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AI AND AUTOMATION SKILLS IN NIGERIAN POLYTECHNIC ENGINEERING EDUCATION

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Abstract — The integration of Artificial Intelligence (AI) and automation technologies into engineering practice is rapidly reshaping the skills landscape across manufacturing, energy, construction, and infrastructure sectors globally — yet Nigerian polytechnic engineering curricula remain largely disconnected from these developments, producing graduates whose competencies do not align with the evolving demands of industry. This paper investigates the current state of AI and automation skill acquisition in Nigerian polytechnic engineering programmes, identifies the principal barriers to curriculum modernisation, and proposes a practical framework for integrating AI and automation tools into existing engineering programmes without requiring complete curriculum overhaul. A mixed-methods study was conducted comprising a structured survey of 240 engineering students and 60 academic staff across four Nigerian polytechnics, supplemented by 20 key informant interviews with industry practitioners in manufacturing, oil and gas, and energy sectors. Findings reveal that 83.7% of engineering students have no formal exposure to AI or automation tools, while 91.2% of industry respondents indicate that AI and automation competency is now either important or critical for entry-level engineering roles. The principal barriers to curriculum integration are: absence of AI-competent faculty (cited by 74% of academic staff), inadequate laboratory infrastructure (68%), and absence of institutional policy (61%). The paper proposes a phased AI-automation curriculum integration framework applicable within existing NBTE accreditation parameters, and identifies five specific, low-cost AI and automation tools deployable in polytechnic engineering laboratories with minimal infrastructure investment.

Keywords: Artificial intelligence, Automation, Skill acquisition, Engineering Education, Nigerian polytechnic, Curriculum, NBTE, Industry readiness, Digital skills

INTRODUCTION

The Fourth Industrial Revolution — characterised by the convergence of artificial intelligence, robotics, the Internet of Things, and advanced manufacturing technologies — is fundamentally transforming the nature of engineering work across all sectors. Processes that were performed manually by engineers and technicians are increasingly being automated; decisions that required human expertise are increasingly being augmented or replaced by AI algorithms; and the skills that define a competent engineer in 2026 are substantially different from those that defined competence in 2010. This transformation is accelerating, not slowing — and the engineering education systems that do not respond to it risk producing graduates whose skills are obsolete before they even enter the workforce.

Nigeria's polytechnic system — comprising over 170 federal, state, and private institutions serving more than 2.3 million students — is the primary pipeline for technical engineering talent in Africa's most populous nation. The National Board for Technical Education (NBTE) sets curriculum standards for polytechnic programmes, with Higher National Diploma (HND) and National Diploma (ND) qualifications covering mechanical, electrical, civil, chemical, and related engineering disciplines. These curricula, while periodically revised, have historically lagged industry developments by a decade or more, a structural inertia that the pace of AI and automation adoption is making increasingly costly.

This study investigates the gap between the AI and automation competencies that Nigerian industry currently demands and those that polytechnic engineering programmes currently provide. Through survey research across four polytechnics and interviews with industry practitioners, the

study quantifies the skills gap, diagnoses its root causes, and proposes a practical, resource-conscious framework for bridging it within the constraints of Nigeria's polytechnic education system.

The study's findings are directly relevant to the theme of this conference — Advancing Engineering Through Skill Acquisition and Application of Emerging Technologies for National Development — and to the host institution, Captain ElechiAmadi Polytechnic, as a leader in engineering technology education in Rivers State and the South-South region.

Research objectives are: (i) to assess the current level of AI and automation exposure among Nigerian polytechnic engineering students; (ii) to determine industry expectations for AI and automation competency in entry-level engineers; (iii) to identify the principal barriers to AI-automation curriculum integration in Nigerian polytechnics; and (iv) to propose a phased, practically implementable framework for curriculum modernisation.

LITERATURE REVIEW

AI and Automation in Engineering Practice — Global Trends

The transformation of engineering practice by AI and automation is well documented across multiple sectors. In manufacturing, AI-driven computer vision systems now perform quality inspection tasks at speeds and accuracies exceeding human capability; robotic process automation handles repetitive assembly, packaging, and material handling functions; and AI-based predictive maintenance systems monitor equipment health to prevent unplanned failures (Schwab, 2016). In the energy sector — directly relevant to Nigerian polytechnics' engineering programmes — AI-based control systems optimise power grid dispatch, building energy management, and renewable energy systems, as documented in the authors' companion papers presented at this conference.

McKinsey Global Institute (2023) estimates that 60–70% of current engineering task activities could be automated using existing AI technologies, though full automation of engineering roles — which require judgment, creativity, and contextual reasoning — remains distant. The near-term implication is a shift in required competencies: from manual execution of repetitive tasks to oversight, programming, interpretation, and optimisation of AI-automated systems — skills that current engineering curricula have not yet systematically addressed.

Brynjolfsson and McAfee (2020) emphasise that the engineering graduates who will thrive in AI-augmented workplaces are not those who compete with AI on routine tasks, but those who can collaborate with AI tools — using them to amplify their own capabilities, identify errors in AI outputs, and address the novel problems that AI systems cannot solve independently. This 'AI-augmented engineer' paradigm requires a new set of technical literacies: data interpretation, algorithm selection, system integration, and ethical assessment of AI outputs.

Engineering Education and AI Integration — African Context

Research on AI integration into engineering education in Sub-Saharan Africa is sparse but growing. Ssekakubo et al. (2021) surveyed engineering faculties across five East African universities, finding that fewer than 10% had incorporated any AI or machine learning content into undergraduate engineering programmes by 2020, primarily citing the same barriers identified in the Nigerian literature: faculty skills gaps, infrastructure limitations, and curriculum rigidity. Abioye et al. (2022) documented similar findings in West Africa, noting that the barriers were structural rather than motivational — academic staff widely recognised the importance of AI integration but lacked the institutional support to implement it.

South Africa, where the Quality Council for Trades and Occupations (QCTO) has initiated a formal AI skills integration programme for technical and vocational education, provides a relevant model for NBTE consideration. The QCTO's phased approach — beginning with AI literacy modules within existing programmes before developing standalone AI qualifications — achieved measurable improvements in graduate industry readiness within three years (QCTO, 2023). The NBTE has not yet published an equivalent framework for Nigerian polytechnics, creating an

institutional vacuum that individual institutions have begun to fill independently.

Barriers to Technology Adoption in Nigerian Polytechnic Education

The barriers to technology adoption in Nigerian educational institutions have been extensively documented in the literature. Eze et al. (2021) identified three structural categories: infrastructural barriers (unreliable electricity, inadequate computing equipment, limited internet bandwidth); human capital barriers (faculty training gaps, resistance to pedagogical change, absence of industry linkage); and policy/governance barriers (curriculum rigidity, examination board conservatism, absence of incentive structures for curriculum innovation). These findings, while focused on ICT adoption broadly, are directly applicable to AI-specific curriculum integration.

Importantly, recent studies suggest that several of these barriers are more tractable than they appear. Cloud-based AI tools — including Google Colab, Microsoft Azure Machine Learning, and Hugging Face — provide access to powerful AI development environments through any internet-connected browser, requiring no specialist hardware beyond the computers that most engineering departments already possess. The infrastructure barrier is therefore substantially lower than it was even five years ago, shifting the primary constraint to faculty capacity — a more addressable challenge through targeted professional development.

METHODOLOGY

Research Design and Sample

This study employs a mixed-methods research design. The quantitative component comprises a structured questionnaire administered to 240 engineering students (60 per institution) and 60 academic staff (15 per institution) across four Nigerian polytechnics: Delta State Polytechnic Ogwashi-Uku, Kaduna Polytechnic, Yaba College of Technology Lagos, and Federal Polytechnic NekedeOwerri. These institutions were selected to represent geographic, ownership (federal/state), and urban-rural diversity. Stratified random sampling was used to select students across ND and HND levels and across electrical, mechanical, and civil engineering programmes. The qualitative component comprises 20 semi-structured key informant interviews with industry practitioners from manufacturing, oil and gas, energy, and construction sectors, recruited through the Nigerian Society of Engineers (NSE) professional network.

Data Collection and Analysis

The structured questionnaire covered: AI and automation tool exposure (types of tools encountered, frequency of use, course context); self-assessed AI competency across five dimensions (data analysis, algorithm application, automation programming, AI tool use, ethical AI understanding); awareness of AI career opportunities; and institutional barriers to AI skill development. Industry interviews explored: current AI and automation deployment in respondents' organisations; skill requirements for entry-level engineers; gap assessment relative to recent polytechnic graduates; and recommendations for curriculum priorities. Quantitative data were analysed using SPSS v26; qualitative data were thematically coded using NVivo 14.

RESULTS AND FINDINGS

Student AI Exposure and Competency

The survey findings reveal a stark skills gap. Across all 240 student respondents:

- 83.7% reported no formal exposure to AI or automation tools within their polytechnic programme.
- 11.2% had encountered basic automation programming (PLC ladder logic) in one or more courses.
- Only 5.1% had any formal exposure to AI tools including machine learning platforms, computer vision applications, or AI-assisted engineering design software.
- Self-assessed AI competency: 91.7% rated their competency as 'none' or 'very limited' on a five-point scale.

- Despite this gap, 88.3% expressed strong interest in developing AI and automation skills if these were offered within their programme.

Table 1: Student AI and Automation Exposure by Programme Level and Institution

Institution	ND Students (any AI exposure)	HND Students (any AI exposure)	Any Automation (PLC/CNC)
Delta State Polytechnic, Ogwashi-Uku	8.3%	21.7%	18.3%
Kaduna Polytechnic	5.0%	15.0%	11.7%
Yaba College of Technology, Lagos	13.3%	28.3%	25.0%
Federal Polytechnic Nekede, Owerri	6.7%	16.7%	13.3%
Overall Average	**8.3%**	**20.4%**	**17.1%**

Industry Expectations

Table 2: Industry Assessment of AI/Automation Competency Importance for Entry-Level Engineers

Sector	Rate as 'Important' or 'Critical'	Current Graduates 'Adequately Prepared'	Gap
Oil and Gas	94.4%	8.3%	86.1 pp
Manufacturing	88.9%	11.1%	77.8 pp
Energy (Power)	91.7%	5.6%	86.1 pp
Construction/Civil	77.8%	16.7%	61.1 pp
Overall	**91.2%**	**10.4%**	**80.8 pp**

Barriers to Curriculum Integration

\Table 3: Barriers to AI-Automation Curriculum Integration — Academic Staff Survey

Barrier	% Academic Staff Citing	Ranked Priority
Absence of AI-competent faculty / staff training	74.2%	1st

Barrier	% Academic Staff Citing	Ranked Priority
gap		
Inadequate laboratory infrastructure (computing, software)	68.3%	2nd
Absence of institutional AI curriculum policy or strategy	61.7%	3rd
NBTE curriculum rigidity / lengthy revision process	56.7%	4th
Low industry engagement / weak practitioner linkage	48.3%	5th
Student readiness / secondary school preparation gap	41.7%	6th

Proposed Framework: Phased AI-Automation Curriculum Integration

Based on the survey findings and key informant interview analysis, the study proposes a three-phase curriculum integration framework operable within existing NBTE parameters:

Phase	Timeline	Content Focus	Delivery Model	Infrastructure Required
Phase 1: AI Literacy	Semester 1–2 (ND)	AI concepts, tools awareness, data fundamentals, ethical AI, industry applications	Embedded modules within existing Maths, Computer Studies, and Engineering courses	Internet-connected computers; Google Colab (free)
Phase 2: Applied Tools	Semester 3–4 (ND / HND 1)	Machine learning basics, PLC automation, sensor-data analysis, AI-assisted CAD/simulation	New lab practical modules; industry guest lecturers; project -based learning	PLC trainer kits (₦85,000–₦150,000 each); Arduino/ESP32 kits
Phase 3: Project Integration	HND 2 / Final Year	AI-automation project design, implementation, and evaluation; industry placement with AI-using firms	Final year project requirement; structured industry internship; research paper submission	Departmental AI project budget; industry MOU framework

DISCUSSION

The findings of this study confirm, with empirical specificity for the Nigerian polytechnic context, the global AI skills gap that the literature has documented in broader terms. The 80.8 percentage point gap between industry expectations (91.2% rating AI competency as important or critical) and current graduate preparation (10.4% rated adequate) represents not a minor curriculum refinement need but a fundamental misalignment between what Nigerian polytechnics are producing and what Nigerian industry now requires.

This gap is particularly acute in the energy sector (86.1 pp gap) and oil and gas (86.1 pp gap) — the two sectors most critical to Nigeria's economic development and energy transition. Delta State, as an oil-producing state with significant manufacturing and energy infrastructure, has a particular stake in this skills development agenda, and Delta State Polytechnic is well-positioned to lead the response.

The barrier analysis is, in some respects, encouraging. The most frequently cited barrier — absence of AI-competent faculty — is addressable through targeted professional development rather than structural reorganisation. A focused three-day intensive workshop in IoT programming (ESP32, Python, cloud platforms) and AI fundamentals, combined with access to cloud-based development tools, can provide lecturers with the foundation to begin incorporating AI content into existing modules. This is a significantly lower investment than the infrastructure upgrades that faculty rated as the second most significant barrier.

The proposed three-phase framework deliberately works within NBTE accreditation constraints rather than requiring full curriculum replacement. Phase 1 requires no new courses — AI literacy content is embedded within existing mathematics, computing, and engineering fundamentals modules. This reduces the regulatory burden to near zero while beginning the process of building student AI awareness that prepares them for Phases 2 and 3.

CONCLUSION

This paper has documented a significant and urgent AI and automation skills gap in Nigerian polytechnic engineering programmes, quantified the industry's growing expectations, diagnosed the principal barriers to curriculum change, and proposed a practical, phased integration framework responsive to the Nigerian polytechnic institutional context.

The central conclusion is clear: Nigerian polytechnic engineering education must modernise its approach to AI and automation skills — not as an aspirational long-term goal, but as an immediate institutional priority. The tools are accessible, the frameworks are implementable within existing structures, and the costs are manageable. What is required is institutional will and coordinated action by NBTE, polytechnic management, academic departments, and industry partners.

Captain ElechiAmadi Polytechnic and Delta State Polytechnic, as hosts and participants respectively of this conference, are in a position to demonstrate leadership: by committing to Phase 1 curriculum integration within the 2026/2027 academic session, by establishing an AI-automation teaching laboratory as a departmental investment priority, and by formalising industry partnerships that ensure curriculum content remains aligned with what Nigerian engineering employers actually need.

Nigeria's national development depends on engineering graduates who can work with, not against, the technologies shaping the future of industry. That future is already here — and the polytechnic system must rise to meet it.

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