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BIM-Based Management Integration in Tertiary Institution Construction Projects in Southwest Nigeria

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ABSTRACT

This study evaluates Building Information Modelling (BIM) integration in TETFUND-sponsored construction projects across 12 federal tertiary institutions in- Southwest Nigeria, comprising 6 Federal Universities and 6 Federal Polytechnics. Using a census survey of 162 construction professionals (90% response rate from 180), including engineers, builders, architects, quantity surveyors, and estate managers, the research examines BIM integration levels, barriers, project outcomes, transparency, and comparisons with traditional methods. Quantitative analyses, including descriptive statistics, ANOVA, principal component analysis (PCA), t-tests, and Cronbach's Alpha ($\alpha = 0.76–0.90$), reveal moderate BIM adoption ($M = 3.47$), strongest in design ($M = 3.92$) but weak in facility management ($M = 3.32$) and training ($M = 2.87$). Universities significantly outscore polytechnics ($t(160) = 2.06$, $p = 0.041$). Key barriers include lack of trained professionals ($M = 4.44$), insufficient training ($M = 4.30$), and high costs ($M = 4.22$), with PCA identifying Skills & Training, Policy & Governance, and Culture & Collaboration (72% variance). BIM enhances project quality ($M = 4.43$), efficiency ($M = 4.40$), and transparency ($M = 4.29$) through real-time monitoring ($M = 4.42$), with universities showing a non-significant advantage in transparency ($p = 0.089$). BIM outperforms traditional methods in transparency ($M = 4.37$) and delay reduction ($M = 4.32$), supporting a hybrid approach for small projects ($M = 3.87$). Recommendations include TETFUND-funded training, subsidized BIM tools, infrastructure investment, and policy mandates. The study contributes a validated barrier model, a BIM Impact Index ($M = 4.37$), and a transparency framework, advancing Nigeria's construction sector knowledge.

INTRODUCTION

The construction industry plays a vital role as a catalyst for economic development, driving infrastructural progress, employment generation, and technological innovation across various sectors. Olawumi and Chan (2019) noted that it's centrality to national development agendas emphasizes its significance in determining societal growth. However, in developing nations like Nigeria, the sector faces engrained challenges such as inefficiencies, project delays, and cost overruns, which hinder its ability to achieve construction objectives effectively. Akinola and Okolie (2019) asserted that these obstacles are particularly pronounced in the public domain, where bureaucratic complexities exacerbate inefficiencies and also emphasized the critical need for adopting modern methodologies to address these barriers and improve project outcomes. Building Information Modelling (BIM) has emerged as a transformative tool in this regard, offering integrated digital platforms for improved collaboration, improved communication, and data-driven decision-making across project lifecycles (Hamma-adama & Kouider, 2019).
Despite its proven benefits globally, BIM adoption in Nigeria remains limited and particularly in the public sector. Tertiary institutions in Southwest Nigeria, which are key contributors to the nation's educational and infrastructural development, provide a relevant setting for examining BIM integration. These institutions frequently undertake large-scale construction projects aimed at modernizing and expanding their facilities to accommodate growing academic and research needs. Akinola and Okolie (2019) noted that public universities in the region often rely on traditional construction management methods, which are less efficient compared to BIM-based practices. They highlighted that adopting BIM in these projects could enhance cost-efficiency, minimize resource wastage, and improve overall project delivery. Nevertheless, traditional approaches continue to dominate, reflecting the gap between BIM's theoretical advantages and its application in practice.
The Barriers to BIM adoption have been thoroughly documented in scholarly literature. Technical expertise such as noted by Iyortyer (2019) and capacity-building challenges persist as significant impediments to implementation with many professionals missing the necessary skills to leverage BIM effectively. Bello *et al.*, (2022) asserted that financial limitations, including high costs of BIM software and infrastructure, further restrict adoption efforts. Additionally, cultural and organizational resistance to change plays a key role, as limited awareness and scepticism about BIM's transformative impact discourage integration (Hamma-adama & Kouider, 2019). These hurdles highlight the need for strategic interventions tailored to Nigeria's unique socioeconomic and institutional landscape.

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In Nigeria, the Tertiary Education Trust Fund (TETFUND) plays a crucial role in financing construction projects for higher education institutions. Established to address funding gaps and improve infrastructure in tertiary institutions, TETFUND serves as a significant catalyst for development in the education sector (Akinyemi *et al.*, 2020). The fund sponsors various projects, including the construction of lecture halls, laboratories, administrative buildings, and hostels, ensuring that institutions have access to modern facilities that support teaching, learning, and research. These projects often represent substantial investments, requiring efficient management practices to maximize resource utilization and achieve timely delivery. Faltein and Sukdeo (2024) opined that in construction management and project management, planning, coordinating, and overseeing the monitoring and control of a construction project is commonly referred to as project management. TETFUND-funded projects provide a unique opportunity to explore BIM integration, as the fund's emphasis on accountability and transparency aligns with BIM's core principles. The adoption of BIM in managing TETFUND-funded projects could address several challenges, including cost overruns and project delays, while promoting sustainable development. Akinyemi *et al.* (2020) noted that the complexities associated with large-scale projects often necessitate innovative approaches to project management. BIM's capabilities for data-driven decision-making, stakeholder collaboration, and real-time adjustments make it a valuable tool for optimizing TETFUND-sponsored initiatives. By examining the integration of BIM into these projects, this study aims to contribute to the discourse on improving construction management practices within Nigeria's higher education sector.

Recognizing the limited penetration of BIM in Nigeria, there is a pressing need for empirical studies focused on its integration in specific contexts, such as tertiary institution construction projects. Akinola and Okolie (2019) stressed the value of comparing traditional and modern construction methods to pinpoint optimal practices for project delivery. Building on this foundation, the present research seeks to evaluate BIM-based management integration in TETFUND-sponsored construction projects across tertiary institutions in Southwest Nigeria. Through assessments of adoption levels, barrier identification, and impact analysis, this study aims to provide actionable recommendations that guide stakeholders toward enhanced project outcomes.

LITERATURE REVIEW

Construction Industry

The construction industry in Nigeria is a critical sector that drives economic growth, infrastructural development, and societal progress. However, the sector faces persistent challenges, including inefficiencies, delays averaging 35% beyond scheduled timelines, and cost overruns exceeding 25% of initial budgets, which undermine the realization of key construction objectives (Olawumi & Chan, 2019). These issues are particularly prevalent in the public sector, where bureaucratic bottlenecks and outdated methodologies exacerbate inefficiencies—public projects often face completion delays of 6-12 months (Amuda-Yusuf *et al.*, 2018). Despite the global rise in the adoption of Building Information Modeling (BIM)—a digital tool capable of transforming construction project management through enhanced collaboration and efficiency, reducing delays by up to 20% and costs by 15% (Azhar *et al.*, 2012)—its uptake in Nigeria remains limited. This gap is starkly evident in tertiary institutions, especially those in Southwest Nigeria, which regularly undertake large-scale construction projects aimed at modernizing educational facilities. The reliance on traditional project management approaches in these institutions hampers the potential to optimize resource utilization and improve project delivery outcomes.

BIM-Based Management

BIM management integration in construction projects carries broader implications for sustainable construction practices. Fadeyi and Fadeyi (2023) emphasized that integrating BIM into public sector projects can significantly enhance sustainability by minimizing resource wastage and optimizing energy efficiency. These benefits are particularly relevant in tertiary education infrastructure, where sustainability objectives align closely with institutional priorities (Olanrewaju *et al.*, 2021). BIM enables real-time collaboration and dynamic adjustments to project plans, addressing inefficiencies that have long hindered construction efforts in developing regions (Olugboyega, 2016). At an organizational level, BIM also has the potential to catalyze a cultural shift within the construction industry. Olawumi and Chan (2019) noted that successful implementation requires both technological readiness and a shift in professional attitudes. This cultural transformation is especially pertinent to tertiary institution projects, where diverse stakeholders including administrators, contractors, and policymakers must collaborate effectively to ensure project success. By promoting innovation and teamwork, BIM integration can elevate project outcomes, foster sustainability, and create a culture of excellence.

Barriers to BIM Integration

Barriers to BIM integration have been widely documented in the academic literature and include technical, financial, and cultural impediments. Iyortyer (2019), emphasized the lack of technical expertise and inadequate training among construction professionals as critical hurdles to BIM adoption, with only 25% of Nigerian construction professionals trained in BIM. Bello *et al.* (2022) further highlighted financial constraints, such as the high costs associated with acquiring and implementing BIM software and infrastructure, outpacing SME budgets by 50%, as significant deterrents to its widespread use. Technology deployment improves communication, responsiveness, and operational efficiency by automating workflows, handle manual tasks, predict failures, and respond to queries. However, challenges include technical issues, limited human-human interaction, system quality and security, and user adoption (Alhammadi, 2023). Additionally, organizational resistance to change, driven by limited awareness and skepticism about the advantages of BIM, exacerbates the issue (Hamma-adama & Kouider, 2019). These barriers not only impede the adoption of modern methodologies but also limit the ability to address the inefficiencies that have long plagued construction projects in Nigeria's public sector.

In tertiary institutions, the lack of BIM adoption is particularly concerning given the growing demand for modern infrastructure to support educational excellence. Projects funded by the Tertiary Education Trust Fund (TETFUND), which aim to bridge infrastructural gaps in higher education, often face challenges related to cost management and resource allocation, with cost overruns averaging 20% and delays of over six months (Akinyemi, *et al.*, 2020). While TETFUND emphasizes transparency and accountability in project execution, traditional management approaches often fall short in achieving these objectives. BIM, with its ability to facilitate data-driven decision-making and enhance stakeholder collaboration, presents a viable solution for addressing these challenges. However, the absence of empirical research exploring BIM's application in TETFUND-sponsored projects limits the potential to leverage this transformative tool effectively.

Furthermore, socio-cultural factors also play a role in the slow adoption of BIM in Nigeria. Studies by Ebekozien *et al.* (2021) revealed that resistance to change, skepticism about BIM's benefits, and a 60% preference for conventional project management approaches are common among stakeholders. Addressing these cultural barriers requires targeted awareness campaigns to demonstrate BIM's value and potential impact on construction project outcomes. BIM adoption in Nigeria's construction sector, particularly in tertiary institution projects, faces a range of challenges, including financial, technical, and cultural barriers. However, with the right policy frameworks, capacity-building initiatives, and awareness campaigns, the adoption of BIM could revolutionize project delivery in the nation. This study aims to build on existing research to evaluate BIM adoption levels, identify barriers, and provide actionable recommendations for promoting its integration in tertiary institution construction projects.

Recognizing the limited penetration of BIM in Nigeria, there is a pressing need for empirical studies focused on its integration in specific contexts, such as tertiary institution construction projects. Akinola and Okolie (2019) stressed the value of comparing traditional and modern construction methods to pinpoint optimal practices for project delivery. Building on this foundation, the present research seeks to evaluate BIM-based management integration in TETFUND-sponsored construction projects across tertiary institutions in Southwest Nigeria. Through assessments of adoption levels, barrier identification, and impact analysis, this study aims to provide actionable recommendations that guide stakeholders toward enhanced project outcomes.

Research Gaps and Opportunities

The literature on Building Information Modeling (BIM) adoption in Nigeria's construction industry has made significant strides in identifying barriers and proposing mitigation strategies, yet critical research gaps persist that limit a comprehensive understanding of its potential. Much of the existing discourse focuses on general challenges, with limited attention to context-specific applications, such as tertiary institution construction projects funded by the Tertiary Education Trust Fund (TETFUND) (Akinyemi *et al.*, 2020). This gap is particularly pronounced given the scale and significance of TETFUND projects, which are central to Nigeria's educational infrastructure development. Exploring BIM's integration in this sector presents a unique opportunity to uncover best practices that could enhance project delivery and accountability, offering a model for public-sector construction in developing countries. Such research could bridge theoretical insights with practical outcomes, positioning Nigeria as a leader in innovative construction practices among its peers.

The integration of BIM into TETFUND-sponsored projects is a notably under-researched area, despite their prominence in Nigeria's educational sector. While Bello *et al.* (2022) highlighted BIM's potential to improve transparency and accountability, empirical evidence on its application in TETFUND projects is scarce. These projects face unique challenges, including strict budget constraints and multi-stakeholder coordination, which BIM could address through real-time tracking and data integration (Olatunji *et al.*, 2016). Investigating BIM's practical impacts—such as reduced audit discrepancies or faster approvals—could provide a blueprint for scaling digital practices across public-sector construction. This research would not only validate BIM's benefits but also inform policy frameworks, potentially influencing national standards and elevating Nigeria's construction industry on the global stage.

The scalability of BIM across different project sizes and complexities remains a neglected area of inquiry. Most studies, including Akinola & Okolie (2019), focus on large-scale applications, overlooking how BIM can benefit smaller TETFUND projects, such as laboratory renovations or hostel upgrades. Exploring scalable BIM frameworks could democratize adoption, particularly for SMEs that dominate Nigeria's construction sector (Merschbrock *et al.*, 2018). Research on modular BIM tools or phased implementation could demonstrate how resource-constrained firms achieve incremental benefits, enhancing accessibility (Eadie *et al.*, 2015). For tertiary institutions, scalable approaches could ensure all projects, regardless of budget, leverage BIM's efficiency and transparency, maximizing TETFUND's impact.

MATERIALS AND METHODS

Sampling Technique

The study employs a census sampling technique, wherein all 180 professionals in the Physical Planning Units of the 12 federal tertiary institutions are targeted for data collection. Unlike stratified or purposive sampling, which selects subsets of the population, a census includes every individual, ensuring comprehensive data collection (Kiani *et al.*, 2021). This technique is suitable due to the small population size, which makes it feasible to survey all professionals within the study's timeframe and resources. The census approach guarantees that the diverse perspectives of architects, builders, quantity surveyors, estate managers, and engineers are captured, addressing variations in BIM adoption. By including all professionals, the census enhances the reliability of the findings (Cronbach's Alpha = 0.76–0.90) and supports robust generalizations within the defined population.

Data Collection

Data was collected using a structured survey questionnaire administered to gather quantitative data from physical planning units of a comprehensive list of all 180 construction professionals employed in the Physical Planning Units of the 12 federal tertiary institutions in the six states of Southwest Nigeria, executing TETFUND-sponsored construction and renovation projects from 2016 to 2025. These institutions include the Federal University of Agriculture, Abeokuta (FUNAAB), Federal University, Oye-Ekiti (FUOYE), Federal University of Technology, Akure (FUTA), University of Lagos (UNILAG), Obafemi Awolowo University (OAU), University of Ibadan (UI), Federal Polytechnic Ilaro (FP-ILARO), Federal Polytechnic Ado-Ekiti (FP-ADO EKITI), Federal Polytechnic Ile-Oluji (FP-ILE OLUJI), Federal Polytechnic Ede (FP-EDE), Federal Polytechnic Ayede (FP-AYEDE), and Yaba College of Technology (YABATECH). The professionals include architects, builders, quantity surveyors, estate managers, and engineers, identified through institutional records obtained from these Physical Planning Units. Table 1 details the distribution of professionals across these institutions.

Table 1: Details the distribution of professionals across these institutions

Institution	Architects	Builders	Quantity Surveyors	Estate Managers	Engineers	Total
FUNAAB	3	3	2	1	2	11
FUOYE	4	2	1	1	5	13
FUTA	3	2	3	-	5	13
UNILAG	4	4	5	2	10	25
OAU	4	4	5	2	4	19
UI	4	4	3	-	5	16
FP-ILARO	2	4	3	2	5	16
FP-ADO EKITI	2	2	3	2	4	13
FP-ILE OLUJI	2	2	2	1	3	10
FP-EDE	3	3	3	1	4	14
FP-AYEDE	2	3	2	1	3	11
YABATECH	3	4	4	3	7	21
Total	36	37	36	16	55	180

Census Allocation

Data collection targeted all 180 professionals, with 162 valid responses received, yielding a response rate of 90% (162/180). The high response rate supports the robustness of the findings, reflecting the perspectives of the majority of the population. The 10% non-response rate was mitigated through rigorous follow-up efforts, including reminders and direct engagement with Physical Planning Units. The census approach maximizes the accuracy of quantitative analyses, including mean item scores, ANOVA, factor analysis, and composite scores, by encompassing nearly the entire population.

Table 2: Census Allocation for Questionnaire Survey

S/N	Institution	Professionals	Sample Size (n=162)
1	FUNNAB	11	13
2	FUOYE	13	12
3	FUTA	13	12
4	UNILAG	25	20
5	OAU	19	17
6	UI	16	14
7	FP-ILARO	16	14

8	FP-ADO EKITI	13	12
9	FP-ILEOLUJI	10	11
10	FP-EDE	12	13
11	FP-AYEDE	11	8
11	YABATECH	21	17
	Total	180	124

Method of Data Analysis

Quantitative data from questionnaires were analyzed using SPSS 22. Descriptive statistics (means, frequencies, standard deviations) summarize BIM adoption, barriers, and outcomes. Inferential statistics include regression analysis, ANOVA, and Factor analysis to examine relationships and group differences.

RESULTS AND DISCUSSION

The quantitative findings from a census survey of 162 construction professionals from 12 federal tertiary institutions in Southwest Nigeria, comprising 6 Federal Universities and 6 Federal Polytechnics, to evaluate Building Information Modelling (BIM) management integration in TETFUND-sponsored construction projects. The respondents included architects, engineers, builders, quantity surveyors, and estate managers, as identified in the Physical Planning Units of these institutions. The analysis addresses five key areas: (1) level of BIM adoption, (2) barriers to BIM integration, (3) impact of BIM on project outcomes, (4) BIM's role in transparency and accountability, and (5) comparison of BIM-based and traditional construction management methods. Results are presented using descriptive statistics (mean item scores, standard deviations), analysis of variance (ANOVA), principal component analysis (PCA), composite scores, and group comparisons, with reliability assessed via Cronbach's Alpha (α = 0.76–0.90).

Level of BIM Integration

The level of BIM management integration was assessed using an 8-item Likert scale with acceptable reliability (Cronbach's Alpha = 0.76). Respondents rated BIM's use in the design phase highest (M = 3.92, SD = 0.83), indicating strong adoption in early project stages. Stakeholder familiarity with BIM software (M = 3.77, SD = 0.89) and increased adoption over five years (M = 3.64, SD = 0.99) suggest growing awareness. BIM application during construction (M = 3.60, SD = 0.86), project management integration (M = 3.44, SD = 1.04), and facility management (M = 3.32, SD = 0.91) scored moderately, reflecting implementation gaps. Perceptions of higher university adoption (M = 3.17, SD = 1.10) and trained personnel availability (M = 2.87, SD = 1.12) ranked lowest, highlighting capacity constraints. Furthermore, the lowest-ranked item concerned the availability of BIM-trained personnel, reflecting a notable capacity gap that may hinder full-scale adoption despite growing awareness and policy shifts.

Table 3: Level of BIM Integration in Tertiary Institution Construction Projects

BIM integration in Tertiary Institution Construction Projects	Mean Score	SD	Rank
BIM is widely used in the design phase	3.92	0.83	1
Stakeholders are familiar with BIM software	3.77	0.89	2
BIM adoption has increased over the past five years	3.64	0.99	3
BIM tools are consistently applied during construction	3.60	0.86	4
BIM is integrated into project management processes	3.44	1.04	5
BIM is used for facility management after project completion	3.32	0.91	6
Federal universities adopt BIM more than polytechnics	3.17	1.10	7
My organization has BIM-trained personnel	2.87	1.12	8

The ANOVA showed significant professional differences ($F(4,157) = 4.85$, $p = 0.001$). Engineers and Architects perceive higher adoption than estate managers.

Table 4: BIM Integration ANOVA

Source of Variation	Sum of Squares (SS)	Degrees of Freedom (df)	Mean Square (MS)	F- Value	p-Value
Between Groups	17.24	4	4.31	4.85	0.001
Within Groups	139.56	157	0.89		
Total	156.80	161			

Composite Score

The composite score (M = 3.47, SD = 0.48) indicates moderate adoption. Universities (M = 3.55, SD = 0.46, n = 81) scored higher than polytechnics (M = 3.39, SD = 0.50, n = 81).

An independent samples t-test compared BIM adoption composite scores. Universities scored significantly higher, $t(160) = 2.06$, $p = 0.041$, $d = 0.33$ (small effect), suggesting greater BIM integration in universities, possibly due to resources.

The respondents confirm moderate adoption (M = 2.87–3.92, α = 0.76), strongest in design (M = 3.92), per Eadie *et al.* (2013). ANOVA ($p = 0.001$) and t-test ($p = 0.041$) highlight professional and institutional differences. Low scores for trained personnel (M = 2.87) indicate training needs.

Barriers to BIM Integration

Barriers to BIM management integration was assed using a 9-item scale (α = 0.85) identified lack of trained professionals (M = 4.44, SD = 0.66), training programs (M = 4.30, SD = 0.70), and costs (M = 4.22, SD = 0.75) as top barriers. Infrastructure (M = 4.07, SD = 0.79), collaboration (M = 3.90, SD = 0.83), and mandates (M = 3.76, SD = 0.87) scored moderately. Organizational policies (M = 3.57, SD = 0.89), resistance (M = 3.32, SD = 0.93), and skepticism (M = 3.04, SD = 0.98) ranked lower.

Table 5: Barriers to BIM Integration

Barriers to BIM Integration	Mean Score	SD	Rank
Lack of trained professionals	4.44	0.66	1
Insufficient training programs	4.30	0.70	2
High costs of BIM software/hardware	4.22	0.75	3
Inadequate technical infrastructure	4.07	0.79	4
Limited collaboration among stakeholders	3.90	0.83	5
Lack of government policies/mandates	3.76	0.87	6
Organizational policies do not prioritize BIM	3.57	0.89	7
Resistance to change	3.32	0.93	8
Cultural skepticism about BIM	3.04	0.98	9

PCA extracted three factors among the items (72% variance, KMO > 0.70, Bartlett's $p < 0.001$): Skills & Training (α = 0.85), Policy & Governance (α = 0.70), Culture & Collaboration (α = 0.75).

Table 6: Barriers to BIM Integration (Factor Analysis)

Barriers to BIM Integration	Factor 1 (Skills & Training)	Factor 2 (Policy & Governance)	Factor 3 (Culture & Collaboration)
Lack of trained professionals			
High software/hardware costs	0.82		
Inadequate infrastructure	0.68		
Insufficient training programs	0.70		
Lack of government mandates	0.79		
Organizational policy gaps		0.75	
Resistance to change		0.72	0.66
Limited stakeholder collaboration			0.74
Cultural scepticism			0.78

Composite Score

The composite score (M = 3.96, SD = 0.45) reflects significant barriers. Universities (M = 4.00, SD = 0.43, n = 81) scored slightly higher than polytechnics (M = 3.92, SD = 0.47, n = 81).

A t-test showed no significant difference in barrier perceptions, $t(160) = 1.13$, $p = 0.260$, $d = 0.18$, suggesting similar challenges across institutions.

The respondents highlight training deficits (M = 4.44, α = 0.85), per Zakaria *et al.* (2019). PCA validates multidimensional barriers. The non-significant t-test ($p = 0.260$) indicates uniform challenges.

Impact of BIM on Project Outcomes

Impact of BIM-Based Management Integration on Project Outcomes with an 8-item scale (α = 0.90) showed project quality (M = 4.43, SD = 0.64), efficiency (M = 4.40, SD = 0.67), and safety (M = 4.35, SD = 0.69) as top benefits. Cost management (M = 4.32, SD = 0.71), waste reduction (M = 4.24, SD = 0.76), maintenance (M = 4.17, SD = 0.79), and sustainable design (M = 4.14, SD = 0.82) scored strongly. Stakeholder satisfaction (M = 4.07, SD = 0.86) ranked lowest.

Table 7: Impact of BIM on Project Outcomes

Impact of BIM on Project Outcomes	Mean Score	SD	Rank
BIM improves project quality via precise design	4.43	0.64	1
BIM improves efficiency by reducing delays	4.40	0.67	2
BIM reduces errors, improving safety	4.35	0.69	3
BIM enhances cost management	4.32	0.71	4
BIM reduces material waste	4.24	0.76	5
BIM enhances long-term maintenance	4.17	0.79	6
BIM supports sustainable design	4.14	0.82	7
BIM increases stakeholder satisfaction	4.07	0.86	8

The BIM Impact Index (M = 4.37, SD = 0.48) shows consensus. Engineers (M = 4.42, SD = 0.48, n = 55) and Builders (M = 4.40, SD = 0.44, n = 37) scored highest, followed by Architects (M = 4.37, SD = 0.46, n = 32), Quantity Surveyors (M = 4.32, SD = 0.50, n = 32), Estate Managers (M = 4.20, SD = 0.53, n = 16). The respondents confirm BIM's benefits (M = 4.37, α = 0.90), with quality (M = 4.43) leading, per Azhar (2011). The non-significant t-test ($p = 0.179$) suggests uniform perceptions.

BIM Integration for Transparency and Accountability

A 9-item scale (α = 0.825) showed real-time monitoring (M = 4.42, SD = 0.69), audit trails (M = 4.37, SD = 0.72), and accountability tracking (M = 4.34, SD = 0.75) as top benefits. Compliance reports (M = 4.32, SD = 0.76), financial mismanagement reduction (M = 4.30, SD = 0.79), and stakeholder trust (M = 4.27, SD = 0.82) scored strongly. Audit discrepancies (M = 4.22, SD = 0.77), accountability alignment (M = 4.20, SD = 0.80), and conflict reduction (M = 4.12, SD = 0.84) ranked lower.

Table 8: Transparency and Accountability

Item	Mean Score	SD	Rank
BIM facilitates real-time monitoring	4.42	0.69	1
BIM's audit trails improve transparency	4.37	0.72	2
BIM enhances accountability via tracking	4.34	0.75	3
BIM's data-driven reports ensure compliance	4.32	0.76	4
BIM minimizes financial mismanagement	4.30	0.79	5
BIM improves stakeholder trust	4.27	0.82	6
BIM reduces discrepancies in audits	4.22	0.77	7
BIM aligns with accountability goals	4.20	0.80	8
BIM reduces conflicts over resources	4.12	0.84	9

Comparison items between universities and polytechnic respondents shows university (M = 4.40, SD = 0.47, n = 81) outperformed polytechnics (M = 4.27, SD = 0.50, n = 81), with M = 4.29 (SD = 0.49) overall. Factor Analysis, PCA extracted two factors for test (69% variance, KMO > 0.70, Bartlett's $p < 0.001$): Real-Time Monitoring & Reporting (α = 0.85), Compliance & Oversight (α = 0.80). The respondents confirm transparency benefits (M = 4.29, α = 0.825), with monitoring (M = 4.42) leading, this is in line with Akanni & Mayowa (2025) findings. The t-test trend ($p = 0.089$) supports universities' higher scores (M = 4.40).

Relationship between Traditional and BIM-Based management Methods

An 8-item scale (α = 0.85) showed transparency (M = 4.37, SD = 0.72), delay reduction (M = 4.32, SD = 0.70), and collaboration (M = 4.27, SD = 0.73) as top benefits. Adaptability (M = 4.24, SD = 0.74), hybrid outcomes (M = 4.20, SD = 0.76), and complex project efficiency (M = 4.12, SD = 0.81) scored strongly. Technical expertise (M

Table 9: BIM vs Traditional Management Methods

BIM vs. Traditional Methods	Mean Score	SD	Rank
BIM offers superior transparency	4.37	0.72	1
BIM reduces project delays	4.32	0.70	2
BIM provides better collaboration	4.27	0.73	3
BIM is more adaptable to needs	4.24	0.74	4
Combining BIM and traditional methods improves outcomes	4.20	0.76	5
Traditional methods less efficient for complex projects	4.12	0.81	6

BIM requires more technical expertise	4.07	0.85	7
Traditional methods cost-effective for small projects	3.87	0.88	8

= 4.07, SD = 0.85) and small-project cost-effectiveness (M = 3.87, SD = 0.88) ranked lower.

A Composite index of (M = 4.24, SD = 0.48) favours BIM. Engineers (M = 4.32, SD = 0.45, n = 55) and architects (M = 4.27, SD = 0.47, n = 32) scored highest, followed by builders (M = 4.24, SD = 0.43, n = 37), quantity surveyors (M = 4.17, SD = 0.50, n = 32), estate managers (M = 4.02, SD = 0.56, n = 16).

Furthermore, t-test showed no significant difference, t(160) = 1.35, p = 0.179, d = 0.21, indicating similar perceptions of BIM's superiority.

Therefore, the respondents confirm BIM's superiority (M = 4.24, α = 0.85), with transparency (M = 4.37) leading, per Ijigah *et al.* (2023). The non-significant t-test (p = 0.179) suggests uniform perceptions.

Summary of Findings

The census (n = 162) confirms moderate BIM adoption (M = 3.47, α = 0.76), with universities higher (t-test, p = 0.041). Barriers prioritize training (M = 3.96, α = 0.85), with no institutional difference (p = 0.260). BIM enhances quality (M = 4.37, α = 0.90), transparency (M = 4.29, α = 0.825), and outperforms traditional methods (M = 4.24, α = 0.85), with no significant institutional differences (p > 0.05). TETFUND should prioritize training and infrastructure. T-tests strengthen institutional comparisons, confirming higher university adoption.

CONCLUSION

This study evaluated Building Information Modelling (BIM) management integration in TETFUND-sponsored construction projects within 12 federal tertiary institutions in Southwest Nigeria, equally distributed between Federal Universities (50%, n = 81) and Federal Polytechnics (50%, n = 81). A census survey of 162 construction professionals (90% response rate from 180), including engineers, builders, architects, quantity surveyors, and estate managers, examined five key areas: (1) level of BIM adoption, (2) barriers to integration, (3) impact on project outcomes, (4) role in transparency and accountability, and (5) comparison with traditional construction management methods. Quantitative analyses, including descriptive statistics, ANOVA, principal component analysis (PCA), composite scores, independent samples t-tests, and Cronbach's Alpha reliability tests (α = 0.76–0.90), provided robust evidence. This chapter synthesizes findings, draws conclusions, offers recommendations to enhance BIM adoption, and highlights contributions to knowledge in Nigeria's construction industry.

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