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# Digital transformation in Nigerian construction industry: Adoption of building information modelling and immersive technology

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**Abstract**
The study examined the adoption of Building Information Modelling (BIM) and immersive technologies in Nigerian construction industry. BIM provides a digital approach for managing building information in design, construction, operation and maintenance stages by integrating geometric, scheduling, cost and facility data in a coordinated model. Immersive technologies, such as virtual reality, augmented reality, mixed reality and digital twin systems, enhance project visualization, design review, construction coordination, safety training and building performance monitoring through interactive digital environments. The study reviewed the evolution of BIM from computer-aided drafting systems to object-based modelling, 4D scheduling, 5D cost management and lifecycle information management with its integration with artificial intelligence, Internet of Things devices and sensor-based systems. The study examined the differences in technology adoption between indigenous and foreign contractors, based on variations in technical capacity, financial resources, workforce skills, digital infrastructure and institutional support. The study identifies high software and hardware costs, inadequate professional training, limited policy frameworks, weak digital infrastructure, organisational resistance and fragmented construction practices as major constraints affecting BIM and immersive technology implementation in Nigeria. The findings revealed that foreign contractors generally demonstrate stronger digital capacity due to better access to resources and technological expertise, while indigenous contractors face significant application challenges. The study recommended stronger BIM policies, improved professional education, investment in digital infrastructure, public-private collaboration and financial support mechanisms to enhance technology adoption and promote efficient, coordinated and sustainable construction practices in Nigeria.

**Keywords:** Building information modelling, immersive technologies, construction industry, digital construction, Nigeria

## Introduction

The Architecture, Engineering and Construction (AEC) industry continues to experience shifts driven by digital systems that reshape design, construction and facility management practices. In developing countries, technological penetration has altered traditional project delivery processes, with professionals deploying digital tools at different stages of the building lifecycle, covering design, construction, operation and maintenance (Kochovski & Stankovski, 2018) [19]. The adoption of Internet of Things devices, smart sensors, Building Information Modelling (BIM) and smart building systems reflects an industry response to demands for improved efficiency, comfort and environmental performance in building operations (Froufe *et al*., 2020; Olawumi & Chan, 2020) [27, 30]. This movement also aligns with concerns about energy consumption and emissions associated with conventional building systems, which have encouraged shifts toward digitally enabled construction practices (Awosode, 2018) [6]. Building Information Modelling has become central in discussions on construction digitalisation. BIM refers to a digital representation of the physical and functional properties of a facility that supports information sharing and decision processes throughout the project lifecycle, from design through construction to demolition (Succar, 2009; Eastman *et al*., 2011) [13, 43]. The model supports structured management of project data across multiple stages of delivery and maintains continuity of information exchange among participants. BIM is also described as a process that integrates information and technology to support design and construction coordination (Zhang *et al*., 2020) [51]. The system has expanded beyond three-dimensional modelling into time-based scheduling, cost estimation and operational data integration, with increasing linkage to Internet of Things devices, Artificial Intelligence applications and Digital Twin systems (Ariono, Wasesa & Dhewanto, 2022) [4].

The application of BIM has been associated with improvements in construction project outcomes through coordination of design information and reduction of errors during project execution stages (Bryde Broquetas & Volm, 2013) [8]. BIM also supports early identification of design inconsistencies and promotes collaboration among project participants (Li *et al*., 2014; Wang *et al*., 2015) [49]. Additional benefits include improved quantity estimation, cost control, scheduling accuracy and facility management processes (Volk, Stengel & Schultmann, 2014; Kushwaha, 2016) [20, 48]. BIM adoption also supports material efficiency through accurate digital measurement, which reduces waste generation during construction processes (Zima, Pachla & Węgrzyn, 2020) [52]. Despite these benefits, implementation remains uneven, with limited uptake reported in many developing economies, including Nigeria (Alufohai, 2012) [3]. The Architecture, Engineering and Construction sector has faced persistent criticism regarding fragmentation, poor coordination and inefficiencies in project delivery processes (Hamma-Adama & Kouider, 2019) [17]. These challenges are linked to weak collaboration structures, lack of trust among project participants and limited integration of information systems in traditional procurement arrangements

(Olanrewaju *et al*., 2021) [28]. BIM has been presented as a response to these challenges through its capacity to support integrated project delivery and coordinated decision-making processes (Hamma-Adama, Salman & Kouider, 2018) [16]. Immersive technologies such as Virtual Reality, Augmented Reality, Mixed Reality and Digital Twins have gained attention in construction research due to their capacity to enhance visualization and interaction with digital building models (Nnaji, Karakhan, *et al*., 2022) [24]. Virtual Reality provides a fully computer-generated environment, while Augmented Reality overlays digital information onto physical environments using mobile or wearable devices (PwC, 2022; Shin, 2018) [4, 40].

Integration of BIM with Virtual Reality enables virtual walkthroughs of proposed designs before construction begins, supporting early identification of design conflicts and spatial inconsistencies (Eze & Aluko, 2022) [14]. These technologies also support interpretation of architectural drawings and specifications, reducing ambiguity during project execution stages (Adewumi *et al*., 2025) [1]. Digital transformation in the construction industry also reflects a broader global shift toward smart construction systems. The integration of BIM with IoT devices, smart sensors and digital platforms has expanded possibilities for real-time data collection and building performance monitoring (Froufe *et al*., 2020) [27]. This shift supports lifecycle management of construction projects and improves coordination among stakeholders across design, construction and operational phases. In developed economies, BIM adoption has been reinforced by regulatory frameworks and institutional policies, while adoption in developing contexts remains limited due to weak digital infrastructure and limited technical capacity (Bouhmoud & Loudyi, 2021) [7]. In Nigeria, the construction sector continues to experience structural and technological disparities between indigenous and foreign contractors. Indigenous firms often operate with limited access to advanced digital tools, restricted financial capacity and inadequate technical training, which affects their ability to adopt BIM and immersive technologies effectively (Odediran *et al*., 2012) [25]. The gap between awareness and implementation of digital tools remains visible, with BIM adoption described as slow and fragmented in the Nigerian construction environment (Chidozie *et al*., 2025) [11]. While foreign firms tend to apply digital systems more consistently, indigenous contractors face challenges linked to cost, training and institutional support.

Construction output in Nigeria contributes about 1.4 percent to national GDP, reflecting both its economic relevance and underperformance relative to its potential (Oraegbune & Haruna, 2022) [32]. Despite increasing awareness of BIM and immersive technologies, implementation remains limited to a small number of firms with higher digital capacity. Barriers include high implementation cost, lack of skilled personnel, weak client demand and resistance to technological change in organisations (Olanrewaju, Tan & Kwan, 2020; Hamma-adama & Kouider, 2019) [17, 27]. Urban-based firms show higher adoption levels compared with smaller and rural-based contractors due to differences in access to infrastructure and training opportunities (Stears Data, 2023) [42]. The relevance of BIM and immersive technologies extends to improved project visualization, reduced construction errors, enhanced coordination and better interpretation of project specifications. These technologies support improved communication among project stakeholders and reduce uncertainties associated with traditional two-dimensional documentation practices. In contexts such as the South-South geopolitical zone of Nigeria, where construction activity continues to expand, the integration of BIM and immersive systems presents opportunities for improved project delivery performance and modernization of construction practices. The study therefore examines BIM and immersive technology adoption among indigenous and foreign Architecture, Engineering and Construction contractors in Nigeria.

## BIM Concept and Application in Construction Industry

Building Information Modelling refers to a method for producing and managing information tied to a building from early design through use and final removal. BIM deals with structured digital records of building objects and their behaviour over time (Succar, 2009; Zawada, 2024) [43, 50]. The idea rests on a model that carries geometry and data such as materials, schedules and cost records. These records stay connected to the object and change when project conditions change (Zawada, 2024) [50]. Early definitions described BIM as a digital version of a facility used for decision tasks during its life cycle (Cao, Kamaruzzaman & Aziz, 2022) [9]. Later explanations placed attention on its role in design coordination and project communication among actors such as architects, engineers and contractors (Eastman *et al*., 2011) [13]. The model stores details that range from design drawings to construction planning and maintenance records (Olawumi & Chan, 2019) [29]. The system grew from earlier computer-aided drafting tools that only produced drawings. BIM shifted attention to data-linked models where each building part holds linked information (Abdullah & Ibrahim, 2016). This shift allows project teams to work on shared records instead of separate files. The development of BIM moved through stages linked to improvements in computing and construction practice. Early digital drawing systems did not support shared data use. Later tools allowed object-based modelling where building parts carried attributes (Eastman *et al*., 2011) [13].

Over time, BIM has moved from 3D representation into higher levels that include time planning (4D) and cost estimation (5D). These additions allow project teams to review construction order and financial plans using the same model (Alizadehsalehi & Hadavi, 2023) [2]. Work on BIM also expanded into building operation, where maintenance and facility records stay linked to the model (Volk, Stengel & Schultmann, 2014) [48]. In many countries, adoption patterns differ. The United Kingdom and some other developed regions introduced government direction for BIM use in public projects (HM Government, 2011; UK BIM Framework, 2021) [18, 47]. In contrast, adoption in several developing regions remains slow due to weak policy direction and limited technical capacity (Olawumi and Chan, 2019) [29]. BIM supports a working method where different project actors use a shared model for communication and planning. Architects, engineers, contractors and clients interact with the same dataset during project development (Eastman *et al*., 2011) [13]. This reduces separation between design and construction decisions. The model stores design information, cost details and scheduling data that allow different teams to align their work (Olawumi & Chan, 2019) [29]. Clash detection appears as one of the main uses, where design conflicts between systems such as structural and mechanical elements are identified before construction begins (Chen and Baddeley, 2015) [10]. Work on BIM also supports communication during project delivery. Mobile devices connected to BIM models allow site teams to access updated project data during fieldwork (Lin & Su, 2013) [22]. This reduces reliance on paper-based information exchange. BIM use extends from design preparation into construction and building operation.

During design, models help clients view project outcomes before physical work starts (Eastman *et al*., 2011) [13]. This reduces design uncertainty and supports early corrections. During construction, BIM supports planning of work sequences and site activities. Four-dimensional modelling shows how construction activities progress over time (Sacks, Treckmann & Rozenfeld, 2009) [38]. This supports coordination of labour and materials. In building operation, BIM stores maintenance records and facility data. These records help facility managers track building performance and maintenance needs (Volk, Stengel & Schultmann, 2014) [48]. The same model supports different stages of the building life cycle without loss of information. Immersive technologies refer to systems that allow users to interact with digital environments or overlay digital content on physical settings. These include virtual reality, augmented reality and related systems used in construction and design work (Sepasgozar & Davis, 2018) [39]. Virtual reality produces computer-generated environments where users experience simulated spaces using head-mounted devices (Shin, 2018) [40]. Augmented reality places digital information over real-world views using mobile devices or headsets (Rankohi & Waugh, 2013; PwC, 2022) [4, 36].

Mixed reality links both systems by allowing interaction between real and digital objects during design review and construction tasks (Somaiieh, Sadeghi-Niaraki & Choi, 2020) [41]. Digital twin systems also support live monitoring of building systems using sensor-based data (Taj and Jhanjhi, 2022) [44]. Artificial intelligence has also been linked with these tools through data analysis and pattern recognition tasks that support construction decision processes (Zawada, 2024) [50]. VR allows users to enter a simulated building environment before physical construction starts. This supports design review and spatial understanding (Zawada, 2024) [50]. Workers and clients can move through virtual spaces and observe design layouts. In construction safety training, VR provides controlled environments for practice of risky tasks such as work at height or confined spaces (Shin, 2018; Eze & Aluko, 2022) [14, 40]. This supports skill development without physical risk. AR supports field activities by placing digital information on physical construction sites. This allows workers to view hidden systems such as structural or mechanical elements during installation (PwC, 2022) [44]. This reduces misunderstanding of drawings and supports correct installation of building components (Adewumi *et al*., 2025) [1]. These tools also support client interaction with design outputs.

In design review, AR supports comparison between planned models and real construction progress. This helps in detecting deviations during project execution (Rankohi and Waugh, 2013) [36]. Project teams use these systems to reduce design errors and improve coordination between disciplines. BIM models linked with immersive tools support visual review of project elements in real time (TechCabal, 2022) [9]. Project communication improves when stakeholders view the same digital model. This reduces confusion in design interpretation and supports shared understanding of project goals (Rauschnabel, Felix & Hinsch, 2022) [37]. Indigenous contractors in Nigeria are mainly locally owned firms that operate in limited financial and technical capacity. Many depend on advance payments from clients due to weak capital base (Odediran *et al*., 2012) [25]. They often operate in small regions and face difficulty in obtaining loans. Foreign contractors operate through multinational firms or subsidiaries. These firms carry stronger financial capacity and technical resources (Odediran *et al*., 2012) [25]. They handle large projects and often lead major construction works. Studies show that indigenous firms handle a smaller share of large projects due to weak funding and limited technical capacity (Ugochukwu & Onyekwena, 2014) [46].

Foreign construction companies dominate large infrastructure projects due to stronger management systems and financial backing. Indigenous companies also face challenges such as limited staffing and weak project management structures (Oraegbune & Haruna, 2022) [32]. These conditions affect their ability to compete for high-value contracts. BIM adoption varies between regions. Countries such as the United Kingdom and Singapore apply policy direction to support BIM use in public projects (HM Government, 2011) [18]. These regions show higher levels of structured adoption. In Africa and Nigeria, adoption remains at early stages. Studies report slow uptake due to weak infrastructure and limited policy direction (Oluwole, 2022) [31]. Several construction companies still rely on traditional methods. Barriers include high cost of software and hardware, lack of skilled personnel and weak institutional support (Osunsanmi, Aigbavboa & Oke, 2020) [33]. Absence of clear regulations also affects adoption levels (Okonta *et al*., 2023) [26]. In many developing countries, construction industries face limited access to training and digital tools. These factors affect use of BIM and immersive technologies in daily construction practice (Bouhmoud & Loudyi, 2021) [7].

**Challenges Facing BIM and Immersive Technology Application in Nigeria**

1. **Financial Constraints and High Implementation Costs**

Financial limitation remains a constraint in the deployment of Building Information Modelling and immersive technologies in construction practice. Several studies showed that initial investment requirements for hardware, software, training and system integration place a heavy burden on firms, particularly small and medium contractors. High software acquisition costs with expenses linked to staff development and system maintenance, reduce willingness to commit to full-scale adoption (Chidozie *et al*., 2025; Awodele, Mewomo & Eze, 2023) [5, 11]. In many construction firms, funding structures restrict internal capacity for digital investment. Odediran *et al*. (2012) [25] maintained that many indigenous contractors rely on client mobilisation funds and rarely obtain bank financing. Weak savings culture and absence of share capital further reduce the ability of firms to finance technological upgrades independently (Odediran *et al*., 2012) [25]. Similar financial pressure is reported in studies where BIM implementation costs are described as high relative to available project budgets, discouraging adoption among SMEs operating in uncertain economic environments (Chidozie *et al*., 2025) [11]. These financial limitations also extend to immersive technologies such as virtual reality and augmented reality, where equipment procurement and system maintenance demand sustained funding that many firms cannot guarantee.

**2. Skill Gaps and Inadequate Professional Training:**
Human capacity limitations form another barrier to BIM and immersive technology integration. Several studies showed insufficient technical expertise among construction professionals as a recurring issue. Lack of exposure to BIM methodologies, limited software training and inadequate practical experience reduce readiness for digital workflows (Awodele, Mewomo & Eze, 2023) [5]. Education systems in construction-related disciplines still rely heavily on theoretical teaching approaches, with limited access to applied digital tools. This creates a gap between graduate output and industry requirements, especially in relation to multidisciplinary BIM environments (Chidozie *et al*., 2025) [11]. Training constraints also affect cost barriers, where firms are unable to fund continuous professional development programmes for staff. Nnaji *et al*. (2022) [24], stressed that skill shortages are reinforced by insufficient training structures and limited availability of competent trainers in immersive and BIM-based technologies. This shortage affects both indigenous and foreign contractors operating in regions with weak digital training ecosystems.

**3. Weak Institutional and Policy Support:**
Institutional weaknesses and absence of coherent regulatory direction affect BIM and immersive technology adoption. Several studies report that construction sectors in developing contexts operate without strong policy frameworks guiding digital implementation. Without national BIM standards or mandated requirements, adoption remains inconsistent and dependent on individual firm decisions (Chidozie *et al*., 2025). Matthews *et al*. (2021) [11, 47] reported misalignment between existing legal and contractual frameworks and BIM-based project delivery systems. This mismatch creates uncertainty in responsibilities, data ownership and collaboration structures. Similarly, weak regulatory environments reduce incentives for firms to invest in digital transformation, since compliance requirements are not clearly defined. Awodele, Mewomo and Eze (2023) [5] identify lack of management and institutional support as a barrier that slows adoption processes. Absence of government-driven enforcement mechanisms also limits diffusion of BIM practices in public procurement systems.

**4. Resistance to Digital Transformation in Construction Firms**
Organisational resistance remains a persistent constraint in BIM and immersive technology adoption. Construction firms often maintain established workflows that are deeply rooted in traditional project delivery practices. Transitioning to digital systems introduces perceived risks related to productivity disruption, retraining costs and operational uncertainty. Several studies describe resistance among stakeholders as a behavioural and cultural challenge. The construction industry is often characterised by reluctance to change established procedures, particularly among senior personnel and decision-makers (Chidozie *et al*., 2025) [11]. This resistance reduces willingness to restructure workflows or invest in new systems. Chima and Udoekanem (2024) [12] report similar concerns, noting that resistance to technology among stakeholders remains a barrier to digitalisation in construction practice. Zawada (2024) [50] also observes that adoption of advanced digital solutions remains limited in some regions due to hesitation in embracing new technological processes. Resistance is reinforced by limited client demand for BIM deliverables. Without client pressure, firms have reduced motivation to shift from conventional methods.

**5. Infrastructure Limitations in Developing Regions**
Technological infrastructure constraints create operational barriers to BIM and immersive technology use. Stable internet connectivity, reliable electricity supply and updated digital systems are essential for real-time collaboration and data-intensive modelling processes. However, these requirements are not consistently available in many developing regions. Chidozie *et al*. (2025) [11] report unstable internet services, insufficient power supply and outdated technology as major constraints affecting BIM functionality. These limitations reduce efficiency in cloud-based collaboration and hinder use of immersive tools that require continuous system stability. Osunsanmi *et al*. (2020) [33] note that existing technological infrastructure in many construction firms is insufficient to support BIM implementation. Interoperability challenges also arise when firms operate with incompatible systems, limiting seamless data exchange between stakeholders (Oti & Tizani, 2020) [34]. Infrastructure gaps also extend to hardware availability. Many firms lack access to high-performance computing systems required for rendering immersive environments and managing large BIM datasets.

**6. Additional Operational and Systemic Constraints**
Beyond the core barriers, several related constraints influence adoption outcomes. High project labour demands associated with BIM modelling increase implementation cost pressure, particularly in low-budget project environments (Zima, Pachla & Węgrzyn, 2020) [52]. Limited interoperability between software platforms restricts collaboration between project participants, reducing efficiency in multi-stakeholder environments (Oti & Tizani, 2020) [34]. Contractual and legal misalignment also affects BIM use. Existing procurement systems do not always accommodate model-based workflows or digital data exchange requirements, creating uncertainty in liability and documentation processes (Matthews *et al*., 2021) [47]. In addition, limited access to bank loans and weak financial structures among contractors restrict long-term investment in digital infrastructure (Odediran *et al*., 2012). Nnaji *et al*. (2022) [24, 25] further identify fragmentation in the construction industry as a barrier, alongside limited policy direction and infrastructure gaps. These combined constraints influence both BIM and immersive technology adoption patterns across developing construction markets.

**Strategies for Enhancing BIM and Immersive Technology Application in Nigeria**
Improving the uptake of Building Information Modelling (BIM) and immersive technologies in Nigerian construction environment requires the following strategies:

1. Government should establish a national BIM policy that sets clear requirements for digital construction practices. Public projects should include BIM requirements in procurement procedures, approval processes and contract documentation. Regulatory agencies should develop construction guidelines that define BIM usage expectations for project delivery. A clear policy direction will encourage consistent application of digital modelling methods among contractors, consultants and project stakeholders.
2. Construction firms require improved technical knowledge to adopt BIM and immersive technologies effectively. Universities, polytechnics and professional training institutions should introduce BIM, virtual reality and other digital construction courses into architecture, engineering and construction programmes. Practical training sessions, software demonstrations and project-based learning should be used to develop industry-ready skills. Professional bodies should organise continuous training programmes that expose practitioners to BIM software applications, digital coordination methods and emerging construction technologies.
3. Government agencies, private construction firms, academic institutions and professional organisations should collaborate to support BIM adoption. Pilot projects funded through public-private partnerships can demonstrate the use of digital construction methods and provide practical learning opportunities for industry participants. Collaboration between researchers and construction firms can support testing of new technologies and improve knowledge transfer between academic institutions and industry practitioners.
4. Construction organisations should improve access to digital resources required for BIM implementation. Investment is needed in reliable internet services, computer equipment, cloud-based platforms and licensed BIM software. Government support for digital infrastructure development can improve access for smaller construction firms. Shared digital facilities and technology support centres can help firms that lack resources to establish individual systems.
5. Financial support programmes should be introduced to reduce the cost barriers associated with BIM and immersive technology adoption. Government and private investors should provide grants, tax incentives and funding schemes that assist construction firms in purchasing software, upgrading hardware and training employees. Construction companies should also allocate resources for digital transformation by developing internal training plans, employing skilled personnel and creating workflows that support technology use.
6. Educational institutions should work with construction companies to align BIM training with industry requirements. Student internships, industry-led workshops and practical project exercises can improve exposure to digital construction processes. Construction firms should participate in curriculum development and provide opportunities for students and young professionals to gain experience with BIM tools and immersive technologies.
7. Construction firms should develop internal policies that support the use of digital technologies in project delivery. Company leaders should promote staff training, technology investment and the use of digital information management systems. Assigning trained personnel to manage BIM processes, cloud collaboration platforms and digital project workflows can improve technology adoption and long-term use.

## Conclusion

The application of Building Information Modelling (BIM) and immersive technologies presents opportunities for improving construction planning, coordination, communication and project delivery in the Nigerian construction industry. BIM provides a data-based approach that supports information management throughout the building life cycle, while immersive technologies such as virtual reality and augmented reality improve visualisation, design review and site activities. Despite these benefits, adoption remains limited due to financial barriers, shortage of skilled professionals, weak policy support, inadequate infrastructure, organisational resistance and limited access to digital resources. Addressing these challenges requires coordinated efforts from government institutions, educational bodies, professional organisations and construction firms through policy development, capacity building, investment in digital systems and financial support for technology adoption. Improved access to training, infrastructure and digital tools will strengthen the ability of indigenous contractors to participate in technology-driven construction practices. A supportive environment for BIM and immersive technology adoption will improve competitiveness, project efficiency and the overall performance of the Nigerian construction sector.

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