requires a comprehensive information system that collects, stores, retrieve, and distributes information seamlessly on facilities and all the related building components. (Abdullahi, 2018).

BIM Implementation Levels

Today, the building construction industry has experienced a gradual shift from paper-based 2D CAD drawings information and data management systems to object-oriented 3D digital models which are driven by the application of BIM. According to Muhammed (2021) BIM maturity level determines the degree of efficiency in implementing the technology and process regarding collaborating and management of building information in a project environment.

BIM level 0

At the zero-level stage, drawings and information are through Computer-Aided Drawing (CAD) tools and this reflects unmanaged CAD in 2D, which is represented and exchanged in paper documents (Muhammed, 2021). He added that the collaboration at level zero is minimum, as information is exchanged using ad-hoc exchange methods that offer very little or no chance of information integration to support collaborative working.

BIM level 1

Level 1 denotes a managed CAD environment that uses 2D and 3D representations of building information. The information content at level 1 is generated using CAD standards approaches to data structures, and it is stored in standard formats that can be exchanged among different CAD applications (Muhammed, 2021). Muhammed (2021) further explained that Level 1 replaces the ad-hoc information exchange mechanisms with the introduction of a Common Data Environment (CDE), which is used to share and exchange CAD files between various project participants.

BIM level 2

Level 2 focuses on how the information is distributed among the members of the project. At this stage, two new dimensions of the project are introduced: 4D which is time management, and 5D which represents the calculation of the budget (PAS 1192-2, 2013). Biblus (n.d), mentioned that although collaborative working is at the Centre of the BIM level 2, it is not necessary that all the team members operate on the same CAD 3D models. Every project member can use a distinct CAD model in a common file type such as International Foundation Class (IFC) file type that contains all the designing information. IFC file format are BIM files, however, unlike other BIM file formats, IFC files are platform neutral and can be read and edited by any BIM software (Spatial, 2021).

BIM level 3

BIM level 3 is the final goal for the building construction sector as the main purpose of this level is to obtain a full integration of information in a cloud-based environment, and this is achievable using a common shared model that will be available to all the stakeholders of the project who can add or modify their own information (PAS 1192-2, 2013 & Biblus, n.d). This model in IFC format is the milestone that can be shared and preserved in a cloud so that all the project members can have access to the same information. In this way, the entire life cycle of a building, from its designing to its construction and maintenance can be managed.

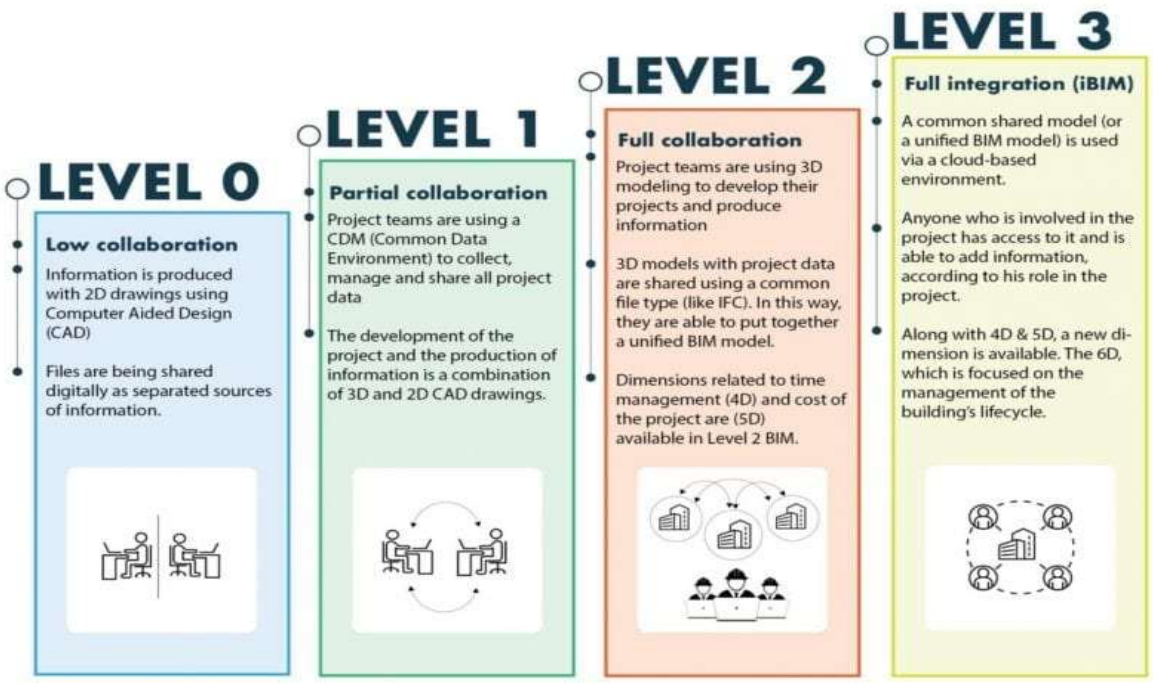

Figure 1: BIM maturity levels
Source: https://biblus.accasoftware.com

BIM in Building Facility O&M

BIM is considered by many researchers and professionals, to offer a solution to the problematic information handling within O&M activities in FM (Hardin, 2011, Eastman *et al.,* 2011). Consequently, the influence of BIM has been seen in the design and construction phase of facilities, facilities owners in recent years to see the potential benefits of the building's later stages on O&M stage (Becerik-Gerber *et al.,* 2012). BIM therefore, is seen to offers the possibility of streamline the information handling during a building's life cycle and thereby improving the building information quality in the FM phase (Nordstrand, 2019). However, in the early history of BIM, it was mainly of benefit to architects and engineers in the design phase and in areas of clash detection, visualization, and quantification (Volk *et al.,* 2014). Hence, a recently, shift in trends indicated an increase focus on the later stages of the building's life cycle which includes maintenance, refurbishment, deconstruction, and end-of-life considerations.

Studies conducted by Cotts *et al*. (2015) and Teicholz, (2013) discussed how conditions for FM practices differ, dependent on where it is performed, and especially the disparities between public and private FM on the application of BIM in their operations. Decisions for building operation and maintenance require the integration of various types of information and knowledge created by different members of the team and phases in a facility life cycle, such as maintenance records, work orders, causes and knock-on effects of failures (Ibrahim & Abdulkareem, 2018). Therefore, O&M requires a comprehensive information system that collects, stores, retrieve, and distributes information on facilities and all their related building components are made easy, effective and efficient with the application of new technology like BIM. Abdullahi (2018) stressed that BIM became popular after 2002, and its adoption in the industry was accelerated due to software vendor's marketing to increased productivity improvement. However, the concept of BIM and the underlying technology is not new and has been an area of research and development in the last three decades with a neglect in areas of maintenance operation of facilities, and mostly known as product modelling for buildings, (Eastman & Augenbroe, 1998; Abdullahi, 2018).

Therefore, to enhance the level of O&M of buildings facilities in Nigeria, new techniques are inevitably required. Hence, there is a need to assess the application of BIM implementation process in the operation and maintenance of information management system in facility management with the major objective to identify novel ways to use BIM during the building operation phase, to support O&M of building facilities in the country.

Challenges of BIM in Building Facility O&M

The nature of BIM allows and expects that new technologies have to be implemented to achieve the true potential of BIM, the characteristic of BIM is close connection to information and communication technologies thus challenges in traditional operation of FM O&M of building facilities. According to Gustav (2014) and Tulenheimo (2015), the implementation of a number of regulations and guidelines are neglected during procurement and acquisition of products and services that are used for FM O&M and this pose a serious challenge to the operation in building facilities. Tijani *et al*. (2016), however, refuted that the challenge of FM O&M is the issue of maintenance strategies. Nordstrand (2019) added that the challenges of FM O&M of building

facilities are affected by process change, when it comes to physical wearing down and user needs and preferences. Consequently, Ahmed (2021) elucidated the challenges in FM O&M of building facilities to include skill shortage in FM using BIM, lack of real-world cases on BIM applications in FM; efforts so far focused on new buildings, lack of processes for updating the designed model with as-built information, facility managers are traditionally included late in the building lifecycle, and interoperability between BIM technologies and current FM technologies.

RESEARCH METHODOLOGY

The quantitative research design was adopted in carrying out this study. The research population targeted comprises of facility professionals (Onsite Facility Engineers, Onsite Facility Technicians, Facility Management Professionals (IFMA) and Facility Management Company owners) who were duly registered with IFMA, Abuja chapter. The sample size of the study is 184. The respondents were selected by a systematic random sampling method which represented the characteristics of the entire population. Primary data for the study were collected via the distribution of a well-structured questionnaire. The questionnaire was divided into Two (2) sections; A and B. Section A considered the general information of the respondents, while section B contains questions relevant to the research objectives of the study, which was ranked based on the 5-point Likert scale.

The questionnaires were administered via Google forms; questionnaires shared through the google form link were answered and the results were collected through google response tools. In all, a total of 121 copies of questionnaires were duly filled, returned and used for data analysis. The responses obtained from the administered questionnaires were analysed using percentile, and mean score with decision been drawn from the mean score after the ranking of the parameters based on the weight from the highest to the lowest as shown in the cut-off points below.

Mean Range	**Decision Rule**
1.0 – 1.49	Not significant/no influence
1.50 – 2.49	Little significance/little influence
2.50 – 3.49	Moderate significance/moderate influence
3.50 – 4.49	High significance/high influence
>= 4.50	Very high significance/very high influence

RESULTS AND DISCUSSION

Demographic Information of the Respondents

In Table 1 below, vast majority of the respondents' acquired their qualifications, with most respondents as bachelor's degree with a percentage of 51.2, 19.8 percent obtained higher national diploma; while 14.9 percent have post graduate diploma; and 9.9 percent have master's degree, while 4.1 percent have Doctorate degree. This means that majority of the respondents obtained the minimum academic qualification of bachelor's degree. It can be observed that 81.8 percent of the respondents worked in the organisation as facilities managers and facilities officers where only 18.2 percent are assistant facilities managers. Furthermore, 81 percent of the members are fully registered with IFMA and only 19 percent had their membership registration with SFP and CFM. More also, only 24.9 percent had their working experience as facilities manager above 10 years, and 45.5 percent had their job training as facilities manager above 5 years where 29.8 percent are within the range of 5 years as facilities training manager on the job.

Table 1**:** Demographic information of respondents

Variables	Classification	Frequency	Percent
Academic Qualifications	Higher National Diploma	24	19.8
	Bachelor's Degree	62	51.2
	Post Graduate Diploma	18	14.9
	Master's Degree	12	9.9
	Doctorate Degree	5	4.1
Position Held in the Organisation	Facility Manager	50	41.3
	Assistant Facility Manager	22	18.2
	Facility Officer	49	40.5
	Maintenance Technician	0	0
Membership/Certification with IFMA	Facility Management Professional (FMP)	98	81
	Sustainability Facility Professional (SFP)	15	12.4
	Certified Facility Manager (CFM)	8	6.6
	Retired Certified Facility Manager	0	0
Years of Working Experience in FM Job	1 -5	36	29.8
	6 -10	55	45.5
	11 -15	25	20.7
	16-20	2	1.7
	More than 20 years	3	2.5

Current Practice of O&M Information Management

From Table 2 it shows that majority of the respondents uses manual systems like papers and boards which rank 1st with mean score value of 4.5; while use of standalone computer software like Excel, Word, and 2D Cad ranked 2nd with mean score value of 4.11. the least utilised is the BIM-enabled system with a mean score value of 1.00. Hence, most respondents however believed that the use of manual system is currently trending and standalone computer software is still being used for the operation and maintenance information management of building facilities in Abuja.

Table 2: Practice of O&M Information Management of Building Facilities

Handling Systems	Mean Score	Rank
Manual systems like papers and boards	4.50	1
Standalone computer software like Excel, MS Project, Word, 2D CAD, 3D CAD, and Computerized Maintenance and Management Systems (CMMS)	4.11	2
BIM-enabled system	1.00	3

Impacts of Implementing BIM in the O&M Information Management in Building Facilities

In Table 3, the respondent's perception shows the level of impact of BIM in the current systems of managing information in the O&M of building facilities in Abuja. The result, therefore, indicates that two of the perceived impact of implementing BIM in O&M of information management have a very high significance as a result of their mean values that is greater than the average weighted mean of 4.045. The impacts with a very high significance are improvement in asset information management that is leading to the increased in efficiency of facility assets and improved team collaboration/communication. Other factors with a high significance are reducing wastage of materials due to rework, misfit, enhances proper information storage/update and quick information retrieval, reducing operational delays. provides basis for adequate analysis of hazards and safety precaution before work, reduction on cost of operations, reducing managerial struggle and improving decision making, improved job planning and control, mitigating work/task abandonment and repetition, improved response to facility maintenance needs, and mitigation of dispute, conflict, misunderstanding and misinterpretation. The result, therefore, shows that there is a great influence on the areas of improving asset information management that will in turn lead to increase in efficiency of assets facility through the improved team collaboration/communication.

Table 3: Impact of implementation of BIM in O&M information management

Impact	Mean Score	Rank	Decision
Improvement in asset information management leading to the increased in efficiency of facility assets	4.66	1	Very High Significance
Improved team collaboration/communication	4.59	2	Very High Significance
Reducing wastage of materials due to rework, misfit etc.	4.42	3	High Significance
Enhances proper information storage/update and quick information retrieval	4.32	4	High Significance
Reducing operational delays	4.11	5	High Significance
Provides basis for adequate analysis of hazards and safety precaution before work	3.98	6	High Significance
Reduction on cost of operations	3.88	7	High Significance
Reducing managerial struggle and improving decision making	3.86	8	High Significance
Improved job planning and control	3.77	9	High Significance
Mitigating work/task abandonment and repetition	3.70	10	High Significance
Improved response to facility maintenance needs	3.65	11	High Significance
Mitigation of dispute, conflict, misunderstanding and misinterpretation	3.60	12	High Significance

Challenges to the Implementation of BIM in O&M Information Management

In Table 4 it was observed that most of the respondents consider facility managers traditionally been included lately in the building lifecycle a very high influencing factors affecting the implementation of BIM in O&M information management in building facilities. Furthermore, the respondents view BIM efforts so far focused on new buildings, skill shortage in FM using BIM, interoperability between BIM technologies and current FM technologies, and lack of real-world cases on BIM applications in FM and lack of processes for updating the designed model with as-built information a high influence affecting the BIM in O&M information management in building facilities whereas poor or inadequate ICT facilities for BIM implementation, and lack of BIM knowledge and awareness are viewed as moderate influence. The result shows that the inclusion of the facility managers lately in the building lifecycle is considered to be the highly influenced barrier to the application and implementation of BIM in O&M information management in building facilities in Abuja.

Table 4: Challenges of Implementation of BIM O&M Information Management in Building Facilities

Barrier	Mean Score	Rank	Decision
Facility managers are traditionally included late in the building lifecycle	4.56	1	Very High Influence
BIM Efforts so far focused on new buildings	4.38	2	High Influence
Skill shortage in Facility Management using BIM	4.23	3	High Influence
Interoperability between BIM technologies and current FM technologies	3.86	4	High Influence
Lack of real-world cases on BIM applications in FM	3.83	5	High Influence
Lack of processes for updating the designed model with as-built information	3.76	6	High Influence
Poor or inadequate ICT facilities for BIM implementation	3.00	7	Moderate influence
Lack of BIM knowledge and awareness	2.56	8	Moderate influence

CONCLUSION

The study concluded that most building facilities in Abuja, Nigeria are still using manual and standalone systems in handling information for the operation and maintenance of building facilities such as papers, shelving and standalone software. Furthermore, the implementation of BIM in O&M information management will lead to overall improvement in facility management resulting in time saving, cost and availability of information for prompt building maintenance management. However, the study is limited to the application of BIM implementation process in the operation and maintenance of information management system in building facilities. Finally, the study concludes that the late inclusion of facility managers in the building lifecycle impede the implementation of BIM in O&M information management system.

This study does not represent exhaustive work, hence, it is recommended that the following suggestions be adopted in other to apply and implement BIM in the O&M information management in building facilities.

1. BIM usage in the O&M of buildings should be encouraged and imbibed right from the planning and designing stages of building facilities
2. Facility managers/professional should be included right from the inception of a building life cycle to the end of the building.

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