

BRIDGING THE AI LITERACY GAP FROM EARLY CHILDHOOD TO UNIVERSITY: A CRITICAL ANALYSIS OF THE NIGERIAN EDUCATIONAL CONTINUUM

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Abstract

Nigeria faces a compounding educational crisis at the intersection of demographic scale and technological disruption. While the federal government has advanced national AI policy frameworks and tertiary-level skilling programmes, artificial intelligence (AI) literacy remains structurally absent from early childhood and primary education, the stages most consequential for long-term cognitive formation. This paper examined the AI literacy gap across Nigeria's educational continuum, from Early Childhood Education (ECE) to the university, using policy analysis, empirical evidence, and an adapted framework that synthesises Vygotsky's Zone of Proximal Development, Long and Magerko's AI literacy competency model, and contextual adaptation theory. A systematic review of Nigerian and global literature identified four structural barriers: infrastructural deficits, teacher unpreparedness, curriculum fragmentation, and equity gaps. A phased, developmentally sequenced policy framework grounded in Nigeria's socioeconomic realities is proposed. Findings carry implications for curriculum developers, policymakers, teacher educators, and development finance institutions operating across sub-Saharan Africa.

Keywords: *AI literacy; early childhood education; Nigeria; educational equity; curriculum policy; artificial intelligence in education; sub-Saharan Africa*

Introduction

Nigeria stands at a paradoxical crossroads. It has the largest youth population on the African continent and a government-backed ambition to

become a regional AI powerhouse, yet the overwhelming majority of its children complete their early schooling without a single structured encounter with artificial intelligence. This contradiction is systemic, and its consequences will be felt for decades if left unaddressed.

The scale of existing deficits sharpens the urgency. A GetBundi STEM survey found that only 19 of 100 NYSC members sampled possessed any form of digital skill, and approximately 75% of Nigerian graduates remain satisfied with theoretical knowledge from an obsolete curriculum, while only 15–27% demonstrate familiarity with AI or technical soft skills (Oparaugo, 2024). At the policy level, the federal government introduced a National AI Policy and the 3 Million Technical Talent (3MTT) programme, which has trained over 300,000 Nigerians across digital platforms and 220 in-person centres (FMCIADE, 2024). Yet these interventions are concentrated at the tertiary and vocational end of the learning spectrum, and research and development accounts for only 0.89% of total education spend (TechCabal Insights, 2025).

What is absent is a developmentally grounded approach that begins at the nursery gate rather than at university entrance. Research on AI in Nigerian Early Childhood Education shows that AI-driven tools can enhance engagement, personalise learning, and support critical thinking, while also revealing infrastructural, pedagogical, and ethical obstacles (IJEDICT, 2025). The equity dimension is equally acute: over 18.3 million Nigerian children are out of school, the highest number globally (World Bank, 2024), and rural classrooms often have one teacher for over 100 pupils (TechNext, 2025). The 2024 World Bank-supported Edo State pilot nevertheless showed what targeted intervention can achieve: participating students gained nearly two years' worth of literacy improvement in six weeks, with girls narrowing historical gender gaps (World Bank, 2024).

This paper argued that bridging Nigeria's AI literacy gap requires a shift from treating AI education as a tertiary-level intervention to embedding it as a longitudinal, developmentally sequenced competency that begins in early childhood and scales through to university. It proposes a framework that is not imported wholesale from Western models but adapted to Nigeria's infrastructure constraints, pedagogical traditions, and demographic imperatives.

Literature Review

Conceptualising AI Literacy: Global Frameworks and Their Limitations

Since 2019, scholarly interest in AI literacy has grown exponentially, yet the concept still lacks a unified definition (Lee & Kwon, 2024; Tenório et al., 2023). Broadly, it encompasses the ability not merely to use AI tools but to understand their underlying logic, evaluate their outputs critically, and engage with them ethically. Long and Magerko (2020) identify seventeen competencies spanning five domains: what AI can and cannot do, how it works, its relationship to humans, how to evaluate it critically, and how to use it responsibly.

Existing frameworks have been designed predominantly for secondary and tertiary learners. A systematic review of 22 empirical K-12 studies found that most focused on secondary education, leaving early childhood largely unattended (Tandfonline, 2025). Frameworks such as Ng et al. (2021) and UNESCO (2022) offer conceptual scaffolding but do not adequately differentiate developmental appropriateness across age groups, and Yim and Su (2024) note that they frequently overlook young learners. AI literacy must also extend beyond technical boundaries to encompass computer science, ethics, sociology, economics, and law (Southworth et al., 2023). For Nigeria, cultural and linguistic contextualisation is a further imperative, given inadequate indigenous software localisation and the dominance of Western assumptions in available AI tools (Adewale & Oduwole, 2024).

AI Literacy in Early Childhood: A Neglected Frontier

Literature on AI literacy in early childhood remains sparse relative to its urgency. Scholars have explored the challenges and opportunities at this stage (Bers et al., 2023), but translating them into scalable, context-sensitive practice in the Global South has proven elusive. Foundational habits of reasoning, pattern recognition, and algorithmic thinking form well before formal schooling ends, making the early years a critical but underutilised window. In Nigeria, the potential of AI-driven tools is documented but delivery is obstructed (IJEDICT, 2025), a disconnect that is especially acute where reliable power, trained teachers, and compatible devices cannot be assumed.

AI Literacy in Nigerian Primary and Secondary Education

At primary level, Aina et al. (2023) and Okunade (2024) suggest that AI applications can ease teacher workloads through automation, intelligent tutoring, and adaptive platforms. However, educators without AI competency risk being left behind, and systemic investment in teacher AI literacy remains absent at the policy level (IJRISS, 2025). In July 2025, the Federal Government introduced digital technology subjects, including AI, robotics, data analytics, cybersecurity, and programming, into the junior and secondary curriculum from September 2025 (IJLSER, 2025). Its preconditions of trained teachers, functioning devices, and reliable electricity remain unmet across much of the country, and a study in Anambra State confirms significant access and training limitations among secondary teachers (UNIOJE, 2025).

The 2024 Edo State pilot is the most instructive empirical case. In it, 800 first-year senior secondary students used Microsoft Copilot productively when teachers acted as “orchestra conductors” guiding structured interactions, although frequent power outages disrupted continuity (De Simone et al., 2024).

AI Literacy in Nigerian Higher Education

At university level, studies confirm a significant skills gap among students and faculty. Unreliable internet and power supply limit the access to and effectiveness of AI tools (Akudo & Ogbonna, 2024; Samuel & Danladi, 2025), while financial constraints and low digital literacy restrict institutional capacity. Policy responses have been more visible: Nigeria's 2024 National Artificial Intelligence Strategy (NAIS) sets out five pillars (infrastructure, ecosystem, sector adoption, ethics, and governance), and the National Centre for Artificial Intelligence and Robotics (NCAIR) provides national compute and storage capacity (Nucamp, 2025). A review of AI readiness in Northern Nigerian higher education stresses infrastructure, curriculum integration, policy support, and public-private collaboration (Reuben & Kabilan, 2024). Yet tertiary interventions cannot compensate for the absence of foundational AI literacy at earlier stages.

Structural Barriers: Infrastructure, Equity, and the Urban-Rural Divide

Across all levels, the literature identifies three structural barriers: infrastructure deficits, teacher unpreparedness, and entrenched urban-rural equity gaps. Rural schools underperform urban schools because of inadequate resources, teacher shortages, and poor infrastructure (Yunusa et al., 2024), and over 13.7 million learners were enrolled in private schools in 2022, reflecting deepening inequality (Journal of Curriculum and Instruction, 2025). Many lecturers and teachers lack the confidence and pedagogical knowledge to deliver AI-enhanced curricula (Omeh et al., 2024). Pilot deployments of educational robots and adaptive platforms show feasibility and engagement but remain fragmented and non-scalable without a national implementation framework (Bolu et al., 2024; Nannim et al., 2025). Both Omeh et al. (2024) and Ugwu et al. (2024) recommend a National AI in Education Policy establishing unified standards, funding mechanisms, and ethical boundaries.

Summary and Identified Gaps

Three conclusions emerge. First, global AI literacy frameworks are inadequately adapted to early childhood and largely inapplicable to Nigeria without significant contextualisation. Second, Nigerian research confirms both the potential and the fragility of AI integration at every level. Third, the continuum from early childhood to university remains fractured: interventions are designed and evaluated in isolation, with no longitudinal framework connecting AI competency development across formal education. This paper sought to address that gap.

Theoretical Framework

This study adopted a synthesised framework combining three complementary perspectives: Vygotsky's Zone of Proximal Development (ZPD), Long and Magerko's (2020) AI Literacy Competency Model, and Contextual Adaptation Theory as applied to educational technology in developing countries.

Vygotsky's Zone of Proximal Development (ZPD)

Vygotsky's (1978) ZPD, the distance between what a learner can achieve independently and with guided support, provides the developmental rationale for early AI literacy. A ZPD-informed approach holds that

scaffolded engagement with algorithmic reasoning, pattern recognition, and computational thinking can begin in early childhood if tools, language, and pedagogy are suitably calibrated. In Nigeria, this means beginning with concrete, culturally resonant tasks and building toward abstraction, with the teacher as the more knowledgeable other mediating the learner's relationship with AI.

Long and Magerko's AI Literacy Competency Model

Long and Magerko (2020) identify five domains: recognising AI; understanding what it can and cannot do; understanding how it works; critically evaluating it; and using it ethically. This study adapts them across three educational bands: early childhood (ages 3–8), primary and secondary (ages 9–17), and tertiary (ages 18+). Early childhood emphasises the first two domains, primary and secondary foreground mechanism and critical evaluation, and university integrates all five, with particular emphasis on ethical and discipline-specific use.

Contextual Adaptation Theory

Pea's (2004) contextual adaptation theory, extended to developing economies by Adewale and Oduwale (2024), holds that technology-mediated learning is most effective when adapted to the socioeconomic, infrastructural, linguistic, and cultural context of implementation rather than imported wholesale. For Nigeria, this means accounting for low bandwidth, multilingual learners, variable teacher confidence, uneven electricity, and urban-rural differences. Together, the three strands yield the Developmentally Sequenced, Contextually Adapted AI Literacy (DSCAAL) framework, which structures the analysis and recommendations that follow.

Methodology

Research Design

This study employed a systematic narrative review of peer-reviewed literature, grey literature, policy documents, and empirical reports published between 2019 and 2026. The approach suits a nascent and heterogeneous literature in which primary empirical data on Nigeria are limited and conceptual synthesis is urgently needed (Omeh et al., 2024).

Search Strategy and Inclusion Criteria

Scopus, Web of Science, Google Scholar, ERIC, and African Journals OnLine (AJOL) were searched using three term clusters: (1) “artificial intelligence” AND “literacy” OR “education”; (2) “Nigeria” AND “AI” AND “curriculum” OR “school” OR “university”; and (3) “early childhood” AND “AI” AND “developing countries”. Sources were included if they (a) addressed AI literacy, integration, or policy in educational settings; (b) were published between January 2019 and May 2026; (c) were peer-reviewed or produced by credible policy institutions; and (d) were relevant to Nigeria or to sub-Saharan Africa with transferable implications. Of 87 sources identified, 54 were retained after abstract screening and full-text review; exclusions were sources with insufficient methodological rigour, duplicated findings, or outside the temporal scope. Policy documents from the Federal Ministry of Education, the Federal Ministry of Communications, Innovation and Digital Economy, UNESCO, the World Bank, and NITDA were included as grey literature.

Analytical Approach

Retained literature was analysed thematically around four barrier categories (infrastructure, teacher readiness, curriculum coherence, and equity) and mapped against the three educational bands. Policy documents were subjected to critical discourse analysis to identify gaps between stated ambitions and implementation provisions. The synthesised findings informed the policy framework proposed below.

Findings: Structural Barriers across the Educational Continuum**Barrier One: Infrastructural Deficits**

Inadequate infrastructure was the most consistently identified barrier. Unreliable electricity disrupts digital learning, insufficient bandwidth limits access to cloud-based AI tools, and the absence of devices, particularly in public primary schools, forecloses even modest technology-mediated instruction (Akudo & Ogbonna, 2024). Urban and private schools are significantly better resourced than rural and public ones, so these deficits compound existing inequalities. No primary-level AI programme in Nigeria has achieved demonstrable scale without external funding and technology provision (IJEDICT, 2025). Even the Edo State pilot depended on Microsoft's infrastructure investment and World Bank funding, conditions

that cannot be assumed across the 36 states and the Federal Capital Territory.

Barrier Two: Teacher Unpreparedness

Teacher readiness for AI encompasses technical skills, pedagogical integration, ethical understanding, and self-confidence (Eke, 2024; UNIOJE, 2025), and Nigerian teachers show deficits across all four, including basic confidence in operating adaptive tutoring or generative AI tools (Omeh et al., 2024). Pre-service education has yet to incorporate AI literacy as a core competency: the National Commission for Colleges of Education (NCCE) minimum standards, last substantively revised before the AI era, do not mandate AI pedagogical training. In-service programmes are episodic, donor-funded, and geographically concentrated, leaving most of Nigeria's estimated 800,000 primary school teachers without meaningful AI literacy development (Akinniranye et al., 2025).

Barrier Three: Curriculum Fragmentation

AI education in Nigeria is fragmented vertically and horizontally. Vertically, there is no coherent progression of competencies from ECE to university. Horizontally, AI literacy exists in isolated pockets without cross-institutional articulation or shared standards (Nannim et al., 2025). The July 2025 reform addresses only the secondary band: it specifies no minimum competencies, assessment standards, or teacher qualifications, and it connects neither downward to early childhood and primary nor upward to tertiary expectations. It adds content without building coherence (IJLSER, 2025).

Barrier Four: Equity Gaps and Gendered Exclusion

Access to AI literacy is stratified by geography, socioeconomic status, and gender. Rural learners, low-income families, girls, and children with disabilities face compounding barriers beyond infrastructure: cultural norms in parts of northern Nigeria restrict girls' schooling and interaction with digital technologies, and many families cannot afford a smartphone or tablet, the minimum threshold for mobile-first approaches (TechNext, 2025). The Edo State finding that girls made disproportionate gains under structured AI-mediated support suggests that well-designed interventions can advance gender equity rather than create new exclusion, but only if equity is designed in from the outset (World Bank, 2024).

A Developmentally Sequenced, Contextually Adapted AI Literacy (DSCAAL) Framework for Nigeria

On the basis of the foregoing analysis, this study proposes the DSCAAL framework, a phased, band-specific approach grounded in developmental appropriateness, contextual realism, and equity.

Band One: Early Childhood (Ages 3–8)

Instruction should focus on recognition, curiosity, and boundary-setting rather than technical operation. Children should encounter age-appropriate AI (voice assistants, simple sorting games, story-generating tools) in teacher-guided settings that build awareness that AI systems exist, are made by humans, and make mistakes, embedded in play-based learning, storytelling, and oral tradition. This requires offline-first, low-power tools adapted to Nigerian languages. Teacher training should emphasise facilitation rather than technical expertise, a threshold achievable within existing NCCE structures in 18–24 months.

Band Two: Primary and Secondary (Ages 9–17)

AI literacy should expand to mechanism understanding and critical evaluation: how recommendation systems, predictive text, and classification algorithms work, and how to evaluate outputs for bias, error, and ethical implications. This band aligns with the July 2025 reform but extends it downward to primary level and demands more explicit competency mapping. A dedicated AI pedagogy module in NCE and PGDE programmes is urgent, with short-cycle intensive training, as piloted in Edo State, bridging the gap while pre-service reforms are institutionalised.

Band Three: University and Tertiary (Ages 18+)

AI literacy should reach its fullest expression: ethical use, discipline-specific applications, research literacy, and the capacity to design, evaluate, and advocate for AI systems. All undergraduate programmes, not only STEM, should include a foundational AI literacy requirement modelled on existing general education mandates, and postgraduate programmes should integrate AI methodological literacy into research training. Universities should also serve as hubs for contextually grounded AI education research, drawing on NCAIR's compute infrastructure, to generate the evidence that early childhood and primary policy requires.

Cross-Band Provisions

Three provisions should operate across all bands. First, a National AI in Education Coordination Body, drawing together the Federal Ministry of Education, NITDA, NCAIR, and development partners, should govern implementation and maintain alignment across levels. Second, gender-responsive design, including community engagement where girls' technology access is structurally constrained, must be embedded throughout. Third, a minimum offline-first, low-bandwidth standard should apply to all publicly funded AI literacy tools so that infrastructure deficits do not become permanent barriers.

Discussion**Implications for Policy**

The July 2025 secondary reform is necessary but insufficient: without downward extension to early childhood and primary levels, it risks producing university entrants with fragmented AI awareness rather than coherent AI literacy. Budget allocation is the most consequential lever. The current 0.89% education R&D allocation is inadequate to sustain the research-to-practice pipeline, and incremental reallocation to at least 2%, consistent with UNESCO recommendations for developing economies, should be a precondition for sustainable progress (TechCabal Insights, 2025).

Implications for Teacher Education

The NCCE and the National Universities Commission (NUC) must embed AI literacy pedagogy in pre-service training and create in-service CPD pathways that reach beyond urban centres. The Edo State model of intensive, short-cycle, teacher-led training offers a replicable design, provided it is adapted to early childhood and primary contexts.

Implications for Development Finance

The World Bank, African Development Bank, and bilateral donors should fund the infrastructure preconditions for AI literacy. Solar-powered device charging, offline-capable AI tools, and community-based learning centres offer higher equity returns than urban-focused institutional grants. Africa's receipt of only 0.02% of global AI funding in Q2 2025 (TechCabal Insights,

2025) reflects a structural injustice that development finance should actively correct.

Limitations

As a systematic narrative review, this study is bound by the limits of the existing literature, which on Nigerian early childhood AI literacy is notably thin. Classroom observations, competency assessments, and longitudinal tracking are largely absent, so the DSCAAL framework is a theoretically grounded policy proposal requiring empirical validation rather than an evidence-proven intervention. Future research should prioritise longitudinal mixed-methods studies across educational bands and diverse Nigerian contexts, particularly rural, northern, and gender-marginalised learners.

Conclusion

Nigeria's AI literacy gap is not a technical problem. It is a structural, political, and developmental challenge accumulated through decades of underinvestment in foundational education and episodic, uncoordinated technology integration. No amount of university-level skilling will compensate for the absence of early childhood foundations, and no secondary reform will reach its potential without aligned teacher preparation and infrastructure.

The DSCAAL framework offers a theoretically grounded, contextually adapted pathway to a coherent AI literacy continuum. It is not a blueprint for immediate mass implementation but a framework for phased, evidence-guided progress that begins in the early years of a child's cognitive formation. The stakes are significant: Nigeria's AI market is projected to grow at 27% CAGR, potentially adding \$15 billion to GDP by 2030 (Nucamp, 2025). Whether Nigerians become producers and critical users of that economy or merely its consumers will depend on decisions made now about what a child learns and when. Those decisions cannot wait for perfect conditions; they must begin, developmentally and deliberately, at the beginning.

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