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Integrating Building Technology in Vocational training for sustainable construction practices in Nigeria

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Abstract

The construction industry is a cornerstone of Nigeria's socio-economic development, yet it faces mounting pressure to adopt sustainable practices amidst rapid urbanization and environmental degradation. Despite the urgent need for "green" transition, a critical skills deficit persists among vocational and technical graduates, directly hindering the adoption of sustainable building methods. This paper explores the integration of modern building technology into Technical and Vocational Education and Training (TVET) as a strategic pathway to bridge this gap. Using a comprehensive review of empirical studies, policy documents, and institutional frameworks, the research evaluates the current state of TVET in Nigeria and identifies essential technological tools, including Building Information Modelling (BIM), renewable energy integration, and sustainable material application. The findings reveal that curriculum obsolescence, insufficient instructor capacity, inadequate infrastructure, and weak industry-institution linkages are the primary barriers to progress. Consequently, the paper proposes a multi-stakeholder framework encompassing curriculum reform, digital tool adoption, and policy incentives. The study concludes that the systematic integration of building technology within TVET is not only achievable but essential for advancing Nigeria's sustainable development agenda and ensuring a future-ready construction workforce.

Keywords: Building Technology, Vocational Training, Sustainable Construction, TVET, Technical Education

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Introduction

The building and construction sector remain one of the largest contributors to national development in Nigeria. It provides employment opportunities, supports urbanization, and contributes significantly to Gross Domestic Product (GDP). However, rapid urban growth, population increase, housing deficits, and climate-related concerns have exposed weaknesses in traditional construction practices. The global construction industry is one of the leading contributors to greenhouse gas emissions, resource depletion, and environmental degradation, accounting for approximately 38% of global energy-related carbon dioxide emissions (United Nations Environmental Programme (UNEP), 2022). In Nigeria, the construction sector contributes approximately 9.8% of the nation's GDP and is experiencing unprecedented growth driven by rapid urbanization, population expansion, and a growing housing deficit estimated at over 22 million units (National Bureau of Statistics, 2022); Nigerian Institute of Building (NIOB, 2022). This expansion, while economically significant, simultaneously amplifies environmental risks and demands a fundamental rethinking of how construction activities are designed, delivered, and sustained.

Building technology refers to the scientific and technical application of construction methods, materials, systems, equipment, and digital innovations used in planning, designing, constructing and maintaining buildings. Building technology education is a branch of technical and vocational education that focuses on the study, design, construction, maintenance, and management of buildings and related infrastructure. It combines theoretical knowledge with practical skills to train individuals in various aspects of the building industry, including construction methods, materials, drawing, estimation, structural design, and site supervision. According to the National Board for Technical Education (NBTE, 2015), Building Technology is designed to produce skilled technicians, technologists, and craftsmen who effectively participate in the planning, construction, and maintenance of buildings using modern technologies and sustainable practices. Similarly, Olaitan (1996) defines building technology education as the systematic training and instruction that prepare learners for occupations in the building and construction sector through the acquisition of relevant competencies, knowledge, and attitude.

Sustainable construction focuses on minimizing environmental impacts, conserving resources, promoting energy efficiency, ensuring social wellbeing, and achieving economic value throughout a building's life circle. Therefore, Nigeria must strengthen vocational training institutions to produce skilled professionals capable of implementing sustainable building solution. Sustainable construction defines as the creation and responsible maintenance of built environments using resource-efficient and ecologically responsible processes-has emerged as the preferred paradigm for reconciling construction growth with environment responsibility (Kibert, 2016). However, the adoption of sustainable construction practices in Nigeria remains markedly limited. Research consistently identifies a shortage of skilled professional trained in green building technologies, sustainable material and modern digital construction tools as a principal barrier (Akindele et al., 2023; Atanda & Olukoya, 2019). This sills deficit is particularly acute at the intermediate and artisanal level of construction workforce-precisely the levels served by TVET institutions.

TVET institutions, including technical colleges, polytechnics and vocational training centres, constitute the foundational pipeline for Nigeria's construction workforce. These institutions train the bricklayers, carpenters, electricians, plumbers, and site supervisors who carry out the vast majority of physical construction work across the country. Yet prevailing curricula in many of these institutions remains anchored in conventional building methods, with limited

integration of contemporary building technologies, energy efficiency principles, or sustainable practices (Okanya, 2023; Adeyemi & Okonkwo, 2021). TVET provides the practical oriented training needed to translate these ideals into on site practices through skilled masons, bricklayers, surveyors, and building construction technicians.

There is, therefore, an urgent need to explore how building technology can be meaningfully integrated into vocational training programmes to equip students with the competencies required for sustainable construction.

Objective of the study

This paper is guided by the following objective

- To examine the current state of building technology integration in Nigeria TVET institutions.
- To identify the key building technologies relevant to sustainable construction training.
- To evaluate the barriers and facilitating factors for technology integration in vocational training.
- To propose an evidence-based framework for integrating building technology in TVET programmes for sustainable construction in Nigeria.

CONCEPTUAL AND THEORETICAL FRAMEWORK

Sustainable construction is rooted in the broader concept of sustainable development, defined by the Brundtland commission (1987) as development that meets the needs of present without compromising the ability of the future generations to meet their own needs. Applied to the built environment, Kibert (2016) articulated sustainable construction through six resource principle: reduce, reuse, recycle, protect nature, use non-toxic materials, and apply life- cycle costing. The concept encompasses not only environmental dimensions but also social equity and economic viability-the three interconnected pillars of sustainability.

In Nigerian context, sustainable construction extends to considerations of local climate adaptation, the use of indigenous materials, community participation, and affordability. Adegun and Adedeji (2017) emphasize the relevance of earthen and locally source materials as culturally appropriate and ecologically sustainable options. The integration of technology in vocational training is grounded in human capital theory (Becker, 1964), which posits that investments in education and skills training directly enhance individual productivity and, by extension, economic development. Applied to construction sector, equipping TVET students with building technology competencies constitutes a strategic investment in the human capital required for sustainable industry transformation.

Complementarily, the constructivist learning theory (Vygotsky, 1978) provides pedagogical support for technology integration in TVET, emphasizing that learners construct knowledge through active engagement with authentic tools and real-word context. Integrating building technology into vocational training can equip learners with practical competencies necessary for sustainable construction delivery.

TVET IN NIGERIA'S CONSTRUCTION SECTOR: CURRENT STATE

Nigeria's TVET system for the construction sector operates across multiple institutional tiers. At the secondary level, technical colleges offer the National Technical Certificate (NTC) and Advanced National Technical Certificate (ANTC) programmes in building-related trades, supervised by the National Business and Technical Examinations Board (NABTEB). At the

post-secondary level, polytechnics, monotechnics, and colleges of technology offer National Diploma (ND) and Higher National Diploma (HND) programmes in building technology and related fields, regulated by the National Board for Technical Education (NBTE). In addition, informal apprenticeship systems — particularly prevalent in artisanal trades — account for a substantial portion of skills acquisition in the construction sector (Okeke, 2020; Eze et al., 2023).

The formal TVET sector is complemented by the Industrial Training Fund (ITF), which provides short-term skills upgrade programmes for industry practitioners, and the National Vocational Qualifications Framework (NVQF), which seeks to standardise competency levels across formal and informal training pathways. Despite these structures, coordination among these institutions remains fragmented, and the alignment of curricula with industry needs — particularly emerging sustainable construction requirements — is weak (Adeyemi et al., 2021).

A review of current building technology curricula in Nigerian TVET institutions reveals a predominant focus on traditional construction methods, manual drafting, and conventional materials. Topics such as brickwork, carpentry, concrete technology, and plumbing retain prominence, reflecting the dominant construction methods of previous decades. While these competencies remain foundational, they are increasingly insufficient in a context where sustainable construction demands proficiency in energy-efficient design, the use of low-carbon materials, digital project management, and renewable energy integration (Ekanya, 2023).

Research by Adeyemi and Okonkwo (2021) found that fewer than 30% of building technology programmes at Nigerian polytechnics included any formal module on sustainable construction or green building standards. Similarly, a study by Okanya (2023) found that the availability of 21st-century instructional delivery tools in TVET institutions was critically low, with many institutions operating without functional computer laboratories, internet connectivity, or modern construction simulation software.

The infusion of green skills into curricula has begun to attract scholarly attention. Obi and Nwachukwu (2025) advocate for a comprehensive curriculum overhaul that incorporates modules on renewable energy systems, waste management, sustainable construction, and environmental ethics, noting that the qualification and continuous professional development of lecturers is central to such reform. Kamana and colleagues at federal technical colleges in North-Western Nigeria similarly identified reflective thinking, resourcefulness, and application skills as green competencies requiring explicit curriculum integration (ICERT, 2024).

A consistent finding across the literature is the inadequacy of instructor capacity in building technology and sustainable construction. Many TVET lecturers were trained under conventional curricula and have not received systematic professional development in emerging construction technologies (Okanya, 2023; Obi & Nwachukwu, 2025). The 2022 Academic Staff Union of Universities (ASUU) strike — which lasted over eight months — further disrupted instructional continuity, with Nwakile et al. (2023) documenting significant academic and psychological deficits among final-year TVET students in its aftermath.

The retention of qualified technical college teachers is itself a systemic challenge. Okanya's (2023) study in Kogi State found that inadequate incentive packages — including poor remuneration, limited career progression, and insufficient access to professional development resources — were primary drivers of teacher attrition in TVET institutions. Without a stable

and qualified instructional workforce, even well-designed curriculum reforms are unlikely to be effectively delivered.

KEY BUILDING TECHNOLOGIES FOR SUSTAINABLE CONSTRUCTION TRAINING

Building Information Modelling (BIM)

Building Information Modelling (BIM) represents one of the most transformative digital technologies in contemporary construction practice. BIM is a digital, object-based information system that integrates geometry, cost, scheduling, and performance data into interoperable, federated models, enabling collaborative and informed decision-making across the entire project lifecycle (Sampaio, 2022). Studies consistently demonstrate that BIM adoption improves construction productivity, reduces waste, minimises errors, and supports sustainable design outcomes (Ebekozien et al., 2024; Scientific Reports, 2025).

In Nigeria, BIM adoption has been gaining traction, particularly among architecture, engineering, and construction (AEC) firms. Research by Babatunde et al. (2020) identified client demand, government mandates, and competitive advantage as key drivers of BIM adoption in Nigerian AEC firms. BIM has also been applied to address affordable housing challenges, providing innovative design solutions adaptable to diverse socio-economic contexts (Ajirotutu et al., 2024). However, BIM penetration in TVET institutions remains extremely limited.

Ebekozien et al. (2024) conducted a stakeholder study on BIM implementation for Nigeria's polytechnic built environment undergraduates, identifying infrastructure deficits, lack of licensed software, insufficient instructor training, and curriculum inflexibility as key challenges. Revit was identified as the most widely used BIM tool in professional practice, yet its teaching in middle-level higher education institutions — precisely where TVET students are trained — remains rare. Furthermore, a study by Frontiers in Built Environment (2025) noted that in Nigeria, three-quarters of federal works staff self-fund their BIM upskilling, indicating that institutional investment in technology training is grossly inadequate.

The case for BIM in TVET is strong. Digital Construction Management (DCM) has the potential to revolutionise Nigeria's construction industry by boosting productivity, quality, and safety, yet adoption has been slow due to a significant skills gap among professionals (Nigerian Journal of Technology, 2025). Introducing BIM fundamentals into building technology curricula at the diploma and higher diploma levels would directly address this gap, preparing graduates to participate meaningfully in an increasingly digitised construction industry.

Green Building Materials and Technologies

The selection and application of sustainable building materials constitute a foundational competency for construction workers in the green economy. Green building materials encompass low-carbon alternatives (including earthen bricks, compressed stabilised earth blocks [CSEB], bamboo, recycled aggregate concrete, and fly-ash blended cement), as well as technologies for reducing embodied carbon and operational energy use (Arenas & Shafique, 2024; Althoey et al., 2023).

In Nigeria, the use of indigenous and alternative materials presents both an opportunity and a pedagogical priority. Ejidike (2023) demonstrated the viability of Hydraform bricks as sustainable construction materials in tropical environments, while Adegun and Adedeji (2017) highlighted the economic and environmental benefits of earthen materials for African

housing. TVET curricula that systematically expose students to these materials — their properties, applications, and environmental advantages — would equip trainees to champion localised sustainable construction approaches.

However, the adoption of sustainable building materials in Nigeria is hindered by multiple barriers. Eze et al. (2023) found that limited awareness among construction professionals and students, high perceived costs, lack of supply chain infrastructure, and scepticism about material performance were primary obstacles to sustainable building material adoption. These barriers underscore the need for vocational training to not only introduce sustainable materials but also address the attitudinal, economic, and practical dimensions of their application.

Renewable Energy Integration in Buildings

Buildings account for a substantial share of energy consumption globally, and the integration of renewable energy systems — including solar photovoltaic (PV), solar water heating, and passive design strategies — is increasingly central to sustainable building design. For Nigeria, where unreliable grid electricity remains a major constraint on productive activity, renewable energy integration in buildings carries particular economic and social significance (Emodi & Boo, 2015; Ekunke et al., 2024).

Strietska-Ilina et al. (2011), as cited in the TVET@Asia green process skills study, emphasise that sustainable construction training must include specific competencies in handling technologies such as solar panels. Similarly, UNESCO's TVET framework advocates for training programmes that prepare workers to install and maintain renewable energy systems, noting that TVET has a critical role in the transition to green construction, particularly for electricians, gas fitters, and plumbers (GIZ/TVET, 2024).

In Nigerian TVET programmes, renewable energy topics are largely absent or superficially covered. Integrating modules on solar PV installation, passive solar design, and building energy auditing would not only improve the sustainability of construction outcomes but would also expand the employability and earning potential of TVET graduates in the growing renewable energy and energy efficiency market.

Digital and Simulation Tools

Beyond BIM, a range of digital tools supports sustainable construction practice and can be effectively incorporated into TVET instruction. These include Computer-Aided Design (CAD) software for technical drawing, energy simulation software (such as EnergyPlus and DesignBuilder) for building performance analysis, and project management platforms for cost and schedule control. The use of augmented and virtual reality (AR/VR) for construction site training is also gaining traction globally as a safer and more cost-effective alternative to physical site exposure (Elkhayat et al., 2024).

The Nigerian Journal of Technology (2025) identifies digital construction management as a priority skill area for Nigeria's construction professionals, encompassing data analytics, digital project monitoring, and technology-enhanced quality control. Introducing these tools at the TVET level — even through basic simulations and computer-based exercises — would create a digital literacy foundation that prepares students for increasingly technology-mediated construction environments.

BARRIERS AND ENABLERS OF TECHNOLOGY INTEGRATION IN TVET

Barriers

The literature identifies multiple, interrelated barriers to the effective integration of building technology in Nigerian TVET institutions. These can be categorised under curriculum, infrastructure, human resource, policy, and financial dimensions.

Curriculum obsolescence represents a foundational constraint. Existing building technology curricula were largely designed for conventional construction methods and have not been systematically updated to reflect sustainable construction practices or digital technologies (Adeyemi & Okonkwo, 2021; NBTE, 2019). The NBTE, which oversees curriculum development for polytechnics and colleges of technology, has been criticised for slow response to industry changes, resulting in a growing mismatch between graduate competencies and employer expectations.

Infrastructure deficits compound the curriculum problem. Many TVET institutions lack functional workshops equipped for sustainable construction demonstrations, computer laboratories with relevant software, internet connectivity, or access to renewable energy installations that could serve as practical learning environments (Okanya, 2023; Ebekozien et al., 2024). The Nigerian government's chronic underfunding of technical education — which has persistently fallen below UNESCO's recommended 26% education budget allocation — directly limits institutional capacity to provide quality technical training.

Limited instructor capacity, as discussed in Section 4.3, represents a third critical barrier. Without instructors who are themselves competent in BIM, green building technologies, and sustainable construction principles, curriculum reform alone will be insufficient. Obi and Nwachukwu (2025) note that the successful integration of green skills in technology education programmes depends significantly on the qualification and continuous professional development of lecturers.

Policy fragmentation and poor enforcement further undermine technology integration efforts. While Nigeria's National Policy on Education (2014) and the NBTE Act recognise TVET as a national priority, implementation has been inconsistent. The Nigerian Building Code, while containing energy efficiency provisions, does not mandate green building practices at the federal level (Adedeji, 2023). Regulatory frameworks are characterised by bureaucratic inefficiencies, inconsistent enforcement, and limited incentives for institutions to pursue innovation (Atanda & Olukoya, 2019; Richard, 2024).

Financial constraints affect both institutions and students. The high cost of green building technologies, simulation software licences, and specialised equipment limits what institutions can provide. Agboola et al. (2024) found that limited awareness of green building technologies among professionals and students, compounded by cost perceptions, restricts their adoption. At the student level, socio-economic barriers may reduce access to supplementary technology training, particularly given the limited availability of student loan facilities in Nigeria.

Enablers and Opportunities

Notwithstanding these barriers, several enabling factors and opportunities present pathways for progress. First, growing national and international recognition of sustainable development imperatives has elevated TVET on the policy agenda. Nigeria's Vision 2050 framework and its commitments under the United Nations Sustainable Development Goals (SDGs) — particularly SDG 4 (Quality Education), SDG 9 (Industry, Innovation, and Infrastructure),

and SDG 11 (Sustainable Cities and Communities) — create a policy environment conducive to TVET reform.

Second, international development partnerships offer significant resources. The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) has produced TVET frameworks for sustainable construction that can inform Nigerian curriculum reform (GIZ/TVET, 2024). The World Bank, the African Development Bank, and UNESCO's TVET division have all supported skills development initiatives in Sub-Saharan Africa, and Nigeria's engagement with these bodies can unlock funding and technical assistance for technology integration.

Third, the expansion of private sector and industry partnership models presents an underutilised opportunity. Dual vocational education arrangements — in which training combines institutional instruction with structured workplace learning — have demonstrated effectiveness globally and are advocated by Chaiyong et al. (2024) as a particularly promising model for TVET in developing countries. Nigerian construction firms, particularly those operating internationally or under donor-funded projects, increasingly have the technological capabilities that could be shared with TVET institutions through structured partnerships.

Fourth, the proliferation of affordable digital tools and open-source construction software has lowered the cost barrier for basic technology integration. Open-source BIM tools, free online CAD platforms, and cloud-based project management applications provide entry-level options for TVET institutions with limited budgets. Leveraging these resources in combination with government and donor support could accelerate technology exposure without requiring prohibitive capital investment.

A PROPOSED FRAMEWORK FOR INTEGRATING BUILDING TECHNOLOGY IN TVET

Drawing on the findings of this review, this paper proposes a multi-stakeholder, phased framework for integrating building technology in Nigerian TVET institutions for sustainable construction. The framework is organised around five interdependent pillars:

Curriculum Reform and Standardisation

The NBTE, in collaboration with the National Universities Commission (NUC), the construction industry, and international partners, should initiate a comprehensive review and reform of building technology curricula. This reform should incorporate compulsory modules on sustainable construction principles, green building materials, BIM fundamentals, energy efficiency, and renewable energy systems. Curricula should be structured to enable progressive skill development, with awareness-level content at the National Technical Certificate stage and applied competency modules at the HND level. The updated curriculum should be reviewed on a five-year cycle to ensure ongoing responsiveness to industry evolution.

Instructor Capacity Building

A National Instructor Development Programme (NIDP) should be established, funded jointly by the federal government, state governments, and the ITF, to provide TVET building technology instructors with structured training in sustainable construction and digital tools. The programme should include both initial certification in key technologies (BIM, energy efficiency, green materials) and ongoing continuing professional development (CPD) requirements. Partnerships with professional bodies — including the Nigerian Institute of Building (NIOB), the Council of Registered Builders of Nigeria (CORBON), and the

Nigerian Society of Engineers (NSE) — should be leveraged to ensure industry-aligned training content.

Infrastructure Investment and Digital Upgrade

Federal and state governments should prioritise targeted capital investment in TVET institutions to upgrade workshops, laboratories, and ICT facilities for sustainable construction training. This should include the provision of BIM-enabled computer laboratories, renewable energy demonstration installations (solar PV, solar water heating), sustainable material sample libraries, and access to broadband connectivity. Public-private partnerships and international donor funding should be mobilised to supplement government budgetary allocations, with performance benchmarks tied to disbursement conditions.

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Industry-Institution Linkages

A structured Dual Vocational Training (DVT) model should be developed and piloted in selected Nigerian states, whereby TVET students spend defined periods in industry settings, gaining practical exposure to sustainable construction technologies under professional supervision. Construction firms that participate in the DVT scheme should receive tax incentives, preferential access to government procurement, and recognition through industry certification schemes. The ITF's training levy system should be restructured to explicitly support industry placements for TVET students in sustainable construction projects.

Policy Coherence and Incentive Structures

The federal government should develop a National Sustainable Construction Skills Policy that explicitly links TVET reform to Nigeria's climate commitments, housing agenda, and industrial development strategy. This policy should mandate the integration of green building standards into building permits and public procurement requirements, creating demand-side pull for sustainably trained workers. Capacity-building grants and skill development loans — as recommended by studies on sustainable construction barriers (Discover Civil Engineering, 2025) — should be made available to TVET institutions and construction firms investing in green skills training. Furthermore, a national Green Building Rating System, aligned with international standards, should be developed to incentivise compliance and recognise excellence in sustainable construction.

POLICY IMPLICATIONS

The findings and framework proposed in this paper carry important implications for multiple levels of governance and practice in Nigeria.

At the federal level, the Ministries of Education, Works and Housing, Environment, and Labour and Employment must work collaboratively to develop integrated policies that align TVET reform with sustainable construction imperatives. The current siloed approach to policymaking — in which education and construction policies are developed independently

— creates implementation gaps that undermine both systems. A dedicated inter-ministerial committee on sustainable construction skills could facilitate policy coherence and coordinated action.

The NBTE, as the primary regulator of TVET at the polytechnic and technical college level, bears the most immediate responsibility for curriculum reform. Its review processes must be accelerated and made more responsive to industry signals, incorporating regular employer surveys, graduate employment tracking, and expert advisory input from professional bodies and international organisations. The NABTEB should similarly reform its trade examination syllabi to include sustainable construction competencies as assessed knowledge areas.

At the institutional level, TVET administrators must champion technology integration as a strategic priority, allocating resources for instructor development, laboratory upgrading, and industry engagement. Student motivation and enrolment in building technology programmes must be supported through scholarship schemes, stipends for sustainable construction specialisations, and transparent career pathway communication.

CONCLUSION

Nigeria's transition to sustainable construction is not merely an environmental aspiration — it is an economic and social necessity. With a housing deficit exceeding 22 million units, chronic infrastructure gaps, and growing climate vulnerability, the quality and sustainability of the built environment will significantly determine the country's development trajectory in the coming decades. At the heart of this transition lies the capacity of the construction workforce, and TVET institutions are the primary engine for producing that capacity.

This paper has demonstrated that building technology integration in Nigerian TVET programmes for sustainable construction is both urgently needed and feasible. The evidence reviewed confirms that current curricula are inadequate, instructor capacity is limited, infrastructure is insufficient, and policy frameworks are fragmented. Yet the same evidence also reveals a growing body of knowledge, international models, and enabling mechanisms that Nigeria can draw upon to accelerate reform.

The five-pillar framework proposed in this paper — encompassing curriculum reform, instructor capacity building, infrastructure investment, industry-institution linkages, and policy coherence — provides a structured and actionable pathway forward. Importantly, this framework recognises that technology integration is not an end in itself but a means to producing construction workers who are equipped, motivated, and empowered to build more sustainable communities.

Future research should focus on empirical assessment of pilot technology integration programmes in Nigerian TVET institutions, evaluation of the dual vocational training model in the Nigerian construction context, and analysis of the labour market returns to sustainable construction skills. Cross-country comparative studies — particularly with other rapidly urbanising Sub-Saharan African nations — would also enrich understanding of transferable models and context-specific adaptations.

The integration of building technology in vocational training is not a peripheral concern for Nigeria's development planning — it is a central one. Investing in this integration today is investing in the quality, resilience, and sustainability of Nigeria's built future.

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