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Factors Affecting Building Information Modelling Usage in Building Industry in Abuja

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ABSTRACT

This study investigated the factors affecting Building Information Modelling (BIM) usage in the building services industry in Abuja, Nigeria. Recognizing the global trend toward digitalization in construction, the research aimed to uncover why, despite high awareness of BIM, its practical implementation remains limited in Abuja. A mixed-methods design was employed, combining quantitative data from a structured questionnaire with qualitative insights from in-depth interviews. The study sampled 265 professionals—including architects, engineers, contractors, and other construction experts—using stratified random sampling from a total population of 5,137. Data were collected on various dimensions such as financial constraints, technical expertise, regulatory support, and overall awareness of BIM. The instrument, validated by expert review and pilot-tested (Cronbach's alpha = 0.87), ensured reliable measurement of the constructs. Findings reveal that BIM adoption is progressing steadily in the building industry, particularly in areas such as 3D modelling, clash detection, and project coordination. However, the usage of BIM in cost estimation, facility management, and throughout the entire project lifecycle remains limited. This reflects a partial adoption of BIM practices, which may reduce its potential benefits in terms of efficiency, integration, and sustainability in construction projects. The study further concludes that although there is a high level of awareness of BIM among professionals, practical usage and formal training remain inadequate. Many professionals are knowledgeable about BIM concepts but lack access to structured training and real-life project experience using BIM tools. The study recommended that the Nigerian government, through regulatory agencies such as the Council for the Regulation of Engineering in Nigeria (COREN) and the Architects Registration Council of Nigeria (ARCON), develop and enforce policies that mandate the use of BIM in public projects. A clear national BIM strategy will provide direction, compliance standards, and deadlines for implementation across the industry; Professional bodies, educational institutions, and construction firms should provide regular training, seminars, and workshops on BIM tools and workflows. This will enhance both theoretical and practical competencies and bridge the skills gap among professionals.

Keywords: Building Information Modelling (BIM), Building Information Modelling (BIM) Adoption in the Nigerian, Building services, Information contents of BIM, Levels of BIM usage, Framework for BIM adoption and implementation, Empirical Literature Review.

1.0 INTRODUCTION

Traditionally, lines and symbols have been used to prepare working drawings, building services plans, bill of quantities and engineering drawings in the building services industry. Effective coordination between design and building services process and interpretation of design concepts on building services sites are a constant challenge; but now, Building Information Modelling (BIM) is driving a revolution in the building services industry The construction industry in Nigeria is evolving, with increasing demands for efficiency and sustainability (Olatunji *et al*., 2014). BIM facilitates the digital representation of a building's physical and functional characteristics, enabling stakeholders to make informed decisions throughout the project lifecycle (Azhar, 2011). Despite its benefits, the uptake of BIM in Abuja's building services sector has been slow due to several constraints. Building Information Modelling (BIM) has revolutionized the global construction industry by enhancing project efficiency, collaboration, and overall quality. BIM serves as a digital representation of a building's physical and functional characteristics, facilitating seamless information sharing among stakeholders throughout the project lifecycle. In developed countries, BIM adoption has become standard practice, leading to significant improvements in project delivery and cost management.

In contrast, the Nigerian construction industry has been slower to embrace BIM, particularly within the building services sector in Abuja. Several studies have identified key barriers to BIM adoption in Nigeria, including high implementation costs, lack of technical expertise, and insufficient awareness of BIM's benefits. For instance, Bamgbose *et al*. (2024) highlighted that small and medium-sized enterprises (SMEs) face challenges such as software functionality issues, inadequate client demand, and limited government support, which hinder BIM adoption. Similarly, Ekemode (2023) emphasized that the high costs associated with BIM implementation and hardware installation are significant deterrents for residential property developers in Nigeria.

Building services play a crucial role in ensuring the functionality, safety, and efficiency of buildings. These services encompass electrical systems, mechanical installations, plumbing, fire safety systems, heating, ventilation, and air conditioning (HVAC). The integration of BIM in building services can significantly improve coordination, reduce errors, and enhance overall project delivery. However, in Nigeria, traditional construction methods still dominate the industry, leading to inefficiencies, cost overruns, and poor project outcomes.

Despite these challenges, there is a growing recognition of BIM's potential to address inefficiencies and enhance productivity within Nigeria's construction industry. Olanrewaju *et al*. (2020) noted that while BIM awareness is relatively high during the design phase, its application during construction and facility management stages remains limited. This gap underscores the need for comprehensive strategies to promote BIM adoption across all phases of building projects. Several factors have influenced the slow adoption of BIM in Nigeria's building services sector. The lack of skilled professionals and inadequate training opportunities hinder effective BIM implementation. Additionally, the absence of regulatory frameworks and government incentives discourages organizations from investing in BIM technology. Furthermore, the fragmented nature of Nigeria's construction industry, where projects often lack proper coordination, further impedes BIM integration. Addressing the factors impeding BIM usage in Abuja's building services industry is crucial for aligning with global best practices and improving project outcomes. By identifying and mitigating these barriers, stakeholders can leverage BIM's full potential to transform the construction landscape in Nigeria. Increased investment in training programs, government-mandated BIM policies, and improved awareness campaigns can foster greater BIM adoption and integration within the Nigerian building services industry.

Globally, the building services industry is experiencing a transformation in the form of BIM. Impressed with the ability of BIM to reduce rework and increase project value, governments around the world are taking steps on the usage of BIM. While BIM adoption has grown globally, its usage in Abuja's building services industry remains minimal. Despite its potential to improve project efficiency, collaboration, and cost-effectiveness, BIM implementation is significantly hindered by multiple challenges in Nigeria. Key among these is the lack of awareness and understanding of BIM's benefits, which results in reluctance from industry professionals and clients to embrace the technology. Moreover, the absence of mandatory BIM regulations and government-driven policies has contributed to the slow pace of adoption (Okonkwo, Umeh & Adeola, 2023). Financial constraints also present a major obstacle, as BIM implementation requires significant investment in software, hardware, and training programs. Many small and medium-sized enterprises (SMEs) in the Nigerian construction industry find it difficult to afford these costs, limiting their ability to integrate BIM into their operations (Afolabi *et al*., 2023). Additionally, the shortage of skilled professionals and the lack of comprehensive BIM training programs in Nigeria's educational institutions further exacerbate the problem (Adamu & Hamza, 2023).

Another pressing issue is the lack of coordination and collaboration among project stakeholders. Effective BIM implementation requires seamless communication between architects, engineers, contractors, and facility managers. However, the fragmented nature of the Nigerian construction industry results in poor integration of BIM across different project phases, further limiting its effectiveness in building services (Umar & Bello, 2024). This call for the investigation into the factors affecting Building Information Modelling usage in Building Industry in Abuja.

1.1 Aim and objectives

The aim of the study is to examine Building Information Modelling usage among building services professionals in Abuja with a view to enhancing project delivery in the Nigerian Building services Industry. The objectives are to:

1. Determine the level of BIM adoption in building services in Abuja.
2. Investigate the level of awareness of BIM in building service practice in Abuja.

2.0 LITERATURE REVIEW

2.1 Building Information Modelling (BIM)

The ongoing digital switch-over in the building services industry and the advancement in Information and Communication Technology (ICT) have provided an ideal vehicle for integrating and disseminating information around a network of participating groups and organizations. It has become a cost-effective, universally accepted and readily available information presentation and delivery system (Zhang, Liu & Chen, 2022). According to Okonkwo *et al*. (2023), BIM gives an accurate model of a building and a database for recording the breadth of information developed and associated with building components; beyond drawing and documentation, BIM offers a platform for enhanced interdisciplinary collaboration, the capability to manage change, and the ability to extend information support throughout the building lifecycle. Also, quantities and shared properties of materials can be easily extracted, scope of work can be isolated and defined, and systems, assemblies, and sequences are displayed in a relative scale with the entire component or group of components. Information can be attached to building components during the design process from manufacturer's specifications to maintenance instructions; thus, offering the potential for an integrated information base available to building owners and operators at project turnover.

BIM covers geometry, spatial relationships, light analysis, geographic information, quantities and properties of building components, project management and post-building services facilities management. BIM at higher level is more than a mere simulation of building's geometry and appearance. It is more than graphic visualizations of buildings. It provides intelligence at the object level for data integration and design analysis and that a software application is capable of 3D functionality does not automatically imply that the software is capable of producing a building information model because BIM gives a model composed of intelligent objects with content and not drawings or images requiring interpretations (BIM Guide, 2013; New York City

Department of Design and Building services, 2012; Autodesk, 2011; Eastman *et al.,* 2011; United State General Services Administration, 2007). In BIM, virtual designs are built in 3D before work proceeds on site; the attributes of all the elements of the building can be found in the model; and spatial 'clashes' can be identified and resolved in the model instead of on site (CPA, 2013).

As observed by RIBA (2012) and Sebastian (2010), BIM is more than 3D, it can be 4D when time or work schedule information is added to the project model or 5D when cost or quantity schedule information is given in the model or 6D when facilities management information is added to the model. Bhargav (2014) described BIM as an accurate parametric and 3D geometrical representation of a building or any structure digitally. The Computer Integrated Building Services Research Group (CICRP, 2012) termed it as an intelligent model which can be more easily modified, and which accurately represented the final building product. As defined by CPA (2013), Autodesk (2011), CICRP (2012), Sebastian (2010) and Azhar, Khalfan and Maqsood (2012), BIM is a process for managing the information produced during a building services project, in a common format in order to make the best and most efficient use of that information (Figure 1). BIM is facilitating a new way of working and creating designs with intelligent objects and providing the basis for new, more efficient collaborative workflows that give all stakeholders a clearer vision of the project and increase their ability to make more informed decisions faster through the production of digital models (Autodesk, 2011). BIM data can be used to illustrate the entire building lifecycle, from cradle to inception, design and demolition and materials reuse; quantities and properties of materials, which can be easily extracted from the model; and the scope of works, including management of project targets and facilities management throughout the building's life. A basis of premise of BIM is collaboration by different stakeholders at different phases of the lifecycle of a building to insert, extract, update or modify information in the BIM to support and reflect the roles of that stakeholder (National Building Specification BIM Report (NBSBR, 2014).

Figure 1: Managing information with BIM throughout the building lifecycle

Source: Bhargav (2014).

BIM can be used to illustrate the entire building lifecycle, from cradle to inception, design and demolition and materials reuse; quantities and properties of materials, which can be easily extracted from the model; and the scope of works, including management of project targets and facilities management throughout the building's life (NBSBR, 2014). Figure 2 illustrated 3D models of architectural, structural, mechanical and electrical services information of a building integrated into a single model. This single model is a digital prototype of the building made up of 'intelligent objects', i.e., objects with shapes, sizes, weight, costs, and so on (BIM Guide, 2013; Autodesk, 2011).

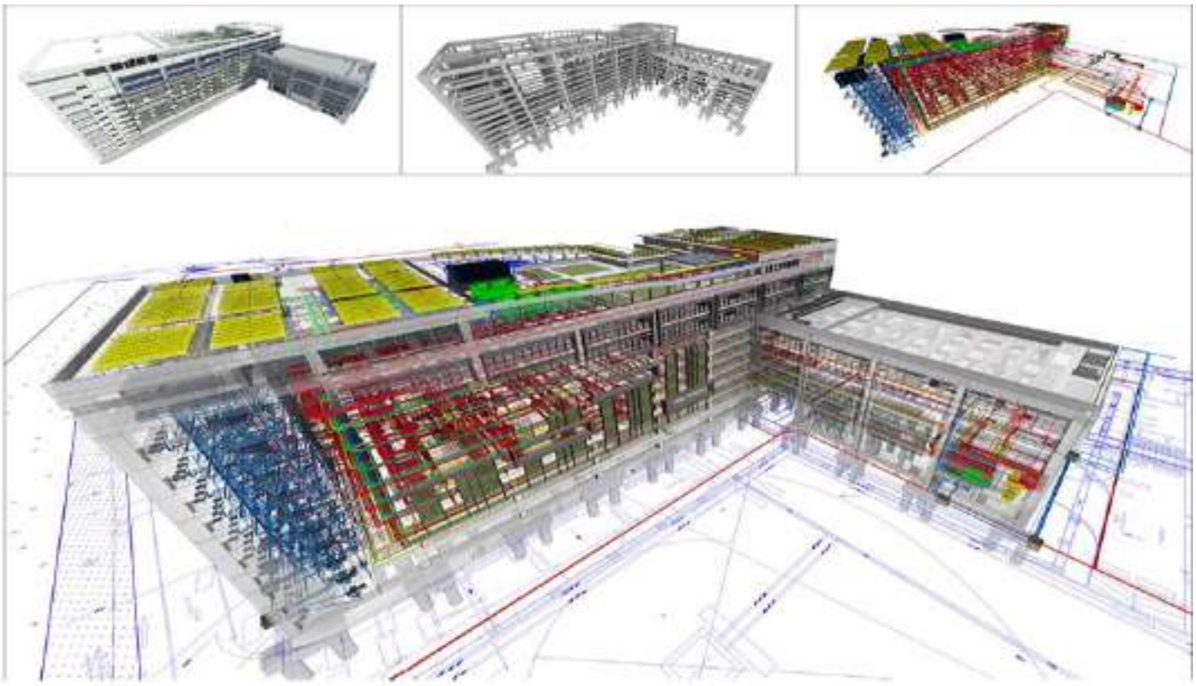

Figure 2: Integrated model in BIM

Source: Building and Building Services Authority of Singapore (2013).

The change occurring in the global economy has presented building services professionals with a window of opportunity to retool their businesses and adopt new tools and workflows that will help them deliver higher quality building and infrastructure projects at a lower cost and thereby help them differentiate themselves in the marketplace and stay competitive in challenging times (Autodesk, 2011). Macdonald (2013) noted that to design realistic projects, it is necessary to assemble the design and building services team at earlier stages in the building services process compared to traditional practice because building services projects of today are dependent on reliable and updated information and this has created a need to break down barriers that building services professionals have carefully and successfully built up over a long period of time (Wilkforss & Lofgren, 2007). BIM is facilitating process, technological and cultural changes in the built environment and does not really require the learning of new software and a new way of working (Macdonald, 2013). UK BIM Strategy Report (2012) described BIM as a key agent for economic growth in both domestic and international markets which is increasingly being recognized as a major force to drive both growth and increase competitiveness. It also found that existing procurement methods can be used with minimal amendment in BIM, only those details of requirement should be described in the BIM protocol and that ownership and coordination of the model should remain within the supply chain.

2.2 Building Information Modelling (BIM) Adoption in the Nigerian

Globally, Building Information Modelling (BIM) has transformed the construction industry by streamlining design, construction, and facility management processes. In developed nations, the widespread adoption of BIM is largely attributed to substantial investments in technology, comprehensive training programs, and supportive government policies (Azhar, 2011; Eastman *et al*., 2011). Nigeria, as one of the largest economies in Africa, presents a unique case within the developing world. While there is a growing awareness of BIM in Nigeria, its adoption in the building services sector has been limited by several interrelated factors such as:

i. Awareness vs. Implementation: Studies indicate that while a significant proportion of Nigerian construction professionals are aware of BIM, actual implementation remains low. This gap between awareness and practical application is attributed to a lack of technical training and the high cost of technology (Olatunji *et al*., 2014).

ii. Economic and financial barriers: The Nigerian construction industry, particularly among SMEs, is heavily burdened by financial constraints. The high costs of BIM software and the associated expenses for training and hardware upgrades have been identified as major deterrents. Financial support, in the form of government incentives or low-interest loans, is minimal, which further discourages investment in BIM (Afolabi *et al*., 2023; Adamu & Hamza, 2023).

iii. Skill and expertise deficit: There exists a considerable gap in the technical expertise required for effective BIM adoption. Many professionals in Nigeria lack the necessary training, resulting in poor implementation despite high levels of theoretical awareness. This skill gap has been highlighted as a significant barrier by multiple researchers (Okonkwo *et al*., 2023).

iv. Policy and regulatory challenges: The Nigerian government has yet to implement comprehensive BIM policies that mandate or incentivize its adoption. The lack of clear regulatory frameworks means that there is little external pressure on firms to adopt BIM, leading to inconsistent practices across the industry (Bamgbose *et al*., 2024).

BIM adoption in developing countries, and specifically in Nigeria, underscores the need for a multi-faceted approach to overcome these challenges. Financial support mechanisms, targeted training programs, improved digital infrastructure, and strong regulatory frameworks are essential for fostering BIM adoption. In Nigeria, efforts to modernize the construction sector must address not only the economic and technical barriers but also the cultural resistance to change. BIM holds the potential to revolutionize construction practices, its adoption in Nigeria is impeded by financial, technical, infrastructural, and regulatory challenges. Addressing these issues through collaborative efforts between government, industry, and educational institutions is critical for enhancing the competitiveness and efficiency of the Nigerian construction sector.

Despite the benefits, several challenges obstruct the widespread adoption of BIM as shown in the figure below.

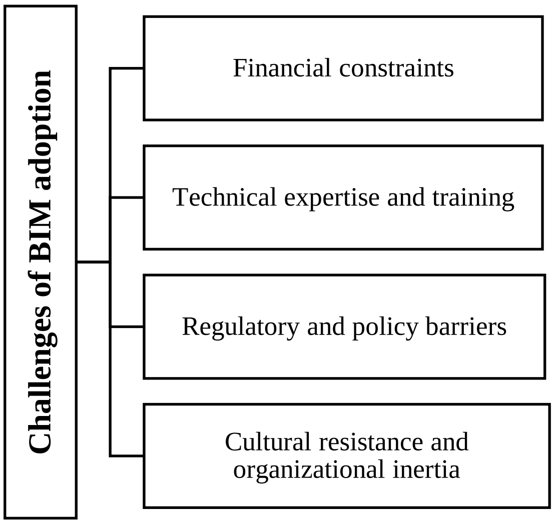

Figure 3: Challenges of BIM adoption

Source: Bamgbose *et al*. (2024); Oke *et al*. (2024); Umar and Bello (2024); Adamu and Hamza (2023); Afolabi *et al*. (2023); Okonkwo *et al*. (2023)

i. Financial constraints: the high initial costs of BIM software, specialized training, and the necessary hardware upgrades can be prohibitive, particularly for small and medium-sized enterprises (SMEs) (Adamu & Hamza, 2023; Afolabi *et al*., 2023). The cost factor is frequently cited as the primary barrier in both developed and developing contexts. Many developing countries face significant financial barriers. High initial costs for BIM software, hardware, and training are often prohibitive for small and medium-sized enterprises (SMEs). Researchers have pointed out that the limited availability of financial resources and government subsidies makes it challenging for firms to invest in BIM technology (Adamu & Hamza, 2023). As infrastructural limitations, and inadequate digital infrastructure, such as unreliable internet connectivity and limited access to modern computing resources, further hinders the adoption of BIM. These infrastructural challenges contribute to slower uptake compared to developed regions (Afolabi *et al*., 2023).

ii. Technical expertise and training: effective use of BIM requires a high level of technical expertise. Many professionals, especially in developing countries, lack adequate training in BIM technologies, leading to suboptimal implementation (Umar & Bello, 2024; Okonkwo *et al*., 2023). This expertise gap is compounded by the absence of standardized BIM training modules in academic curricula. Thereof, technical expertise needs successful implementation of BIM with specialized technical skills. In many developing economies, there is a notable gap in the availability of adequately trained professionals. This gap is exacerbated by the limited integration of BIM into academic curricula and professional training programs (Okonkwo *et al*., 2023).

iii. Cultural resistance and organizational inertia: the transition from traditional methods to a digital workflow often encounters resistance from industry professionals accustomed to conventional 2D drafting techniques. This resistance to change can slow down the adoption process (Oke *et al*., 2024). As cultural and organizational resistance regarding traditional construction practices remain deeply ingrained in many developing countries. Resistance to change, coupled with a preference for conventional 2D drafting methods, often results in reluctance to adopt BIM. The transformation from traditional practices to a digital workflow is met with both cultural and organizational inertia (Oke *et al*., 2024).

iv. Regulatory and policy barriers: in many regions, including Nigeria, the lack of mandatory BIM policies and comprehensive regulatory frameworks significantly impedes its adoption. Unlike countries with enforced BIM mandates, Nigerian firms often lack the external pressure to integrate BIM into their projects (Bamgbose *et al*., 2024). As the regulatory environment unlike developed countries, where BIM adoption is frequently mandated by government policies, many developing nations lack comprehensive regulatory frameworks. The absence of clear mandates and supportive policies further discourages BIM uptake (Bamgbose *et al*., 2024).

2.3 Building Services

Building services encompass the systems and technologies integrated into buildings to ensure functionality, safety, comfort, and sustainability. These services include mechanical, electrical, plumbing, fire safety, and HVAC (heating, ventilation, and air conditioning) systems. This review synthesizes global and regional literature on building services, focusing on design, implementation, challenges, and the role of digital tools like Building Information Modelling (BIM) in optimizing these systems, with a special emphasis on contexts like Abuja, Nigeria. Building services are critical for modern infrastructure, enabling buildings to meet user needs and regulatory standards. Ensures thermal comfort and indoor air quality. Modern systems integrate energy-efficient designs to reduce carbon footprints (Wang *et al*., 2021). Elevators and escalators require precise coordination with architectural layouts (Chow *et al*., 2020). Reliable electrical grids and renewable energy integration (e.g., solar panels) are essential for sustainable buildings (IEA, 2022). Smart lighting systems reduce energy consumption while enhancing occupant comfort (Boyce, 2021). Efficient water management systems prevent waste and ensure hygiene (WHO, 2023). Safe piping systems for natural gas or medical gases in hospitals (ASHRAE, 2022). Automated fire alarms, sprinklers, and emergency exits are mandated by codes like the NFPA (2023). IoT-enabled systems monitor and control building operations in real time (Deng *et al*., 2022). Poor collaboration between architects, engineers, and contractors leads to clashes in MEP (mechanical, electrical, plumbing) systems (Eastman *et al*., 2018). Suboptimal HVAC and lighting designs contribute to 40% of global energy consumption in buildings (UNEP, 2021). Technicians often lack training in modern systems like smart grids or BMS (Akinradewo *et al*., 2022). Globally, BIM has been widely recognized as a transformative technology that offers significant advantages over traditional 2D drafting. In many developed countries, BIM is not only used as a tool for design and documentation but is also integrated into the project management process to enhance collaboration among stakeholders (Smith, 2024). Building Information Modelling (BIM) emerged as a revolutionary digital technology in the early 2000s, fundamentally transforming the construction industry by enabling the creation and management of digital representations of physical and functional building characteristics. Globally, BIM has evolved from a design visualization tool to a comprehensive project management platform that integrates various phases of a building's lifecycle—from planning and design through to construction, operation, and maintenance. In developed economies such as the United Kingdom, Singapore, and the United States, BIM is widely implemented due to supportive government policies, substantial investments in technology, and well-established training programs (Smith, 2024). The transition from traditional 2D drafting to 3D digital modelling has been credited with significant improvements in efficiency, error reduction, and cost savings.

2.4 Information contents of BIM

Basically, a BIM is expected to contain six major information models required for the design and construction of a building projects, namely; Architectural Information Model, Structural Information Model, Cost Information Model, Construction Information Model, Building services Information Model, and Maintenance Information Model (Smith, 2014; BIM Guide, 2013; RIBA, 2012). Architectural Information Model consists of information such as 3D building model, parametric data and specifications and quality which can be developed using BIM platforms such as Autodesk REVIT, AutoCAD, e-SPECS, and Nematschek Vectorworks. Structural Information Model comprises of structural analysis, system and materials; Orion, StarPro, Bentley Structure and Tekla are examples of BIM platform that can be used to develop the information. Cost analysis and data and Bill of Quantities are some of the information that can be got from Cost Information Model, with Sigma, SPONS and Innovaya as examples of software platform that can be used to develop this information. Building Service Information Model can be developed using Bentley Mechanical and Electrical Systems, AutoCAD MEP, Hydra CAD, Energy+; examples of information that can be found in Building Service Information Model include:

i. Lighting analysis,

ii. Fire rating of materials,

iii. Electromechanical data and thermal simulation.

Building services Information Model can be developed for 3D design coordination, detection and to show site utilization plan and analysis among other information using BIM platform such as MS Project, Bentley Schedule Simulator and Primavera, DAYSIM, ApacheSIM, Trimble LM80, Jetstream or Bentley Navigator. Building services Information Model is usually developed by the main contractor and sub-contractors with each having separate models. BIM platforms such as Bentley Facilities Systems, Maximo, and One Tools can be used to develop Maintenance Information Model (Singapore BIM Guide, 2013; CICRP, 2011; Laiserin, 2010).

2.5 Levels of BIM usage

The building services industry in the developed world is rapidly adopting BIM, although the level of BIM usage differs in different region. In the United State of America, the General Services Administration has developed a BIM guidelines and standards and pioneered the usage of BIM for public sector projects; while the usage in the United Kingdom, France and Germany was 35, 38 and 36% respectively (McGraw-Hill, 2010). SmartMarket Report (2010) argued that the United State of America is the leader in BIM usage with over 70% of the building services projects using BIM; closely followed by Europe, where BIM was used in almost one-third of the projects. Autodesk (2011) noted that six out of ten architects create architectural information model and that half of all contractors are currently using BIM in US. Also, BIM International Report (2013) reported that the Danish government has adopted BIM and mandated its use for all the projects of the Danish state clients. The same report also showed that Hong Kong government has developed a set of modelling standards for effective BIM in the country and has been using BIM in all of its projects since 2014. Chartered Institute of Building (2015) reported that the Russian government has set up 25 pilot BIM-based projects to increase BIM usage and that in Ireland, demand for BIM usage on projects was growing among clients; while the Scottish government has proposed the use of level 2 BIM for projects over £4.32M. Also, Finland's state property services agency has been using BIM for its projects since 2007. In Australia, the majority of firms are using BIM in their projects; while South Korea's public procurement services has mandated the use of BIM for all private sector projects over US$40 million and for all public sector projects by 2016 (SmartMarket Report, 2010).

The progress of BIM adoption in developing countries is far below expected levels. McGraw-Hill (2010) concluded that India, China and the Middle East are still lagging in the usage of BIM. In India, Sawhney (2014) found that BIM is gaining popularity among professionals within the Indian built environment sector and that it is being implemented for private projects, but still largely in visualization phase. The study regarded BIM as the lever that the Indian built environment sector needs to attain the desired productivity gains.

2.6 Framework for BIM adoption and implementation

In order to implement changes in an established method of work, a framework of implementation is required. Mom, Tsai and Hsieh (2011) developed a framework for BIM adoption as shown in Figure 6 where he proposes 4 adoption phases in which BIM processes diffuse into an organisation. During each adoption phase, the main factors that can affect an organisation's decision to adopt BIM are perceived benefits, internal readiness and external pressure. The initial phase of adoption is Visualisation, which is associated to BIM maturity level 1. This adoption level is initiated through the integration of BIM enabled 3D parametric tools, yet usage is limited to specific disciplines and involves the production of 3D BIM models for an organisations own purposes, thus maintaining the lack of interoperability and fragmentation of stakeholders present in maturity level 0.

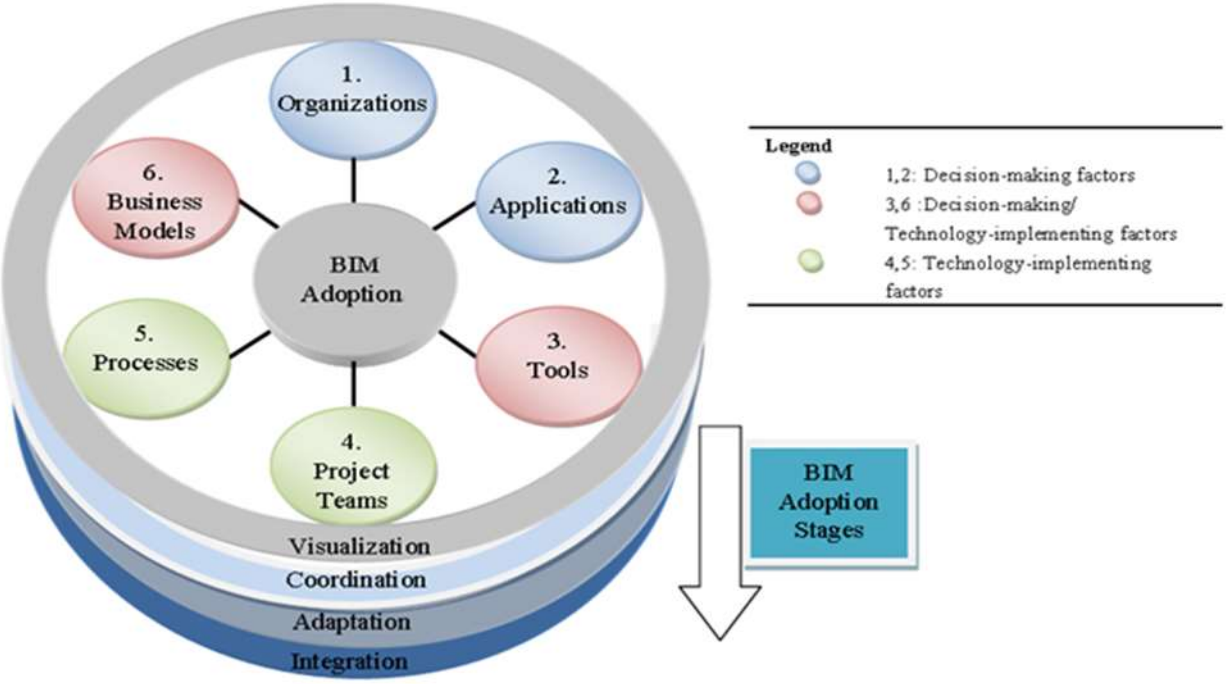

Figure 6: Framework for BIM adoption

Source: Mom *et al*., (2011)

It could be argued that this initial phase is ineffectual for implementation as BIM processes require interoperability among the discipline-specific models (Mom *et al*., 2011; Ozorhon *et al*., 2010; Sabol, 2008). **Coordination** is the second phase, which incorporates initial concepts of BIM maturity level 2 in the sharing of digital information attached to BIM models between project disciplines. Next is the **Adaption** phase, this is represented by BIM maturity Level 2. The adaption phase involves the adjustment of an organisation's work environment to BIM processes in addition to full interoperability of BIM models attached data between building services disciplines. Outputs of the adaption phase include the development of 4D and 5D BIM models. The concluding phase of BIM adoption is **Integration**, characterised by BIM maturity level 3. The integration phase involves the diffusion of BIM in an organisation to enable the sharing of data rich multi-disciplinary BIM models on a universal web-based server. Models are developed, shared and maintained collaboratively by stakeholders throughout all project phases, facilitating the utilisation of integrated project teams (Mom *et al*., 2011; Sabol, 2008).

Additionally, Mom *et al*. (2011) BIM adoption framework details 6 components of BIM adoption namely organizations, applications, tools, project team, processes and business model. These components define the extents within an organization where specific changes must occur to implement BIM; all 6 components requirements must be achieved before succeeding to the subsequent phase of adoption.

Organizations as a BIM adoption component relates to the decision making of an organisation, it proposes a shift in an organisation's culture of work which must occur including strategies for service and the attaining of new skills to adopt BIM processes. Liu, Issa and Olbina (2010) opines that topdown management support and awareness to the perceived benefits is the optimum factor to this adoption component. Conversely unwillingness by employees to change could limit this components adoption process (Ozorhon *et al*., 2010).

The applications component of BIM adoption outlines an alignment between an organisation's objectives and BIM deliverables. Through defining objectives, a company can develop their business strategy around BIM usage. Success factors to this process include leadership from management in determining the company's business strategy to implement BIM processes and an awareness of the perceived benefits of BIM and its deliverables (Mom *et al*., 2011; Ozorhon *et al*., 2010). The tools component of BIM adoption is the obtaining and implementing of BIM technologies to gain internal readiness. Skill development of personnel as argued by Mom *et al*. (2011) lays the foundations for successful BIM adoption, and therefore the selection and implementation of BIM enabled tools that are suited to both a company's competencies and organisational objectives is of paramount significance to the success of this component. Project teams are considered a critical success factor in the adoption and use of BIM, this component refers to an organisation forming teams consisting of project stakeholders and harnessing a collaborative working environment in which digital information is shared and interoperability promoted. Bachelder (2010) claims trust is the key that leads project success thus indicating trust and collaboration between project stakeholders are the key factor to this component.

The organizational processes as a BIM adoption component requires organisations to develop BIM enabled workflows and integrate BIM applications into their projects. This component would imbed BIM orientated quantity surveying practices into organisations processes and workflows replacing old methods of work and developing greater levels of BIM maturity through its usage. Critical success factors to this component include the learning and application of BIM processes through BIM training and pilot schemes to develop an organisational understanding of its use, thus increasing internal readiness and the company's comprehension of perceived benefits (Mom *et al*., 2011; Ozorhon *et al*., 2010).

The concluding component of the adoption framework which is 'business model' involves adjusting the organisations business model towards BIM practices. The adapted business model should account for project delivery, procurement selection criteria and contractual relationships that facilitate BIM usage (Mom *et al*., 2011).

Maturation from a lower level of BIM to a higher level of BIM requires far more than acquiring software and upgrading hardware. It requires the understanding of BIM software technologies and related processes and a plan for implementation before the maturation can begin (BIM Handbook, 2011). Software developers are also developing add-on solutions to extend the capabilities of BIM applications in their new generations of their products; implementing BIM in an organization requires the understanding of how to use these products and why BIM is important to the organization. This helps to establish a mission, which must be followed with the development of a list of standard project goals that would be beneficial to the organization. The organization should also design standard collaboration procedures and considers all the resources and infrastructure required to perform information modelling processes. The quality of a model can significantly impact a project; therefore, the organization should have standard quality control processes that are well documented and allow for easy implantation (CICRP, 2011).

Autodesk (2011) asserted that the implementation of BIM in an organization requires a corporate will and the determination of the technology infrastructure requirements such as hardware, software platforms, software licences, network, and modelling content, because BIM implementation will alter the staffing needs, operational processes and technology requirements. Firms typically require networking upgrades and collaboration technology such as large display screen and video conferencing technology. CICRP (2012) noted that the software platforms and versions that are interoperable should be selected and that the understanding of the hardware specifications is also a valuable information to be considered as it is important to ensure that the downstream hardware is not less powerful than the hardware used to create the information. BIM Planning Guide for Facility Managers (2012) and Eastman *et al*. (2011) observed that organizations and governments have to develop guidelines for BIM on projects to identify goals for BIM use, scope and use of BIM across phases of project, scope of standards or formats related to BIM and the exchange of BIM, roles of participants in the BIM process; develop internal knowledge about BIM software technologies; select service provides proficient with BIM software technologies; educate a qualified network of BIM services providers through workshops, conferences, seminars, and guides; determine areas of focus for BIM implementation, the level of BIM to be adopted and define the transition process for the integration of BIM into organization business practices; and modify contracts and contract language including the scope and detail of the model information, uses of model information, organization of model information.

According to CICRP (2011) and (2012), a process mapping procedure for planning the BIM implementation needs to be performed with a high-level map showing the sequencing and interaction between the primary BIM uses on the project. The high-level map is required to show how the BIM authoring, energy modelling, cost estimating and schedule are sequenced and interrelated. Team members are also required to develop detailed process maps for their respective models. The process map is required to allow the team to understand the overall BIM process, identify the information exchanges that will be shared between the projects team, and clearly define the various processes to be performed for the identified BIM uses. BIM Guide (2013) maintained that BIM plan should address key project contracts, project information, project objectives, organizational roles and staffing, process design, information exchanges, data requirements, collaboration procedures, quality control procedures, technology infrastructure needs, model structure, delivery strategy, and project deliverables. As stated by CICRP (2012), BIM planning takes two-level approach: development of overview map and detailed process map. The overview map contains the high-level information exchanges that occur throughout the project lifecycle and shows the relationship of BIM uses on the project; while the detailed process map identifies the responsible parties for each process, reference information content, and the information exchanges which will be created and shared with other processes. It clearly defines the sequence of various processes to be performed. Each of the identified BIM uses on a project is taken as a process within the map to be sequentially ordered and each process should include a process name, project phase, and the responsible party. In the overview map, the critical information exchange may either be internal to a particular process or shared (external) between processes and parties. The sequence of the various processes to be informed within BIM use must be created for each identified processes; dependencies between the processes and reference information and information exchanges are identified and defined (BIM Guide, 2013; CICRP, 2011).

2.7 Empirical Literature Review

Bamgbose *et al*. (2024) empirically examines the regulatory challenges that impede BIM adoption in Nigeria's construction industry. By analyzing survey data and case studies, the study finds that the absence of mandatory BIM policies and inconsistent regulatory enforcement are major obstacles. The research advocates for the development of robust regulatory frameworks to promote and standardize BIM usage across the sector.

Umar & Bello (2024) conducted a study on the empirical study that explores the disparity between BIM awareness and technical expertise among Nigerian construction professionals. Survey results indicate that although a majority of respondents are aware of BIM, a considerable proportion lack the necessary technical skills for its effective implementation. The study calls for comprehensive training programs to bridge this gap, thereby facilitating more widespread and effective BIM adoption.

Adamu and Hamza (2023) conducted a study on the empirical study investigates the primary challenges faced by Nigerian construction firms in implementing BIM. Utilizing a quantitative survey and qualitative interviews, the research identifies key barriers such as inadequate technical expertise, resistance to change, and high initial costs. The study recommends enhanced training programs and stronger government support to overcome these challenges and improve BIM adoption rates.

Afolabi *et al*. (2023) examines the impact of financial constraints on the adoption of Building Information Modelling (BIM) among small and medium-sized enterprises (SMEs) in Nigeria. Through a mixed-methods approach involving surveys and case studies, the authors found that high costs associated with BIM software, training, and hardware upgrades significantly hinder BIM adoption. The research concludes that targeted financial incentives and subsidies are critical for improving BIM uptake in Nigerian SMEs.

Okonkwo *et al*. (2023) conducted a study on the role of Technical Expertise in BIM Adoption in Nigeria. The study focuses on the critical role of technical skills in BIM adoption, this study surveys construction professionals in Nigeria to assess their level of BIM knowledge and practical expertise. The findings reveal a significant gap between BIM awareness and actual technical competency, which impedes effective implementation. The authors emphasize the need for integrating BIM training into academic curricula and continuous professional development initiatives.

Zhang *et al*. (2022) investigates the integration of artificial intelligence (AI) with BIM to improve construction lifecycle management in emerging markets. The empirical analysis demonstrates that AI-driven BIM solutions enhance data accuracy, streamline project workflows, and reduce errors. The authors conclude that the adoption of AI-enhanced BIM can significantly improve project outcomes, offering valuable insights for markets facing similar technological and infrastructural challenges as Nigeria.

Kim *et al*. (2021) conducted a study on Cloud-Based BIM for Enhanced Project Collaboration in Emerging Economies, the case study examines their effectiveness in fostering project collaboration in emerging economies. The findings indicates that cloud-based BIM significantly improves real-time information sharing and stakeholder coordination, leading to better project management and reduced delays. The study suggests that cloud-based solutions could be a viable pathway for enhancing BIM adoption in resource-constrained environments, such as those found in developing countries like Nigeria.

3.0 RESEARCH METHODOLOGY

3.1 Study Area

The area selected for this study was Abuja, the capital city of the Federal Republic of Nigeria and the administrative center of the Federal Capital Territory (FCT). Geographically, Abuja is situated between latitude 8.8941° N and longitude 7.1860° E, with its central coordinates approximately at 9.0579° N, 7.4951° E. Covering a total land area of 713 square kilometres for the city proper and about 7,315 square kilometres for the greater metropolitan region, Abuja was established as Nigeria’s capital in 1991 to replace Lagos, and it was designed to reflect order, efficiency, and modernity. Abuja’s central geographical location in Nigeria gives it a strategic advantage, making it accessible from all parts of the country. This centrality is not only symbolic but also functional, as it hosts the headquarters of most federal ministries, departments, and agencies (MDAs), foreign embassies, and international organizations. Abuja’s location within the Guinea Savannah Zone also means that its urban development must address environmental challenges such as high temperatures, seasonal flooding, and energy efficiency—all of which underscore the need for smart design solutions provided by BIM. Building services professionals (e.g., MEP engineers, HVAC specialists, lighting designers, and fire safety engineers) in this context are expected to plan and coordinate intricate systems to meet safety, comfort, and sustainability standards objectives BIM is uniquely equipped to support. The choice of Abuja as the study area is also reinforced by the presence of construction regulatory bodies and professional institutions headquartered within the FCT. These include the Council for the Regulation of Engineering in Nigeria (COREN), the Nigerian Institute of Building (NIOB), the Nigerian Society of Engineers (NSE), and the Architects Registration Council of Nigeria (ARCON).

3.2 Research Design

The study adopted a descriptive survey research design, which is particularly suitable for social science investigations where the aim is to observe, describe, and document aspects of a situation as it naturally occurs.

3.3 Population of the Study

The population of the study include 5,137 registered building services professionals who have substantial involvement in Building Information Modelling (BIM) processes and have utilized BIM in project execution within Abuja.

Table 1: Source and Distribution of Population of Building Services Professionals in Abuja

SN	Profession	Estimated Population	Percentage (%)
1	Architects	1,020	19.9%
2	Builders	715	13.9%
3	Civil Engineers	1,135	22.1%
4	Electrical Engineers	672	13.1%
5	Mechanical Engineers	735	14.3%
6	Quantity Surveyors	860	16.7%
Total		**5,137**	**100%**

Source: FCTA (2024); COREN (2023); NIQS (2023).

3.4 Sample Size and Sampling Technique

275 was the sample size calculated using Yamane (1967) formula for determining sample size. A stratified random sampling technique was utilized to ensure representation across the different professional groups (Architects, Builders, Civil Engineers, Electrical Engineers, Mechanical engineers and Quantity Surveyors) was treated as a stratum, and respondents were randomly selected from each group. The Yamane's formula shown in equation 1 below:

$n = \frac{N}{1+N\,(e)^2}$……………………………………….. (1)

Where:

N = Total population = 5,137

e = Margin of error (set at 0.06 for this study)

Substituting the values:

$$\mathrm{n} = \frac{5137}{1 + 5137\,(0.06)^2} = \frac{5137}{1 + 5137(0.0036)} = \frac{5137}{1 + 18.49} = \frac{5137}{1 + 19.49} = 275$$

3.5 Validity and Reliability of the Instrument

The questionnaire was assessed by the panel of experts in construction management, quantity surveying, and educational infrastructure to ensure its validity for relevance, comprehensiveness, and alignment with research objectives. Modifications were made based on their feedback to improve construct validity (Ogbodo & Yahaya, 2021). Face validity was achieved through the pilot study, which confirmed that respondents understood the questions as intended and could answer them accurately. Also, reliability was further enhanced by using the test-retest method with 10 respondents (Ogbodo & Yahaya, 2021). Results showed consistent patterns of response over time, confirming the stability of the instrument, as it revealed the internal consistency of the instrument Cronbach's alpha value of 0.87, indicating high reliability and internal consistency.

3.6 Method of Data Analyses

Quantitative data were analyzed using both descriptive statistical method (frequency distributions, percentages, mean scores, and standard deviations) and inferential statistical method (regression analysis), using a software called Statistical Package for the Social Sciences (SPSS). Qualitative data obtained from interviews were analyzed thematically to extract key insights that complemented the quantitative findings.

4.0 PRESENTATION OF DATA ANALYSIS AND DISCUSSION

This chapter presents and analyses the findings obtained from a critical review of the literature. The goal is to examined the Building Information Modelling usage among building services professionals in Abuja with a view to enhancing project delivery in the Nigerian Building services Industry. The structure of this chapter follows the study's objectives, as the study administered a total of two-hundred and seventy-five (275) questionnaires; two-hundred and sixty-five (265) questionnaires were retrieved amounting to 92% response rate for analyses. However, according to Collis and Hussey (2014) any response rate greater or equal to 70% is excellent for analyses.

4.1 Presentation of Data Analyses

4.1.1 Objective 1: To Determine the Level of BIM Adoption in Building Services in Abuja

This objective is analyzed using a descriptive method of data analysis with the used of mean score and standard deviation to reach a decision defined on Likert-scales. A Likert scale is a psychometric tool used to measure attitudes, opinions, or behaviours by asking respondents to rate their level of agreement with a series of statements.

Table 2: Decision Table

Weight	Classification	Rating Scale
1	0.00 – 1.49	Very Low (VL)
2	1.50 – 2.49	Low (L)
3	2.50 – 3.49	Moderate (M)
4	3.50 – 4.49	High (H)
5	4.50 – 5.00	Very High (VH)

Source: Miller (2020).

Table 3: Showing the descriptive the Level of BIM Adoption in Building Services in Abuja

Items	Mean	Standard Deviation	Decision
BIM supports project coordination across disciplines	4.22	0.85	High
BIM is used for clash detection and conflict resolution	4.15	0.88	High
Our firm uses BIM for 3D design modelling	4.05	0.92	High
BIM is integrated into our cost estimating/tendering process	2.75	1.10	Moderate
BIM is used in our facility management and maintenance planning	2.65	1.12	Moderate
Average Mean Score	**3.56**	**0.97**	**High**

The results indicate that BIM adoption in Abuja's building services sector is high in the design and coordination stages of construction projects. The respondents' agreement from the Likert-scales showed a high adoption of BIM to supports project coordination across disciplines (i.e., interdisciplinary coordination) with M = 4.22, SD = 0.85, used for clash detection and conflict resolution with M=4.15, SD=0.88, and used of BIM for 3D design modelling with M=4.05, SD=0.92. These values show that professionals find BIM useful for visualizing designs, resolving potential conflicts, and enhancing collaboration among architects, engineers, and builders before construction begins. However, some responses showed moderate adoption to BIM related to usage in cost estimation/tendering process with M=2.75, SD= 1.10 and, related to usage in facility management and maintenance planning with M=2.65, SD=1.12, suggesting that adoption is still limited in the post-design stages of the project lifecycle.

Average mean score value of 3.56, suggesting that this pattern highlights a high adoption of BIM in Abuja where it is perceived as a design tool rather than a comprehensive lifecycle tool.

4.1.2 Objective 2: To Investigate the Level of Awareness of BIM in Building Service Practice in Abuja

Table 4: Showing the descriptive the Level of Awareness of BIM in Building Service Practice in Abuja

Item	Mean	Standard Deviation	Decision
I am familiar with the concept of BIM	4.31	0.80	High
I can distinguish BIM from traditional CAD systems	4.12	0.84	High
I have attended a BIM awareness seminar or workshop	3.65	0.95	High
BIM has been used in my recent project documentation	3.45	1.00	Moderate
I have received formal training in BIM tools	3.05	1.01	Moderate
Average Mean Score	**3.72**	**0.92**	**High**

The study revealed a high level of awareness of BIM in building service practice in Abuja among professionals with an average mean score of 3.72. Respondents rated their degree of agreement on a Likert scale which showed a high level of awareness as the respondents are familiarity with the concept of BIM (M= 4.31, SD=0.80), high level of awareness as the professionals can distinguish BIM from traditional CAD systems (M=4.12, SD=0.84), also there is high level of awareness among the professionals as they attended BIM awareness seminar or workshops (M=3.65, SD=0.95). This suggests that most professionals in Abuja understand what BIM is and its distinct features such as real-time collaboration, parametric design, and integration of various project elements. However, in the BIM being used in recently for project documentation, the level of awareness is moderate (M=3.45, SD=1.00) as well as, the professionals receiving formal training in BIM tools, the awareness is moderate (M=3.05, SD=1.01), suggesting that awareness of BIM is not enough for its successful implementation.

4.2 Discussion of Findings

4.2.1 Objective 1: Level of BIM Adoption in Building Services in Abuja

The findings of this study objective revealed a high adoption of BIM in Abuja where it is perceived as a design tool rather than a comprehensive lifecycle tool as shown by the average mean score value of 3.56, with BIM to supports project coordination across disciplines (M = 4.22, SD = 0.85), BIM used for clash detection and conflict resolution (M=4.15, SD=0.88), and BIM used for 3D design modelling (M=4.05, SD=0.92) as the three most BIM adopted among the professionals in Building services in Abuja.

This result is consistent with international trends, where the early adoption of BIM typically focuses on design visualization and coordination among multiple disciplines (Succar, 2009; Eastman *et al*., 2011). However, the study also revealed low levels of adoption in areas such as cost estimation and facility management. These findings are critical because they point to a limited lifecycle approach to BIM usage. While BIM is intended to support project development from design through construction and into operations, the findings suggest that its usage in Abuja does not yet extend into these downstream activities. This is concerning, as the full benefits of BIM-including cost savings, risk reduction, and operational efficiency-can only be realized when it is deployed across the entire lifecycle of a project (Azhar, 2011). The results corroborate the findings of Babatunde *et al*. (2020) and Olawumi & Chan (2019), who identified similar trends in Nigerian cities, attributing partial adoption to limited technical know-how, lack of training, and cost-related barriers. This indicates that BIM adoption in Abuja is function-driven rather than strategy-driven, where professionals use BIM when it is convenient but have not institutionalized its usage across all project dimensions.

4.2.2 Objective 2: Level of Awareness of BIM in Building Service Practice in Abuja

The findings of this study objective revealed high level of awareness of BIM in building service practice in Abuja among professionals with an average mean score of 3.72, familiarity with the concept of BIM (M= 4.31, SD=0.80), distinguishing BIM from traditional CAD systems (M=4.12, SD=0.84), and attending BIM awareness seminar or workshops (M=3.65, SD=0.95) were the high level of awareness of BIM in Building service practice in Abuja and that confirmed that most professionals in Abuja understand what BIM is and its distinct features such as real-time collaboration, parametric design, and integration of various project elements.

This objective outcome supports the argument of Aghimien *et al*. (2019) and Arayici *et al*. (2011) that in developing countries, awareness often surpasses practical skill acquisition, primarily due to the absence of structured training programs and limited access to licensed BIM software for practice. Additionally, despite awareness, many firms in Abuja do not yet integrate BIM deeply into their workflows, and individual understanding of BIM varies widely in depth and application. Rogers' Diffusion of Innovation Theory (2003) supports this by highlighting those innovations often progress from awareness to interest, evaluation, trial, and adoption. In this context, Abuja's professionals are likely between the "interest" and "trial" phases, with full adoption requiring stronger institutional support.

By implication, the data suggest a need for more hands-on training, mentorship, and access to BIM software tools to bridge the gap between theory and practice. This would empower professionals to move beyond awareness into active and efficient BIM usage. This is a positive sign, as awareness is the first step toward technology acceptance and adoption. It shows that BIM is no longer an unfamiliar concept among professionals in Abuja, thanks to educational institutions, conferences, and online platforms.

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This study examined the Building Information Modelling usage among building services professionals in Abuja by determining the level of BIM adoption in building services in Abuja, and investigating the level of awareness of BIM in building service practice in Abuja. The study concluded based on the study objectives that:

i. The level of BIM adoption in building services in Abuja is high as perceived as a design tool with BIM to supports project coordination across disciplines, BIM used for clash detection and conflict resolution, and BIM used for 3D design modelling as the three most BIM adopted among the professionals in Building services in Abuja.

ii. The level of awareness of BIM in building service practice in Abuja is high among the professionals with the familiarity in the concept of BIM, distinguishing BIM from traditional CAD systems, and attending BIM awareness seminar or workshops as the highest level of awareness of BIM in Building service practice in Abuja.

5.2 Recommendations

Based on the conclusions drawn from the study, the following recommendations are made to promote full and effective adoption of BIM in Abuja's building services industry:

i. The Nigerian government, through regulatory agencies such as the Council for the Regulation of Engineering in Nigeria (COREN) and the Architects Registration Council of Nigeria (ARCON), develop and enforce policies that mandate the use of BIM in public projects. A clear national BIM strategy will provide direction, compliance standards, and deadlines for implementation across the industry.

ii. Professional bodies, educational institutions, and construction firms should provide regular training, seminars, and workshops on BIM tools and workflows. This will enhance both theoretical and practical competencies and bridge the skills gap among professionals.

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