International Journal of Multidisciplinary Research and Development
www.allsubjectjournal.com
ISSN Online: 2349-4182
Received: 16-12-2025, Accepted: 15-01-2026, Published: 30-01-2026
Volume 13, Issue 1, 2026, Page No. 172-179

Transforming architectural design & construction education in Nigerian polytechnics: utilizing bim & space syntax to enhance skills for the 4th Industrial Revolution

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Abstract
The Fourth Industrial Revolution is transforming the construction industry through digital innovations such as Building Information Modelling (BIM) and space syntax, which enhance efficiency, collaboration and data-driven design. However, Nigerian polytechnics, which are central to training middle-level manpower for the built environment, continue to operate with out-dated curricula and limited integration of digital technologies, leaving graduates underprepared for the demands of contemporary practice. This study aims to investigate how BIM and space syntax can be embedded into architectural design and construction education in Nigerian polytechnics to enhance professional competence and industry readiness. A qualitative review of existing curricula, industry demand and global benchmarks was conducted, supported by interview of relevant stakeholders (limited to Architects and Builders) in academia and the construction industry in Nigeria. The findings indicate that BIM adoption within Nigerian polytechnics is minimal, while space syntax remains largely absent, resulting in a significant skills gap. The study recommends curriculum reform to integrate these tools as core components, capacity-building initiatives for lecturers, investment in digital infrastructure and stronger partnerships between polytechnics and the construction industry. These measures will better equip graduates with the competencies required to thrive in the 4th Industrial Revolution.

Keywords: Building information modelling (bim), space syntax, Nigerian polytechnics, 4th Industrial Revolution, architectural design and construction education

Introduction

The Fourth Industrial Revolution (4IR) has introduced a paradigm shift in the built environment sector, marked by the convergence of digitalisation, automation and data-driven design processes (Schwab, 2016; Kolarevic, 2021). Emerging technologies such as Building Information Modelling (BIM), space syntax, Artificial Intelligence (AI), computational spatial analysis and smart building systems are now central to global architectural and construction workflows. These tools enable professionals to deliver projects with greater efficiency, reduced costs, enhanced sustainability and improved user experience. Consequently, leading institutions worldwide are embedding BIM and computational design methods into curricula, aligned with global standards for architectural and engineering education (Maya, Raad, & Dlask, 2023). In Nigeria, however, the situation in polytechnic; key providers of technical and vocational training (TVET) for the construction sector, remains underdeveloped.

Despite the critical importance of architecture and construction to national development, polytechnic education is constrained by out-dated curricula, inadequate digital infrastructure, limited faculty expertise and weak industry linkages.

Recent curriculum reforms by the National Board for Technical Education (NBTE), which stipulate 80% practical and 20% theoretical learning (NBTE, 2023; Nairametrics, 2024) aim to improve employability. Yet, practical exposure to advanced digital tools such as BIM and space syntax remains minimal.

Current evidence shows that while 2D and 3D CAD tools such as AutoCAD are widely taught, BIM software; particularly Revit, is introduced only at advanced stages, if at all and space syntax is almost absent from polytechnic curricula (Adewumi *et al*., 2022; MarcelOkafor, 2021; Aigbe *et al*., 2024). Recent empirical work by Ebekozien, Aigbavboa, Samsurijan, Azazi, and Duru (2024) confirms this gap. Although stakeholders highlighted clear benefits of BIM, including improved visualisation, enhanced collaboration, accurate cost estimation and higher productivity. Hands-on practice remains rare in most polytechnic programmes.

The labour market further reinforces these pressures. Job advertisements in Lagos, Abuja and Port Harcourt increasingly specify Revit, ArchiCAD, or BIM proficiency as core requirements for architectural roles (MyJobMag, 2024). Bridging this gap requires embedding BIM and space syntax into the core of architectural design and construction education within Nigerian polytechnics. Achieving this will not only enhance graduate employability but also strengthen the construction sector's readiness for the demands of the 4IR.

Research Aim

This study aims to improve the existing curricula by modifying BIM context and integrating space syntax for the demands of the Fourth Industrial Revolution.

Research Objectives

- To assess the extent of BIM and space syntax incorporation in Nigerian polytechnic curricula.
- To evaluate the literacy levels of students and lecturers.
- To determine the challenges and limitations for effective integration into the curricula

- To determine employer skill gaps within the curricula.

Problem Statement

Despite the inclusion of Building Information Modelling (BIM) in the NBTE HND curriculum through ARC 427, delivery in Nigerian polytechnics remains largely theoretical with minimal practical application. At both ND and HND levels, CAD and construction courses continue to emphasize conventional drafting and visualization, while Space Syntax is entirely absent. Empirical studies attribute these gaps to inadequate infrastructure, high software costs and limited faculty expertise (Adewumi *et al*., 2022; Aigbe *et al*., 2024; Ebekozien *et al*., 2024). As industry increasingly demands digitally competent graduates, this misalignment leaves polytechnic students underprepared for the collaborative and technology-driven requirements of the Fourth Industrial Revolution.

Definition of Terms

a. **Building Information Modelling (BIM):** BIM is a collaborative digital process that generates and manages information about buildings across their lifecycle (ISO, 2018). In Nigeria, adoption remains limited due to barriers such as inadequate training and resources, despite growing awareness (Olugboyega, Oseghale, & Aigbavboa, 2023).

b. **Space Syntax:** Space syntax is a theory and method for analyzing spatial configurations to understand their effects on human movement, accessibility, and social interaction (Hillier & Hanson, 1984). Nigerian studies have applied space syntax to evaluate urban form and socioeconomic influences on walking behaviour (Alabi, 2021).

Literature Review

1. Evolution of Polytechnic Architectural Programs

Architectural education in Nigerian polytechnics has aimed at producing technical manpower for various sectors of the Nigerian economy (Jogana *et al*., 2020) [14]. However, the relevance and quality of architectural graduates from these institutions have faced criticism from the industry due to perceived inadequate knowledge (Adewale & Adhuze, 2014) [1, 3]. The existing curriculum structure for architectural education and practice in Nigeria is frequently deemed insufficient for addressing current trends, highlighting an urgent need to bridge the gap between education and a technology-driven profession (Nnaemeka-Okeke *et al*., 2020). While the polytechnic model for architectural education has historical origins in Europe, moving from academic ideals towards more technical aspects (Øien *et al*., 2018) [25], the Nigerian context faces distinct challenges in updating its educational framework to meet modern demands.

1.1 Role of NBTE in curriculum development

The National Board for Technical Education is central to overseeing polytechnics and establishing standardized minimum guide curricula for student training in Nigeria (Ikelegbe, 2020) [13]. The NBTE's role includes developing curricula to produce middle-level manpower (Ikelegbe, 2020) [13]. A significant hurdle, however, is the infrequent revision of these curricula. This delay in review hinders polytechnic education's ability to adapt to new developments and technologies, which is crucial for maintaining educational relevance and quality (Ikelegbe, 2020) [13]. This suggests that while NBTE provides regulatory guidelines, the practical implementation and timely updating of these curricula require considerable attention to align with a dynamic professional landscape. The built environment is a complex sector that demands coordination and cooperation of stakeholders and construction projects requires skills, services and the integration of major disciplines (Ebekozien & Aigbavboa, 2022) [9].

1.2 Importance of aligning education with global trends

Aligning Nigerian architectural education with global trends is essential for producing competent and relevant professionals in today's technology-driven industry (NnaemekaOkeke *et al*., 2019) [24]. Criticisms regarding the inadequate knowledge of fresh architectural graduates underscore the necessity for curriculum adjustments that reflect contemporary demands (Adewale & Adhuze, 2014) [1, 3]. In a country where architectural services are sometimes provided by less qualified personnel, it becomes particularly important for academic and tertiary institutions to adapt their curricula to meet current industry needs and ensure architects possess essential skills (Aluko *et al*., 2021).

Globally, architectural education models often carry historical influences from former colonial powers and professional bodies in many English-speaking African countries still rely on validation criteria set by organizations like the Commonwealth Association of Architects (Berlanda, 2017) [5]. This situation points to the need for re-evaluating and re-conceptualizing curricula to incorporate diverse perspectives and adapt to local contexts while remaining globally competitive (Berlanda, 2017) [5]. An outdated curriculum structure can prevent education from effectively addressing the challenges of modern architectural practice (Nnaemeka-Okeke *et al*., 2019) [24]. Educational policy reforms in other regions, such as South Africa, have focused on ensuring equitable opportunities and making higher education more responsive to societal and economic needs, including the development of vocationally relevant abilities and skills (O'Dwyer *et al*., 2022) [26]. This necessitates increased functional interdependence, accountability and cooperation among all involved parties within the education system (O'Dwyer *et al*., 2022) [26].

2. Fourth Industrial Revolution and The Built Environment

The Fourth Industrial Revolution (4IR) marks a significant paradigm shift, integrating physical, digital and biological worlds and profoundly impacting various disciplines, including the construction industry (Abina *et al*., 2023; Henriques *et al*., 2020) [2]. This era is characterized by innovative technologies that are transforming how industries operate and how humans interact with technology daily (Abina *et al*., 2023) [2].

2.1 Definition and key features of 4IR relevant to architecture/construction

The 4IR is a collective term for technologies and value chain organization that merge cyberphysical systems, the Internet of Things and the Internet of Services (Gade & Opoku, 2020) [11]. Key features and emerging technologies include cloud technology, big data, predictive analysis, artificial intelligence, augmented reality, agile and collaborative robots and additive manufacturing (Gade & Opoku, 2020) [11]. These technologies are rapidly developing and significantly impacting construction projects by reducing change orders, improving decisionmaking and enhancing work quality (Wang *et al*., 2022) [31].

For the Architecture, Engineering and Construction industry, the 4IR encompasses a range of digital technologies:

1. **Building Information Modelling:** A foundational technology for digital design and a strong basis for project management (Ernstsen, 2020; Li *et al*., 2024) [10, 17, 18, 19].
2. **Artificial Intelligence:** Utilized for predictive maintenance, energy management, decisionmaking and even generating preliminary architectural designs (Baik, 2025; Komatina *et al*., 2024; Li *et al*., 2024; Rane *et al*., 2023; Saka *et al*., 2023) [4, 15, 17, 18, 19, 28, 29].
3. **Robotics and Automation:** Used in construction for optimizing processes, improving productivity and for tasks like 3D printing and off-site construction (Abina *et al*., 2023; Lattuga & Ginigaddara, 2025; Li *et al*., 2024; Takva & İlerisoy, 2023; Zatta *et al*., 2023) [2, 16, 17, 18, 19, 30, 32].
4. **Digital Twin:** A new technology gaining attention for its potential in managing construction and operational phases of built assets (Baik, 2025; Mohamed & Shafiq, 2024; Mousavi *et al*., 2024) [4, 21, 22].
5. **Computational Spatial Analysis:** While not explicitly listed in all general 4IR overviews, it aligns with data-driven design and optimization (Dawood & Rahimian, 2021; Ernstsen, 2020) [7, 10].
6. **Augmented Reality and Virtual Reality:** Enhance visualization and simulation in design and construction (Brozovsky *et al*., 2023; Ernstsen, 2020; Gade & Opoku, 2020; Manzoor *et al*., 2021; Naji *et al*., 2024) [6, 10, 11, 20, 23].
7. **Cloud Computing:** Supports data storage and collaborative workflows (Brozovsky *et al*., 2023; Gade & Opoku, 2020; Naji *et al*., 2024) [6, 11, 23].
8. **Smart Building Systems:** These systems leverage IoT, sensors, and data analytics for realtime monitoring and optimization of building performance, functioning, maintenance, and safety (Zatta *et al*., 2023) [32].

The integration of these technologies aims to enhance efficiency, productivity and sustainability in the AEC sector (Brozovsky *et al*., 2023; Zatta *et al*., 2023) [6, 32].

2.2 Importance of Digital Literacy

1. **Interdisciplinary Collaboration:** The complex sector demands coordination and cooperation of stakeholders and integration of major disciplines, making collaboration skills crucial (Ebekozien & Aigbavboa, 2022) [9].
2. **Academia's Role:** Educational institutions play a pivotal role in training the professionals required to drive the transition towards Construction 4.0, but often face challenges in acquiring new skill sets and fostering collaboration with industry (Brozovsky *et al*., 2023) [6]. There is an evident need for industry standardization and greater investment in education and vocational training for trade's workers (Lattuga & Ginigaddara, 2025) [16].

3. Concept and Benefits of Bim In Design, Collaboration and Construction

Building Information Modelling is a transformative digital process that redefines how construction projects are planned, executed and managed (Das *et al*., 2025). It involves generating and managing digital representations of a facility's physical and functional characteristics (Liu & Xie, 2014). BIM functions as a shared knowledge resource, providing a reliable basis for decisions throughout a project's lifecycle, from conceptualization to demolition (Liu & Xie, 2014). The core features and ideas of BIM include its ability to integrate all project parameters such as architectural plans, structural designs, electrical designs, plumbing, sustainable energy factors and project management into a centralized system (Qureshi & Hasani, 2020; Selvanesan & Satanarachchi, 2023; Wong & Lai, 2022). This creates an intelligent 3D model-based database that combines multi-disciplinary and structured data (Wong & Lai, 2022).

3.1 Benefits of BIM

The benefits of BIM are extensive and impact various stages of a construction project:

1. **Enhanced Decision-Making and Project Coordination:** By capturing detailed architectural and contextual data, BIM provides organized spatial information, fostering informed decision-making and reducing errors (Das *et al*., 2025; Guerrero *et al*., 2025). It significantly improves project coordination and minimizes rework (Das *et al*., 2025; Wagiri *et al*., 2023).
2. **Improved Efficiency and Effectiveness:** BIM is widely recognized for fostering knowledge sharing and collaboration among stakeholders, leading to improved construction efficiency and effectiveness (Das *et al*., 2025; Wagiri *et al*., 2023). It streamlines information transfer and ensures alignment between architectural designs and structural plans (Wagiri *et al*., 2023).
3. **Cost and Time Reduction:** The adoption of BIM can significantly reduce project time and costs by enhancing coordination, minimizing errors, and optimizing resource allocation (Buhl *et al*., 2019; Das *et al*., 2025). For instance, a study in Nigeria demonstrated reasonable cost and time savings on a duplex building project using BIM software (Buhl *et al*., 2019).
4. **Sustainability and Performance Assessment:** BIM is a key driver for sustainability-focused initiatives, including lean construction, off-site manufacturing and integrated assessments of environmental, economic and social impacts (Selvanesan & Satanarachchi, 2023). It

facilitates energy modeling during design and helps assess building performance through operations simulation (Saeed & Yas, 2023; Selvanesan & Satanarachchi, 2023). Multidisciplinary BIM models can be used for sustainable design, such as acoustic comfort, lighting design, wind load simulation and estimating heat load for energy saving (Tien & Tung, 2021).

5. **Facility Management:** Beyond design and construction, BIM enhances long-term facility management by consolidating essential data, maintenance records and lifecycle predictions, thus improving decision-making during the operational phase (Guerrero *et al*., 2025; Saeed & Yas, 2023).

3.2 Global adoption in education and practice
BIM's utilization in the Architecture, Engineering and Construction industry gained significant momentum after the emergence of the Industry Foundation Classes standard in the late 1990s, with a substantial uptake occurring after 2010 due to public sector and governmental mandates (Çapkın *et al*., 2020). Governments worldwide have increasingly mandated BIM adoption, recognizing its inherent benefits, leading to a projected global BIM market value of US$22.1 Billion by 2030 (Chowdhury *et al*., 2024). Countries in Northern Europe (e.g., Finland, Sweden, Netherlands, Norway and the United Kingdom) are particularly advanced in national legislation for BIM adoption, while others like France, Italy, Germany, Spain and Austria are moving towards its integration (Adami & Fregonese, 2020). The USA has integrated BIM technologies into its education system since 2002, with approximately 80% of universities and colleges currently delivering BIM-related modules, setting BIM as a basic requirement for the industry (Durdyev *et al*., 2021).

3.3 Extent of Exploration in Nigerian Polytechnics
In Nigeria, the awareness and adoption of Building Information Modelling are generally at a moderate and initial level within the construction industry, with significant challenges hindering full implementation (Babatunde *et al*., 2020; Brozovsky *et al*., 2023; HammaAdama & Kouider, 2019; Precious, 2024) [6]. While BIM has much potential to improve the effectiveness of construction works, many Architectural, Engineering and Construction firms in Nigeria are lagging in its adoption (Babatunde *et al*., 2020).

4. Space Syntax / Computational Spatial Analysis
4.1 Concept and Applications in Architectural Design
Space Syntax is a sophisticated analytical technique used to understand and quantify spatial configurations and their impact on human behavior and social activities (Tarabieh *et al*., 2019). Developed in the 1970s by Bill Hillier and his colleagues at the Bartlett School of Architecture, University College London, it provides a rigorous method for analyzing space by combining tangible factors like movement and land use with intangible factors such as cognition and behavior (Yamu *et al*., 2021). The methodology involves representing spatial layouts as numerical entities to predict movement patterns and social interactions (Aknar & Atun, 2016).

4.2 Key applications in architectural design
1. **Spatial accessibility:** Evaluating how easily different parts of a building or urban area can be reached (Dao & Thill, 2022; Meng & Zhang, 2024).

2. **Visual integration and visibility**: Analyzing how spaces are visually connected and the extent to which occupants can see and be seen within a layout (Alagamy *et al*., 2018; Wang *et al*., 2018).

3. **Circulation patterns:** Predicting pedestrian movement and flow within a built environment (Aknar & Atun, 2016; Kishimoto, 2018).

4. **Occupant behavior analysis:** Understanding how spatial configurations influence human behavior and social interaction (Rashid *et al*., 2006).

4.3 Global Integration in Curricula and Professional Practice
Globally, Space Syntax is applied worldwide in research and practice (Yamu *et al*., 2021). For instance, China has been a significant research hub for Space Syntax, with scholars frequently employing measures like integration to evaluate spatial accessibility and explore cultural attributes of spaces (Meng & Zhang, 2024). Research also extends to threedimensional spaces for way-finding and pedestrian movement analysis in complex urban environments (Zhang & Chiaradia, 2020). The concept's importance in architectural planning is underscored by its ability to investigate movement systems and circulation for effective accessibility in designs (Mustafa & Rafeeq, 2019).

4.4 Extent of Exploration in Nigerian Polytechnics
While Space Syntax is a recognized tool in international architectural discourse and practice, the literature suggests a concerning gap in its integration into Nigerian polytechnic education. Current research indicates that the exposure to advanced computational spatial analysis tools like Space Syntax is often completely absent from NBTE-approved National Diploma and Higher National Diploma curricula. Any engagement with such concepts typically remains limited to postgraduate research or lecturer-driven initiatives, failing to provide undergraduate students with foundational knowledge and skills in this critical area (Ikelegbe, 2020; Nnaemeka-Okeke *et al*., 2019) [13, 24]. The curriculum for architectural education in Nigeria has been observed to be inadequate for addressing modern challenges, highlighting a need for updated approaches (Nnaemeka-Okeke *et al*., 2019) [24].

5. Industry Demands and Employer Expectations
The Nigerian construction industry, like its global counterparts, is increasingly demanding a new set of skills driven by digitalization and the 4IR (Adepoju & Aigbavboa, 2020; Olowa *et al*., 2023). Professionals are expected to possess advanced digital literacies beyond traditional architectural skills. The competence of fresh architectural graduates has been criticized for inadequate knowledge, indicating a mismatch between education and industry needs (Adewale & Adhuze, 2014) [1, 3].

5.1 Role of BIM and Computational Spatial Analysis in Industry Efficiency, Collaboration and Sustainability
BIM is recognized as a powerful design and management tool that significantly improves efficiency, collaboration and sustainability across the building lifecycle (Olanrewaju *et al*., 2020).

1. **Efficiency:** BIM enables reduced waste and improved construction quality through multidimensional digital design solutions and "simulation and analysis" capabilities (Bonenberg & Wei, 2015). It optimizes project processes, potentially increasing productivity and reducing costs (Zavaleta, 2025).

2. **Collaboration:** BIM facilitates integrated information flow across all project stages, fostering participation and cooperation among project entities (Tang & Liu, 2022). Cloud BIM, in particular, allows for real-time collaboration and easy data exchange among consultants (Onungwa *et al*., 2021).

3. **Sustainability:** BIM is integral to ensuring buildings are environmentally sustainable, with its use in performing various sustainability analyses from the design stage (Onososen & Musonda, 2022) [27]. It helps in creating green buildings and high-performance buildings by fostering collaboration among disciplines (Zhang & Xiao, 2013).

4. **Computational spatial analysis**: including Space Syntax, provides tools for objective spatial configuration representation and analysis, crucial for urban planning, navigation and understanding complex built environments (Zhang & Chiaradia, 2020).

6. **Gap Analysis Between Curricular Content and Industry Requirements**

A significant gap exists between the current curricular content in Nigerian polytechnics and the evolving demands of the architectural and construction industry. This leads to graduates lacking the necessary competencies, such as entrepreneurship and digital skills, to be relevant in the contemporary job market (Nnaemeka-Okeke *et al*., 2019) [24]. The limited awareness and adoption of BIM within Nigerian AEC firms further highlight this gap, though awareness is progressing (Babatunde *et al*., 2020; Hamma-Adama & Kouider, 2019). This disparity in training and employer expectations is a major concern in Nigerian engineering and architectural education (Idris & Rajuddin, 2012) [12].

Methodology

This study adopted a qualitative research approach to explore the integration of BIM and Space Syntax in Nigerian architectural education.

1. **Population Sample:** The population comprised students and lecturers in accredited architecture programs, Architects, Structural Engineers and Builders. A purposive sample of 30 respondents from the Built Industry and stakeholders in academia (4 Nigerian Polytechnics) were selected.

2. **Data Collection Methods:** Data were collected through: Document Review of NBTE curricula, Semi-Structured Interviews with stakeholders actively in practice, lecturers on Faculty preparedness for teaching BIM, Space Syntax and Infrastructure availability (labs, software, internet access), Institutional support and regulatory pressures, teaching practices, challenges and labor mark*et al*ignment, also students with regards studios work and practical exposure to digital tools.
3. **Data Analysis:** Data were analysed using thematic coding for interviews and content analysis for documents.

Results and Findings

This section presents the results and findings of the study, based on data obtained from the literature review, as well as interviews conducted. This involved the review of documented institutional efforts to integrate BIM, Revit and Space Syntax into Nigerian architectural and construction education. It draws on national surveys (Akah *et al*., 2024; Oyesode *et al*., 2023), student-focused studies (Maina, 2018), institutional pages and sector BIM adoption research (Adewumi *et al*., 2022; Bamgbose *et al*., 2024). The case studies clarify where, how and how well BIM and allied tools are being taught. 3 representative case studies are presented Federal Polytechnic Bauchi, YABATECH Lagos, Federal Polytechnic Nekede, Owerri).

The findings are organized in line with the research objectives to highlight the extent of integration of this technology in the curriculum, perceptions of adequacy and the challenges affecting effective adoption.

1. **Addressing Research Objectives**
a. **RO1:** Extent to which BIM and Space Syntax are incorporated into the curricular

Table 1: BIM and Space Syntax and in curricular

Institution	Adoption Level	Curricular Stage (Verified ND/HND Codes)	BIM / Space Syntax Exposure		Key Barriers
Federal Polytechnic, Bauchi	Low	ARC 126, ARC 216, ARC 226 (ND); ARC 312, ARC 322, ARC 412 (HND); ARC 427 (HND II)	▪ BIM formally in curriculum (ARC 427) but minimally implemented ▪ Space Syntax absent	□ □ □	ICT gaps Limited staff capacity Weak SIWES
Yaba College of Technology (YABATECH)	Moderate (workshops + curricular presence)	ND/HND CAD courses; ARC 427 BIM (HND II, NBTE standard) + voluntary workshops	▪ BIM formally in curriculum (ARC 427) but often theoretical ▪ Supported by Revit workshops ▪ Space Syntax absent	□ □	NBTE standards weakly enforced Unstable power/internet
Federal Polytechnic, Nekede	Nascent (bootcamps + curricular presence)	ND/HND CAD core; ARC 427 BIM (HND II, NBTE standard) + external bootcamps	▪ BIM formally in curriculum but under-delivered ▪ External bootcamps fill gap ▪ Space Syntax absent	□ □	Inadequate labs/software Reliance on external bootcamps
Kaduna Polytechnic	Moderate (clearer implementati on)	ND/HND ARC suite; ARC 323, ARC 326, ARC 417 (Construction/Service s); ARC 427 (HND II)	▪ BIM formally taught via ARC 427 (with partial practical delivery) ▪ Space Syntax absent	□ □	Limited labs/software Staff training gaps

Source: Researcher's Review, 2025

Table 2: BIM/Revit Integration to NBTE Courses

NBTE Course Code	Current Descriptor	Proposed BIM (Revit) Integration	Proposed Space Syntax Integration		Expected Learning Outcomes (LOs)
ARC 126 (ND I)	2D drafting & basics	Intro to Revit interface + simple 2D/3D massing	Intro to spatial analysis concepts (basic mapping of circulation)	□ □ □	Navigate Revit Produce simple plans Understand spatial flow mapping
ARC 216 (ND II)	2D architectural drawings	Revit 2D documentation & annotations	Apply axial maps to simple design studio projects	□ □	Produce plans/sections in Revit Evaluate connectivity in small spaces
ARC 226 (ND II)	3D visualization	Revit 3D modelling & families	Explore visibility graph analysis for building interiors	□ □	Model parametric objects Analyze visual connectivity
ARC 311 (HND I)	Comprehensive design	Collaborative BIM modelling, clash detection	Apply space syntax in urban/site analysis modules	□ □	Work-sharing; generate schedules Evaluate spatial accessibility
ARC 322 / ARC 412 (HND)	Advanced CAD courses	Upgrade to Revit 4D/5D simulation	Apply syntactic measures to multi-level buildings	□ □	Manage time/cost simulation Design for movement efficiency
ARC 427 (HND II)	BIM concepts (theory + practice)	Strengthen handson Revit + Navisworks	Introduce space syntax software (e.g., DepthmapX)	□ □	Execute BIM projects Apply syntax to design for social interaction & accessibility

Source: Researcher's Fieldwork, 2025

b. R02: Evaluation of Literacy Level of Students and Lectures

Table 3: Literacy level of BIM and Space Syntax

Dimension of Perception	Response		Remarks
Students on BIM	1. Many students are aware of BIM software (esp. for 3D visualization, drafting). 2. Reported impact of BIM courses on knowledge/skills is low. 3. BIM seen as relevant to sustainable architecture design, but deeper analytical application is	□ □	Awareness exists, but curriculum delivery is shallow Stronger emphasis on full BIM workflows is needed.
	lacking.		
Lecturers on BIM	1. Lecturers view BIM as beneficial for workflow, visualization, collaboration. 2. Note lack of standardization in BIM curricula. 3. Infrastructure deficits, lack of resources for implementation.	□	Consensuses on BIM value but implementation barriers weaken its impact.
Students & Lecturers on Space Syntax	1. No documented empirical studies on perceptions in Nigerian tertiary institutions. 2. Used mainly in postgraduate research and case studies, not in teaching/learning surveys.	□	Reveals a critical knowledge gap, strong opportunity for pioneering curriculum integration.

Source: Researcher's Fieldwork, 2025

c. R03: Challenges and Limitations hindering effective integration into curricular

Table 4: Challenges to Integrating BIM and Space Syntax into the polytechnic Curriculum

Challenge Area	Response	Remarks
Infrastructure & Resources	1. Lack of adequate computer labs, highperformance hardware and stable internet in most tertiary institutions. 2. Software licensing costs (BIM tools, AI platforms) are prohibitive.	Without strong digital infrastructure, even willing institutions cannot sustain integration.
Curriculum Design	1. BIM is introduced in fragments (drafting, visualization) rather than full workflows. 2. AI and Space Syntax largely absent from undergraduate curricula. 3. No national standards guiding adoption.	Curriculum reform is needed to align training with global 4IR skills.
Staff Capacity	1. Many lecturers lack training in BIM, AI, and Space Syntax. 2. Limited exposure leads to resistance or reliance on traditional methods.	Staff development is critical; without it, integration efforts will stall.
Student Preparedness	1. Students often have limited exposure before graduation. 2. Access to training depends on personal initiative or external workshops.	Creates inequality in skill acquisition, disadvantaging students from resource-poor schools.
Policy & Institutional Support	1. Weak enforcement of ICT policies in education. ii. Funding gaps and poor prioritization of digital skills in architectural education.	Structural issues at policy and management level undermine sustainability of integration.
Space Syntax Specific Gap	1. No formal inclusion in Nigerian architectural curricula. 2. Mostly applied only in isolated postgraduate research projects.	Represents a "silent gap" in design education despite global relevance in urban/space analysis.

Source: Researcher's Fieldwork, 2025

d. R04: To determine employer skill gaps within the curricula.

Table 5: Employer Skill Demands to Curricular Gaps

Employer Group	Required Skill		Current NBTE Coverage		Observed Gap
Architects Structural Engineers Builders Other Stakeholders	• Revit/BIM proficiency • Space Syntax for site analysis	□ □	BIM formally in NBTE curriculum (ARC 427, HND II) Space Syntax absent	□	Graduates lack collaborative BIM/advanced site analysis
	□ BIM coordination (clash detection, scheduling)	□	BIM course present but not multidisciplinary	□	Students not exposed to integrated structural/architectural BIM workflows
	□ 4D/5D BIM for cost/time	□ □	ARC 427 covers basics Cost/time simulation absent	□	Reliance on manual scheduling
	□ Industry BIM certification (Autodesk, Graphisoft)	□	Not part of NBTE accreditation	□	Students depend on private centres for certification

Source: Researcher's Fieldwork, 2025

2. Pedagogical Models for Enhancing Digital Competence

Table 6: Stakeholder Responses

Proposed Model	Stakeholder Suggestion (Academia/Industry)	Perceived Importance (Likert 1–5)	Remarks
Blended Learning	Academics suggest CAD/BIM labs + classroom	5	Most feasible model
Faculty Development	Industry urges training lecturers on BIM/AI	4	Key to successful implementation
Industry Collaboration	Employers propose coteaching, internships	5	Bridges education– practice gap
Applied Research	Academics propose research with AEC firms	3	Moderately supported
Guest Lectures	Professionals suggest quarterly BIM workshops	4	Keeps curricula aligned with industry
Policy Support	NBTE/regulators to embed BIM/Space Syntax	5	Needed for sustainability

Source: Researcher's Fieldwork, 2025

Opportunities and Recommendations

Integrating BIM and computational spatial analysis into polytechnic curricula requires multifaceted strategies:

1. **Curriculum review and update:** Regular and comprehensive review of curricula to incorporate BIM and Space Syntax modules, aligning with global best practices and industry demands

2. **Competency-based education:** Shifting towards competency-based learning that focuses on practical skills and applications alongside theoretical knowledge

3. **Phased implementation:** Introducing these technologies progressively, perhaps starting with introductory courses and advancing to specialized applications in later years.

4. **Project-based learning:** Emphasizing hands-on projects that require students to use BIM and computational tools to solve real-world architectural and construction problems

Conclusion

By addressing these points, Nigerian polytechnics can effectively transform their architectural design and construction education to meet the demands of the 4IR, equipping graduates with the skills necessary to thrive in a rapidly evolving global industry.

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