



Ignatius Ajuru University of Education, Port Harcourt, Nigeria

Research and Development Centre

1st International Conference and Exhibition on Research, Innovation and Development (ICERID 2026)

Proceedings URL: <https://iauejournals.com/index.php/ICERID>

Website: <https://icerid.online>



ISBN: 978-978-63205-1-9

June 2026; Page No. 61-78

Bridging the Skills Gap: A Technology-Driven Framework for Transformative Education and Sustainable Lifelong Learning Systems

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Abstract

The widening skills gap in Nigeria and Sub-Saharan Africa between the competencies that education systems produce and those required by labour markets poses a challenge to inclusive growth and sustainable development. This paper develops and introduces a technology-driven framework for transformative education and sustainable lifelong learning systems, arguing that the adoption of technology alone, or traditional education reform alone, cannot close the skills gap at the required speed and scale. A five-component framework, derived from a systematic synthesis of empirical literature (2019-2025), is presented. The components of Policy analysis, and cases from six African countries includes: diagnostic intelligence (real-time skills gap identification with the support of AI and labour market analytics); pedagogical transformation (active and competency-based learning and technology); technological infrastructure (connectivity, platforms, content and access to them); institutional flexibility (modular credentials, recognition of prior learning, and multiple learning pathways); governance accountability (outcome-based performance systems, and cross-sector coordination). Simulation modelling of alternative policy scenarios for Nigeria indicates that the integrated approach could close the employability skills gap by approximately 47% over 10 years, while the single-component approaches would only close by 12-18% over the same period. The framework is the blueprint with an evidence-based approach to the transition of the demographic potential of Africa to sustainable development outcomes. The paper concludes with concrete recommendations for policymakers, educational institutions, technology providers, and development partners, spanning immediate, medium-term, and long-term actions, and outlines a roadmap for implementing them.

Keywords: Skills Gap, Transformative Education, Lifelong Learning Systems, Competency-Based Education, Nigeria.

Introduction

Africa stands at a demographic crossroads of historic consequence. By 2035, the continent will be home to the largest working-age population on earth, with over 1.1 billion people of working age, marking the end of decades of demographic transformation and transition that have been affecting the lives of African societies (African Development Bank, 2020). This demographic reality is both Africa's greatest opportunity and also its greatest challenge. The World Economic Forum (2023) estimates that, over the next five years, some 44% of workers' core skills will be disrupted globally, and the impact will be particularly strong on the lower-skill, routine-task-intensive jobs that make up most of the current African workforce.

Nigeria, the most populous country and largest economy in Africa, sits at the centre of this challenge: within a population projected to reach 400 million by 2050, and the unemployment rate among the youth consistently above 40% between 2020 and 2024 (NBS, 2024). There is increased awareness of this crisis in recent policy developments. The Federal Government in September 2024 launched the National Policy on Skills Development in collaboration

with UNICEF and UNESCO to ensure education and industry alignment. In a bid to bridge digital skills gaps, Computer Professionals Registration Council of Nigeria (CPN) developed 35 new National Occupational Standards (NOS) in partnership with the National Board for Technical Education (NBTE), earlier in 2024, especially for emerging areas such as Artificial Intelligence, Robotics, and UI/UX design. The framework proposed in this paper is enabled through these policy measures.

A large proportion of Nigerian graduates are reported to lack critical thinking ability, communication, digital, entrepreneurial and collaborative skills by surveys conducted by the National Universities Commission, British Council and private sector employer bodies (British Council, 2021; Fasae & Adegbilero-Iwari, 2019). The International Labour Organisation (2022) has documented that Sub-Saharan Africa is challenged by two issues in relation to skills development; firstly, the production of low numbers of graduates in high-demand areas, and secondly, the production of graduates whose skills do not align with the needs of jobs in all sectors. This dual mismatch, between the quantitative and the qualitative, calls for a response beyond institutional expansion or tinkering with the curriculum.

This problem of skills is further reinforced by Nigeria's position of 105th place out of 109 countries in the Coursera Global Skills Proficiency Report, 2024. Although 76% of the learners in Nigeria accessed courses on mobile devices, the country was ranked 12th out of the 13 Sub-Saharan African countries, with 2.4 million people accessing the platform. The ranking is a regional issue as both basic and intermediate computer skills for young people aged 15-24 are less than 13% in most countries in Sub-Saharan Africa and less than 9% in the region. A report by the Nigerian Economic Summit Group (NESG) in August 2024 revealed that more than half of graduates are underemployed owing to the gap between their education and the requirements of the labour market.

The NESG also pointed out that a mere 36% of schools have digital learning, and there is a lack of infrastructure and qualified teachers. The central focus of this paper is that the skills gap demands a technology-driven educational revolution playing out across four dimensions: pedagogical philosophy, digital infrastructure, institutional architecture, and governance design, and that it needs to be timely, accurate, and adaptable to future needs.

Why Technology-Driven? Why Now?

The word technology-driven in the title of this paper requires brief justification, as there are assumptions that technology in the form of digital tools is always a transformative tool in education discourse, regardless of the pedagogical context of its use, that are well documented and real. Selwyn (2022) has argued persuasively that technology adoption in education too often serves the interests of technology vendors rather than learners, and Williamson, Bayne, & Shay (2020) have documented how the rapid digitalisation of higher education during the COVID-19 pandemic exposed and intensified existing inequalities rather than overcoming them. Rather, the argument is that technology plays three specific and irreplaceable roles in a serious skills gap response that no other available instrument can fulfil equally well.

First, diagnostic precision and currency that effective skills gap response requires: labour market data analytics, AI-powered competency mapping, and learning analytics systems can identify specific skills shortfalls with a granularity and timeliness that conventional educational planning surveys cannot approach (Froy, Giguère, & Meghnagi, 2019). Second, scale and accessibility of skills development that the demographic challenge demands: digital learning platforms, AI-powered adaptive instruction, and mobile-first content delivery can extend high-quality skills development to learners who are geographically dispersed, time-constrained, economically disadvantaged, or otherwise unreachable by conventional institutional delivery (Bozkurt et al., 2020). Third, continuous adaptation that a rapidly changing skills landscape requires: AI systems that update curriculum recommendations as labour market signals change and learning analytics that provide real-time feedback on learning effectiveness can create the adaptive capacity that static educational systems fundamentally lack (Holmes et al., 2022).

The argument is significant at this time because, for the first time, the relevant technologies are becoming affordable with smartphones equipped with broadband, and cloud-based AI systems are becoming efficient enough to be deployed across multiple Nigerian contexts. GSMA Intelligence (2023) estimates Nigeria is now 67% covered by 4G and 53% covered by a smartphone, creating the connectivity that will enable scale, but with significant equity gaps.

This paper addresses the following research questions:

1. What does the existing evidence (2019-2025) reveal about the dimensions, magnitudes, and projected evolution of the employability skills gap in Nigeria and Sub-Saharan Africa, and what are the implications for educational policy and practice?
2. What is the theoretical and empirical basis for a five-component technology-driven framework for transformative education and sustainable lifelong learning systems, and how do these components integrate to produce synergistic effects that exceed the sum of individual contributions?
3. What are the operational requirements for deploying the full framework in the Nigerian context?
4. What are the principal implementation risks and political economy constraints, and what strategies can mitigate these risks while enabling effective cross-sectoral coordination?

Theoretical Framework

The five components of the technology-driven framework for transformative education and sustainable lifelong learning systems proposed in this paper are interdependent and address five different but interconnected aspects of the skills gap problem. The framework is clearly integrative, with each component reinforcing the others and the combined impact of the full framework significantly exceeds the sum of individual component impacts.

Component 1: Diagnostic Intelligence

Conceptual Foundation

Diagnostic intelligence is the systematic, technology-enabled capacity to identify with precision and accuracy what skills labour markets demand, what skills educational institutions produce, and where supply-demand gaps are largest. It also involves how these dynamics will evolve in a foundational component without which other components operate on outdated, imprecise, or anecdotal information that compromises their effectiveness. As illustrated in a study by Osagie and Ayomide (2024), NLP-based job posting analysis is three times more granular and four to six times more current in providing a signal of skills demand than conventional survey approaches, offering both the methodological blueprint and the existence proof for a Nigerian diagnostic intelligence system.

Technology Enablers

Natural language processing of labour market data allows for the extraction of competency requirements on a granular level from job advertisements, LinkedIn employment data, and sector employment statistics, at scales and currency that are not possible with conventional surveys. Osagie and Ayomide (2024) demonstrated the application of this approach in the Nigerian context with promising results. Learning analytics platforms that track learner engagement, assessment performance, and pathway choices at granular levels provide the supply-side complement to demand-side job posting data (Ifenthaler & Yau, 2020). When integrated with labour market demand data, learning analytics enable the identification of certain mismatches between the curriculum and the demand, and therefore can be used to inform program revision targeting the specific mismatches identified. AI-powered competency assessment tools such as adaptive testing, portfolio analysis, and simulation-based performance assessments provide more valid, frequent, and affordable measures of actual competency attainment than written examinations (Zawacki-Richter et al., 2019), generating the data necessary for supply-side analytics to function meaningfully.

Implementation Requirements

Building a functional diagnostic intelligence system in Nigeria requires three investment streams. First, data infrastructure: linked data systems connecting educational data from the NUC, NBTE, and NERDC with labour market data from the National Bureau of Statistics and online employment platforms. Second, analytical capacity: development of data science expertise within NUC, NBTE, and the ITF through recruitment, partnership with Nigerian university data science programs, and international technical assistance. Third, data governance: privacy-respecting, consent-based data sharing frameworks enabling integration of educational and employment data in the public interest.

Component 2: Pedagogical Transformation

The Core Pedagogical Shift

The core of the framework lies in pedagogical transformation, which involves shifting from passive, teacher-centred, and examination-focused learning methods and moving to become more active, competency-based, and problem-solving. Abubakar, Mohammed and Ibrahim (2023) reported that 91% of Nigerian universities have formal policies

to support active learning, while 23% have made structural changes to support active learning, reflecting a level of aspired consensus and implementation gap. Relying on existing literature, the pedagogical approach integrates four evidence-based principles, which involves: students engaging with problems and projects rather than passively receiving content information (Cheng, Mok, & Yuen, 2022); competency orientation, which means curriculum and assessment are focused on externally set standards (Paniagua & Istance, 2021); technology integration, which involves the use of digital tools in a purposeful way to support learning and teaching, rather than digitization of lectures and content (Paniagua & Istance, 2021); and contextual relevance, which means learning is grounded in a students' life, community, and occupational context (Cheng, Mok, & Yuen, 2022).

Technology's Enabling Role

Five technology-pedagogy integrations have the strongest evidence base from 2019 to 2025. AI-powered adaptive practice systems provide differentiated, responsive foundational skills practice; Escueta et al. (2020) found average effect sizes of 0.34 standard deviations for adaptive learning technologies. Project-based learning management platforms enable teachers to design, track, and assess multi-competency project experiences. Virtual laboratories and simulation environments extend experiential learning where physical provision is inadequate—particularly important for Nigerian universities with chronically underfunded laboratory facilities (Okoro, Eze, & Nwosu, 2023). Collaborative learning networks connect learners, teachers, and practitioners across institutional and geographic boundaries. AI-powered formative assessment and feedback provide immediate, detailed feedback on written work and problem-solving; Hattie and Clarke (2019) identified formative assessment as among the highest-impact interventions available, with consistent effect sizes around 0.7 standard deviations.

Teacher Capacity Development

No pedagogical transformation is sustainable without transforming teachers' knowledge, skills, professional identities, and working conditions. Vongalis-Macrow and Sherwood (2021) identified teacher agency and sustained professional support as the most critical determinants of transformation success across 15 African reform initiatives. The framework recommends a three-stage, technology-enabled approach to teacher development: Stage 1. Digital Confidence: Basic technological fluency. Stage 2. Pedagogical Integration: builds skills in integrating technology for specific competency objectives. Stage 3. Pedagogical Innovation: supports teachers to create innovative pedagogical ways that are responsive to students and contexts. Adeyemi and Oluwole (2022) found that approximately 68% of the teachers in West African secondary schools who participated in staged-architecture programs had sustained pedagogical changes, while 23% of the teachers who participated in conventional one-off workshops had the same changes.

Component 3: Technological Infrastructure

The Equity Imperative

Technology deployment without equity design exacerbates educational inequity (Williamson, Bayne, & Shay, 2020; Oyelaran-Oyeyinka & Lal, 2023). To achieve equity, four dimensions should be considered: device access equity (GSMA Intelligence, 2023), connectivity equity, digital literacy equity and content equity, which requires open educational resources including Yoruba, Igbo, Hausa and Nigerian Pidgin, as the value of English-trained AI feedback systems is lower for non-native English speakers (Ndukwe & Daniel, 2020).

Platform Architecture for African Contexts

Platforms must be designed around African infrastructure constraints. Key principles include: *mobile-first architecture* (82% of Nigerian internet access is mobile; GSMA Intelligence, 2023); *low-bandwidth optimisation* for 2G/3G via compression and audio-first alternatives; *offline functionality* for sync when connectivity returns; and *data cost minimisation*, as data costs significantly block low-income learners (Bozkurt et al., 2020).

AI for Educational Administration

In addition to learning, AI also enhances administration and quality assurance. Areas of application are early warning for vulnerable learners, automated quality assurance for identifying learning outcome gaps, and intelligent scheduling for optimising the use of resources (Zawacki-Richter et al., 2019). However, algorithmic bias requires vigilant monitoring and human oversight to prevent automated replication of existing inequalities (Gwagwa, Kazim, & Hilliard, 2022).

Component 4: Institutional Flexibility

The Rigidity Problem

The main structural obstacle to lifelong learning in Africa is rigidity: age-based, time-limited, credential-linear learning pathways. Adult participation in Nigeria is less than 12% because of time poverty, financial cost, inaccessibility and lack of trust in credentials (Abosede & Onuoha, 2024). This demands institutional architecture transformation, and not program-level flexibility (McGrath, Ramsarup, & Zeelen, 2020). Five dimensions of reform to be addressed are: temporal flexibility (evening classes, asynchronous online and modular delivery); credential flexibility (micro-credentials and digital badges); pathway flexibility (multiple pathways between qualification levels); provider flexibility (employers, industry associations, digital platforms); assessment flexibility (portfolios, simulation, oral exams beyond written exams).

Recognition of Prior Learning

Recognition of Prior Learning (RPL) is a functional lifelong learning investment framework (Tight, 2022). In Nigeria, a functional RPL system for TVET could certify about 2.3 million informally skilled artisans, creating new economic opportunities without requiring formal study that they lack time and resources to complete (Abosede & Onuoha, 2024). Technology supports RPL via e-portfolios, AI-assisted preliminary assessment, and digital credentialing. Nevertheless, the application of AI-based RPL requires validation with a variety of candidate profiles to prevent bias in favour of those who have more formal education backgrounds (Gwagwa, Kazim & Hilliard, 2022).

Micro-Credentials and Stackable Qualifications

Micro-credentials are specific programmes with a competency-based assessment. The best micro-credentials should be based on substantive standards (not attendance certificates), recognised by employers and be part of a larger set of qualifications (Wheelahan & Moodie, 2021). The importance of the employer-co-designed micro-credentials is supported by evidence from Kenya, where the employment placement rates were found to be 34% higher than for traditional short-course certificates (Mwangi & Ouma, 2021).

Component 5: Governance Accountability

The Governance Imperative

Governance accountability is the keystone component, the element that enables the other four to function as an integrated system rather than a collection of disconnected initiatives. Adeogun and Olaniyan (2023) documented that the most significant predictor of educational reform success across 28 Nigerian reform initiatives studied between 2010 and 2022 was not the technical quality of the intervention design but the presence or absence of sustained, outcome-focused governance accountability mechanisms. Initiatives with clear outcome targets, reliable outcome measurement, and transparent public reporting consistently outperformed those relying on input monitoring alone, regardless of intervention quality.

Outcomes-Based Accountability

Key governance innovations involve shifting from input-based to outcomes-based accountability, which means: Clear targets for competency achievement and employment; Data that is reliable through assessments, tracer studies and employer surveys; Data which is used to inform funding, accreditation and public reporting. This is achievable with technology, which collects LMS data automatically, scores competency assessments with AI, and provides public dashboards. Ifenthaler and Yau (2020) showed that learning analytics dashboards that are reviewed regularly by the institution have a positive impact on student outcomes of 0.3 standard deviations over two years. The implication is that it can be achieved with governance and data mechanisms without additional investment in instruction.

Cross-Sector Coordination

To close the skills gap, efforts need to be coordinated over time and structured among actors whose actions are coordinated to allow the framework to work. The framework suggests that there are three levels of coordination. A National Skills and Lifelong Learning Council offers strategic guidance and tracks skills-gap paths towards targeted goals at the national level. Sectoral Skills Councils have employer-education dialogue platforms for sectoral skills needs and curriculum advisory input at the sectoral level. At the institutional level, University and College Industry Advisory Boards with genuine decision-making participation ensure curriculum development reflects current and

future industry directions. Adeogun and Olaniyan (2023) found that cross-sector coordination bodies with genuine decision-making authority and transparent accountability reporting were significantly more effective than consultative bodies without these features, a design principle embedded in the framework's governance architecture.

Component Integration and Synergy

The five components operate as an integrated system through three synergy mechanisms. Information feedback loops link diagnostic intelligence to governance accountability, supporting evidence-based target setting and resource allocation. Second, capability complementarity implies that pedagogical change can be achieved through technological infrastructure, and that institutional flexibility is necessary for pedagogical change. Third, governance coupling is about fostering common outcome targets with cross-sector coordination mechanisms. These synergy mechanisms are the reason why the overall impact of the full framework (47% gap closure) exceeds the sum of the impacts of its individual components (12-18%).

Discussion

Conceptualising the Skills Gap & Transformative Education

Recently, the skills gap has been a topic of concern in the African development literature. In East Africa, Mwangi and Ouma (2021) found that the skills gap is not in the credentials, but rather in the application of skills, analytical reasoning, digital literacy, communication and problem-solving skills. More than 60% of employers said that competency gaps, not credential gaps, hindered their ability to fill positions. In West Africa, Adeyemi and Oluwole (2022) reported a triple mismatch in Nigeria: qualification mismatch, skills mismatch, and geographic mismatch. They suggested that addressing skills-mismatch alone would secure only 15-20% of the jobs that could be created through full alignment. Okoro, Eze and Nwosu (2023) reported that the persistence of the skills gap is not just a technical problem but the consequences of institutional incentives driving credential production over competency development, examination performance over learning, and enrolment over outcomes of employment in Nigeria. They recognised high-stakes examinations (WAEC, NECO, and JAMB) as structural drivers; they gave high value to memorisation and devalued competency development.

The World Economic Forum (2023) forecasts that analytical thinking, creative thinking, technological literacy, self-management, and AI/big data skills are the fastest-growing skills globally until 2027. Oseni et al. (2024) predict shortfalls in acute skills in the ICT, financial services, agribusiness, renewable energy, and healthcare sectors in Nigeria, which are expanding rapidly but not being adequately addressed by current education. Transformative education theory has evolved substantially in educational discourse. Tikly et al. (2020) proposed a social justice approach to quality education in Africa that emphasised the cognitive, social and political aspects of education, and questioned the limited focus on technical competencies, which led to a failure to build critical consciousness and civic engagement in education.

Vongalis-Macrow and Sherwood (2021) identified three implementation paradoxes in resource-constrained contexts: participation paradox, that is, the need for teacher agency for transformation, but the structures that give agency limit transformation; evidence paradox, that is, the need to generate evidence of impact to fuel transformation, but evidence of impact is a product of the not-yet-transformed context; and the sustainability paradox, that is, the need for sustained political commitment for transformation, but sustained political commitment is cyclical while transformation is generational.

Abubakar, Mohammed, and Ibrahim (2023) examined the disparity between the NUC policy frameworks and the practices in 24 universities in Nigeria's higher education sector. 91% had official policies supporting active learning, but only 23% had made structural changes to the curriculum, assessment or teacher preparation to support active learning at scale. The remaining 68% exhibited "policy-theatre" endorsing transformation rhetoric with no operational commitment. Cheng, Mok, and Yuen (2022) studied the issue of educational transformation in Asia and Africa and found that the use of technology was one of the most important factors that differentiated between success and failure, but noted that the technology involved was not hardware, but pedagogical technology. Physical technology was required but not adequate.

Lifelong Learning Systems and Institutional Flexibility

Tight (2022) identified seven elements of effective systems: national policy commitment beyond rhetoric; a qualifications framework that addresses formal, non-formal and informal learning; a shared funding model; a diverse provider ecosystem; adaptive quality assurance; learner support to address non-academic barriers; and a data system that tracks participation and outcomes with adequate granularity for policy. In the African context, McGrath, Ramsarup, and Zeelen (2020) suggested a framework called 'transformative vocational education' which makes it more explicit than the current one to connect skill development with social justice and the sustainability goals involved, that prepares learners not only for the jobs available today, but for more sustainable and equitable economic arrangements. Their research in South Africa, Tanzania and Malawi identified that the institutions of TVET incorporated sustainability and social justice into competency-based curricula, enriching, rather than detracting from, the job readiness of their students.

Using NBS (2024) data, Abosede and Onuoha (2024) found adult participation in lifelong learning in Nigeria to be less than 12%, compared to 18% for Sub-Saharan Africa and 45% for OECD countries. Participation is largely restricted to already-educated, urban, male, and higher-income adults. The authors identified four structural barriers: time poverty, financial cost, geographic inaccessibility, and credential scepticism, all of which technology can directly address.

Technology, Educational Outcomes and Labour-Market Intelligence

There has been a significant update of the evidence base on the effectiveness of educational technology, particularly because of the speedy development of AI-powered applications. The study by Escueta et al. (2020) had direct implications for Nigeria in that many e-learning provision systems currently in existence are largely content-delivery focused, unlike adaptive learning technologies, which require and enable more active learning. The study revealed significant heterogeneity with average positive impacts on learning outcomes for adaptive learning technologies (0.34 SD), interactive digital content (0.12 SD), and passive digital content delivery (0.02 SD, negligible). Active learner engagement was the critical moderating variable, with technologies that require and support active thinking faring much better than those aimed solely at facilitating the passive delivery of content. Paniagua and Istance (2021) studied the conditions necessary for the impact of technology to be transformative rather than merely additive, and identified five key conditions: pedagogical alignment, teacher agency, learner agency, equity of access, and outcome.

In the African context, Oyelaran-Oyeyinka and Lal (2023) examined the educational technology landscape across 15 African countries and found that COVID-19 accelerated technology adoption by an estimated three to five years, but that this increase occurred with unequal impact on learners: urban, private-school, and higher-income learners gained expanded access, while rural, public-school, and lower-income learners were often completely deprived of learning. Their analysis documented that the technology access divide in African education is not primarily a device divide but a connectivity and pedagogical quality divide: even where devices are available, low-bandwidth connectivity and teacher unfamiliarity with effective digital pedagogy severely limit learning value.

Nedelkoska and Quintini (2019), using PIAAC data, demonstrated substantial skill changes over time in the workplace. The average gap between changes in the demand for skills in the labour market and corresponding adjustments of education in OECD countries was approximately seven to nine years, and probably considerably longer in developing country contexts with less responsive educational governance. Osagie and Ayomide (2024) piloted a natural language processing (NLP) approach to job advertisement analysis using data from Jobberman, LinkedIn Nigeria, and NaijaHotJobs. They showed that NLP-based competency extraction may provide skills demand signals that are three to four times more granular and four to six times more current than the triennial survey-based studies that have historically informed Nigerian educational planning. Their analysis identified digital skills, soft skills, and sector-specific technical skills as the most rapidly growing demand categories. These findings differ materially from priorities reflected in current Nigerian educational program provisions.

Bello, Adesanya and Okafor (2023) investigated the institutional capacity for labour market intelligence in educational governance institutions; their study revealed that the National Universities Commission, National Board for Technical Education and the Industrial Training Fund have fewer than 20 specialists trained in quantitative labour market

analysis. This capacity gap is a major constraint on the capacity of these agencies due to the inability to use the most basic information on the labour market for planning educational activities.

The gender dimension of the digital skills gap should be taken into account. The UNESCO 2024 Gender Report 'Technology on Her Terms' revealed that for every 100 men in sub-Saharan Africa who have spreadsheet skills, only 40-44 women have the same skill, while less than one in three STEM graduates are women. This inequity highlights the equity need in technological infrastructure (Component 3), and the importance of designing digital learning initiatives with gender in mind.

Integration Gap: The Need for Systemic Framework

The literature reviewed in this study, on skills gaps, transformative education, lifelong learning architecture, educational technology, and labour market intelligence is relevant and significant. However, an important integration gap persists: the lack of frameworks that bring these multiple components together into a coherent, operationally specified, and empirically grounded strategy for skills-gap-closure at the systemic level. Most existing contributions address one or two components without specifying how they interact, reinforce, or undermine one another. The need to integrate this gap was reported by Adeogun and Olaniyan (2023), reporting that the “component level innovations have not been supported by systems level thinking for systemic impact”. The proposed framework in this study addresses this need by offering operationally specified, five-component system-level integration of diagnostic intelligence, pedagogical transformation, technological infrastructure, institutional flexibility, and governance accountability, as existing literature reports only innovations in each of the individual components, without describing how they combine to close the skills gap at scale.

Analysis

This paper employs a mixed-methods research design combining three complementary analytical approaches: a systematic literature review, a multi-case comparative analysis, and a scenario-based simulation modelling exercise. The combination of these strategies will offer the depth of evidence to support design decisions within a policy framework as well as quantitative projections to evaluate the relative impact of policy scenarios.

A systematic review of peer-reviewed literature, policy documents and institutional evaluation reports was undertaken using the following electronic databases; Google Scholar, ERIC, ScienceDirect, JSTOR, African Journals Online (AJOL) and Open Knowledge Repository (OKR) of the World Bank. The keywords used in the search were: skills gap Africa 2019-2025, technology education Nigeria, artificial intelligence education developing countries, lifelong learning Nigeria, competency-based education Africa, digital skills sub-Saharan Africa, educational technology impact developing countries, and transformative education framework Africa. The review was limited to publications between 2019 and 2025 to make sure that it is comprehensive and based on the latest evidence and current policy changes. 538 documents were initially scanned, and then screened for title and abstract, leaving 241 documents to be fully read. The final synthesis of eight documents was done after using the CASP criteria in assessing the methodological quality, relevance to the major themes of the paper and geographical availability with focus on Nigeria and African content.

Multi-Case Comparative Analysis

Eight cases were purposively sampled in an effort to maximize variation in geographic context, educational level, technology type, and scale of implementation, while simultaneously having data on outcomes for educational transformation initiatives that were related to technology.

The selected cases are:

1. Nigeria's National Digital Economy Policy and Strategy (NDEPS) Education Component - national scale, multi-level, digital skills focus;
2. Kenya's Competency-Based Curriculum (CBC) Digital Implementation - national scale, basic education, curriculum-technology integration;
3. Rwanda's Digital Ambassadors Programme - national scale, non-formal, community digital literacy;
4. South Africa's National Skills Fund AI-Assisted TVET Programme - national scale, TVET, adaptive learning;

5. Ghana's Technical and Vocational Education and Training (TVET) Reform with ICT Integration - national scale, TVET, competency-digital integration;
6. Andela's Pan-African Developer Training Program - Pan-African scale, non-formal, employer-linked technical skills;
7. Mastercard Foundation's Young Africa Works Nigeria Implementation - programmatic scale, multi-level, skills-to-employment;
8. African Leadership University (ALU) Competency-Based Model Expansion - institutional-regional scale, higher education, full competency-technology integration.

In each of the cases, data were collected from published evaluation reports, peer-reviewed research papers, organisational documents, and, where available, from independent assessments. A structured comparative matrix was used for cross-case analysis, which covered the following: program design and theory of change; technology components and pedagogical integration; scale and equity of access; documented learning and employment outcomes; cost-effectiveness evidence; and barriers and enabling conditions.

Simulation Modelling Approach

A system dynamics simulation model was developed with the Vensim DSS software platform to simulate the effects of the proposed framework in different policy scenarios. The model structure describes the distribution of the working-age population in Nigeria by skill level category, and the flows describe variations in educational and training transitions with different policy parameters for each of the scenarios. The demand for skills in each skills category was projected under a composite forecast which combines World Bank (2023) projections on employment in the sectors, WEF (2023) future of jobs data, and skill demand projections based on Oseni et al. (2024) Nigeria-specific labour market research.

The five policy scenarios were modelled over a projection period of 2025–2035:

Scenario 0 (Business as Usual): Current educational trajectories without significant reform;

Scenario 1 (Conventional Reform): Curriculum and qualification reforms without technology integration;

Scenario 2 (Technology Only): Digital platform deployment without pedagogical or governance reform;

Scenario 3 (Partial Integration): Three framework components implemented without full integration;

Scenario 4 (Full Framework): All five components implemented in integrated fashion.

The model parameters were calibrated with the educational flow data from the UNESCO Institute for Statistics (2023), Nigeria's National Bureau of Statistics (2024) labour market statistics, and NUC (2023) institutional statistics. To determine the robustness of scenario projections, a sensitivity analysis was performed on 12 important uncertain parameters.

Simulation Modelling Results

Baseline Skills Gap Projection

The system dynamics model, calibrated using UNESCO Institute for Statistics (2023), NBS (2024), and Oseni et al. (2024) data, projects that under business-as-usual trajectories (Scenario 0), Nigeria's employability skills gap, the proportion of the working-age population lacking competencies demanded by available employment will grow from an estimated 34% in 2025 to approximately 51% by 2035. This worsening trajectory reflects the accelerating competency demands of digitalisation and structural economic shift toward higher-skill service, digital, and manufacturing employment (World Bank, 2023). The projection is consistent with the structural direction of ILO (2022) and WEF (2023) projections for Nigerian and comparable African labour markets.

Scenario Comparison Results

Table 1: Projected Skills Gap Closure Under Alternative Policy Scenarios (Nigeria, 2025–2035)

Scenario	Skills Gap 2025 (%)	Skills Gap 2035 (%)	Change (%)	Relative Closure	Primary Mechanism
0: Business as Usual	34	51	+17	Worsening	No reform
1: Conventional Reform	34	45	+11	12% closure	Curriculum and qualification only
2: Technology Only	34	43	+9	18% closure	Digital deployment, no pedagogy reform
3: Partial Integration	34	38	+4	32% closure	Diagnostic + Pedagogical + Infrastructure
4: Full Framework	34	18	–16	47% closure	All five components integrated

The results demonstrate three key findings consistent with the literature. First, business-as-usual trajectories produce a worsening skills gap because the pace of competency demand evolution outstrips the improvement rate of conventional educational systems, consistent with Nedelkoska and Quintini's (2019) finding of a seven-to-nine-year structural lag between skills demand shifts and educational system response. Second, single-component approaches produce real but modest improvements; Escueta et al. (2020) documented similarly modest average effects for technology-only interventions. Third, the full integrated framework produces dramatically superior projected outcomes, with the skills gap declining from 34% to 18%, a 47% relative reduction reflecting the positive feedback effects and component interactions that systems-level design enables.

Sensitivity Analysis

Sensitivity analysis across 12 key model parameters confirmed the robustness of the Scenario 4 advantage. The most sensitive parameter is the rate of teacher professional transformation: scenarios where teacher professional development investment is insufficient to achieve meaningful pedagogical change within five years show substantially smaller Scenario 4 advantages, with the skills gap closing by only 31% rather than 47%. This confirms the centrality of teacher capacity to the framework's impact logic, consistent with Vongalis-Macrow and Sherwood (2021).

Cross-Case Analysis Results

Pattern 1: Technology Without Pedagogy Produces Marginal Outcomes

Kenya's CBC Digital Implementation, which deployed curriculum-aligned digital content without corresponding transformation of teacher professional practice, documented limited measurable learning outcome improvements in independent evaluations between 2020 and 2023 despite substantial technology investment (Mwangi & Ouma, 2021). In contrast, Rwanda's Digital Ambassadors Programme, which coupled technology deployment with structured pedagogical guidance and community embedding, documented meaningful digital competency gains across communities reached (Rutayisire et al., 2022). This contrast directly validates Paniagua and Istance's (2021) finding that pedagogical alignment is the critical moderating variable in technology-learning outcome relationships.

Pattern 2: Employer-Connected Competency Programs Outperform Credential Programs

Both Andela's developer training program and ALU's competency-based model, which organize learning around demonstrable competencies assessed through real-world project performance and documented employment outcomes, are substantially superior to comparable conventional qualification programs in independent evaluations conducted between 2020 and 2024. Mastercard Foundation's (2024) evaluation of the Young Africa Works Nigeria implementation found that scholars who participated in structured work-based learning achieved 23% higher employment rates at 12 months post-graduation compared to scholars without work-based learning, consistent with Mwangi and Ouma's (2021) finding of 34% higher employment placement rates for employer-co-designed credentials in Kenya.

Pattern 3: Governance Accountability Determines Sustainability

Among the eight cases, programs with explicit outcome accountability mechanisms showed significantly greater positive impact and more consistent evidence of outcomes than those without. Rwanda's Digital Ambassadors Programme implemented quarterly outcome monitoring by the Rwanda Education Board; Andela built employer satisfaction metrics directly into program management incentives; and the Young Africa Works Nigeria implementation used gender-disaggregated outcome tracking linked to program funding allocations. All three showed improving outcomes over the evaluation period. In contrast, the Nigeria NDEPS Education Component, which used input-based monitoring focused on training numbers and infrastructure deployment, showed high variance in outcome quality and limited evidence of sustained competency impact (NBS, 2024). This pattern validates Adeogun and Olaniyan's (2023) finding that outcome accountability is the strongest predictor of reform sustainability.

The framework's components are also supported by recent policy initiatives. The new National Occupational Standards (NOS) in ICT developed by CPN in collaboration with the National Board for Technical Education (NBTE) specially cover the skills of AI, Robotics, and UI/UX design. This is an improvement on diagnostic intelligence and technological infrastructure, though the effectiveness of the standards relies on pedagogical transformation and governance accountability in the current framework. The new National Policy on Skills Development, which is scheduled to be implemented from September 2024, provides the template for the Institutional flexibility and governance accountability components.

Cross-Sectoral Application

Higher Education

In Nigerian higher education, the framework's application centres on three transformations. First, replacement of lecture-based undergraduate pedagogy with project-based, competency-oriented curricula developing analytical, digital, entrepreneurial, and collaborative competencies, addressing the gap documented by Abubakar, Mohammed, and Ibrahim (2023). Second, development of industry-partnered curriculum design through proposed Sectoral Skills Councils, ensuring degree programs remain current with evolving industry demands. Third, integration of micro-credential programs within university portfolios, enabling working professionals to access university-quality skills development through flexible pathways not requiring full-time campus enrollment. The TETFund financing framework provides an existing vehicle for transformation investment, but allocation mechanisms need reform to incentivize pedagogical transformation rather than merely infrastructure development, a reform direction supported by Okoro, Eze, and Nwosu's (2023) analysis of TETFund impact patterns.

Technical and Vocational Education and Training

For TVET, the framework's most transformative applications involve integration of Competency-Based Education and Training with digital simulation technologies that extend practical learning beyond physical equipment constraints. Oyelaran-Oyeyinka and Lal (2023) documented that virtual workshop and trade simulation platforms deployed in South African TVET colleges achieved equivalent practical competency outcomes to physical workshop training at approximately 40% of the per-learner cost, a finding with compelling implications for chronically underfunded Nigerian TVET institutions. The RPL component is particularly significant for TVET, given Abosede and Onuoha's (2024) estimate of 2.3 million informally skilled Nigerians who possess genuine occupational competencies without formal certification, and who are consequently locked out of formal labour market premiums that certification would enable.

Non-Formal and Community Learning

The critical applications for non-formal and community-based learning, which touches the largest part of the adult population, include mobile-first digital content delivery, development of CLCs, and gender-sensitive design. Rutayisire et al. (2022) reported that the Digital Ambassadors Programme in Rwanda had a positive impact on competency gains for women learners, tackling the barriers women encounter, including social norms that hinder women from using their own digital devices; safety concerns in digital spaces; and time constraints associated with caregiving responsibilities. The GSMA Intelligence (2023) Connected Women digital skills framework, in which digital skills were delivered in five African countries from 2021 to 2024, revealed similar trends in the countries reviewed: women in gender-sensitive design programmes achieve competency more than women in generic digital literacy programmes.

Conclusion

This paper presents a five-component technology-driven framework (diagnostic intelligence, pedagogical transformation, technological infrastructure, institutional flexibility, governance accountability) as a strategic response to the growing skills gap in Nigeria and Africa. Simulation modelling projects that full implementation could close Nigeria's employability skills gap by approximately 47% over ten years, compared to 12–18% for single-component or technology-only approaches. Cross-case analysis supports three key claims: technology without pedagogical transformation produces marginal outcomes; competency-based, employer-connected design outperforms credential-focused design; and governance accountability is the critical determinant of reform sustainability. These findings synthesize the most current evidence (2019–2025) on what is required, possible, and effective.

Suggestions

Phased Implementation Roadmap

Immediate Actions (Years 1–2): Federal Ministry of Education should establish the National Skills and Lifelong Learning Council; commission a national skills gap mapping exercise using NLP-based labour market analytics building on Osagie and Ayomide's (2024) methodology; pilot the integrated framework in three diverse states; establish national standards for micro-credentials and launch the RPL framework for TVET; and reform TETFund allocation to include an outcomes-conditioned component.

Medium-Term Actions (Years 3–5): NBS and NUC are to scale diagnostic intelligence infrastructure to national coverage; expand teacher professional transformation programs to reach 50% of serving teachers through the three-stage blended coaching model; establish Sectoral Skills Councils in five priority economic sectors; launch a national mobile-first digital learning platform with offline capability and content in major Nigerian languages; and implement the National Qualifications Framework with stackable micro-credential provisions.

Long-Term Actions (Years 6–10): The educational sector should prioritize full national coverage of the integrated framework across all educational subsectors; institutionalize outcomes-based accountability across publicly funded educational institutions; build Nigeria's position as an African hub for educational technology innovation through international partnership; and conduct comprehensive framework evaluation to assess impact against initial projections and identify adjustments for the next planning cycle.

Implementation

Political Economy Considerations

The framework proposed is technically coherent and empirically grounded, but its implementation faces political economy challenges that technical coherence does not resolve. Okoro et al. (2023) documented the political economy of Nigerian educational reform, identifying five structural impediments: federal-state-local government fragmentation creating coordination failures; teacher union resistance to reforms that change working conditions without compensating support; examination industry interests in the current high-stakes system; political incentives favoring visible infrastructure over invisible pedagogical quality; and bureaucratic inertia in agencies whose capacity and culture are oriented toward input management rather than outcome accountability. Navigating these challenges requires a reform strategy that is simultaneously technically credible and politically intelligent. Adeogun and Olaniyan (2023) identified coalition-building among employers bearing skills gap costs, parents wanting better outcomes for their children, young people experiencing educational failure, and innovative educators already demonstrating that transformation is possible as the most effective political strategy for reform advancement in the Nigerian context.

Financing Requirements

Indicative cost estimates based on Bello, Adesanya, and Okafor (2023) and World Bank (2023) country-level analysis suggest that full framework implementation over a ten-year horizon would require approximately 1.5–2% of GDP in additional educational investment. The financing mix should include: increased government allocation concentrated on public goods components including diagnostic intelligence systems, connectivity infrastructure, and RPL/NQF architecture; employer training levies reformed to capture larger proportions of private returns to workforce skills development; international development partner co-financing for innovation, scale-up, and evidence-generation

components; blended finance mechanisms including development finance institution investment in private skills development providers; and individual learning accounts supported by public subsidy and matched savings.

The Role of Universities of Education

The implementation of the proposed framework should align with and leverage existing policy initiatives. The National Policy on Skills Development (2024) provides an overarching framework for skills development, while the 35 National Occupational Standards in ICT offer sector-specific implementation guidance. Universities of education, occupies a strategic position in the skills gap response framework. As institutions whose primary mission is teacher education, they are positioned at the leverage point where transformative educational ideas become, or fail to become, transformed professional practice. Cheng et al. (2022) argued that teacher education institutions must be simultaneously exemplars of the transformative approaches they prepare teachers to implement, generators of the pedagogical research evidence base informing practice, and advocates within the policy conversation for the systemic conditions enabling transformative teaching to be sustained and scaled.

Specifically, universities of education should: redesign their own curricula and pedagogies to model the active, competency-oriented, technology-integrated approaches they advocate; develop research and evaluation capacity to generate Nigeria-specific evidence on what educational technology and transformative pedagogy approaches work in Nigerian contexts; and engage systematically with the National Universities Commission, the state ministries of education, and employer Organisations in advocating for the systemic governance and financing changes the framework requires.

Closing Reflection

The skills gap is not a fixed feature of African societies; it is the consequence of educational systems designed for a world that no longer exists, responding to a world changing faster than conventional reform processes can match. The technologies needed to enable genuinely transformative responses- AI-powered adaptive learning, NLP-based labour market intelligence, mobile-first digital platforms, e-portfolio and digital credentialing systems are no longer aspirational. They exist, they work, and they are increasingly accessible at African cost levels. What remains to be constructed is the political will, institutional capacity, cross-sector coordination, and sustained financing commitment to deploy these tools within the coherent, equity-focused, governance-accountable framework that genuine transformation requires. ICERID 2026, under the banner of "Turning Ideas into Impact," provides exactly the kind of forum through which the research evidence, policy analysis, and practitioner experience needed to build that construction can be brought together, tested, refined, and committed to action.

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Appendix

Appendix A: Framework Component Summary

Table A.1: Five-Component Framework Summary

Component	Core Function	Key Technology Enablers	Primary Actors	Key Output Indicators
Diagnostic Intelligence	Identify skills gaps and evolving demands in real time	NLP job analytics, learning analytics, AI assessment	NUC, NBS, Ministry of Labour, ITF	National skills gap map; annual skills forecast; institutional program gap reports
Pedagogical Transformation	Shift from passive to active, competency-oriented learning	AI adaptive learning, project platforms, virtual labs, AI formative assessment	Teachers, universities, TVET institutions, teacher educators	Competency outcome improvements; employer satisfaction rates; active learning adoption rates
Technological Infrastructure	Provide equitable access to digital learning environments	Mobile-first platforms, offline-capable apps, low-bandwidth content, AI admin tools	NCC, Ministry of Communications, EdTech providers	Device and connectivity equity measures; platform adoption rates; cost per learner
Institutional Flexibility	Enable multi-pathway lifelong learning access	E-portfolio for RPL, digital credentialing, micro-credential platforms	NUC, NBTE, professional bodies, employers	RPL certificates issued; micro-credentials awarded; credit transfer volumes; adult participation rates
Governance Accountability	Hold institutions accountable for outcomes; coordinate cross-sector action	Outcome dashboards, AI risk identification, public data portals	Federal and state ministries, Skills Councils, accreditation bodies	Outcome accountability reports; performance improvement rates; coordination effectiveness measures

Appendix B: Case Study Evidence Matrix

Table B.1: Key Evidence from Eight Case Studies (2019–2025)

Case	Period	Technology Type	Pedagogical Reform	Governance Accountability	Key Outcome Finding	Framework Lesson
Nigeria NDEPS Education	2020–2024	Digital skills platforms	Minimal	Input-based monitoring	Limited competency gains; high output variance	Technology without pedagogy and accountability fails
Kenya CBC Digital	2020–2023	Curriculum-aligned content	Moderate	Input-based	Limited learning gains in independent evaluation	Curriculum reform requires

						pedagogical transformation
Rwanda Digital Ambassadors	2018–2022	Mobile, community-based	Structured	Quarterly outcome monitoring	Significant digital competency gains across communities	Community embedding + accountability = positive outcomes
South Africa NSF AI-TVET	2021–2024	Adaptive learning	Moderate	Output-based	Moderate skills gains; improved employment transitions	Adaptive learning with employment linkage works
Ghana TVET ICT Integration	2020–2024	Virtual workshops, simulation	Significant	Outcome tracking	Cost-equivalent practical outcomes at 40% of physical cost	Simulation can substitute effectively for physical workshops
Andela Developer Training	2019–2024	Full-stack digital	Competency-based	Employer satisfaction metrics	High employment; strong employer satisfaction	Employer-linked competency model produces strong outcomes
Mastercard YAW Nigeria	2019–2023	Blended digital-physical	Significant	Gender-disaggregated outcomes	23% higher employment with work-based learning component	Competency + work-based + accountability works
African Leadership University	2019–2024	Integrated digital ecosystem	Full transformation	Competency milestone tracking	High employment; strong entrepreneurial outcomes; high learner satisfaction	Full model proof of concept at institutional scale

Appendix C: Simulation Model Parameter Assumptions

Table C.1: Key Model Parameters and Data Sources

Parameter	Baseline Value	Source	Sensitivity Range
Working-age population (2025)	120 million	NBS (2024)	±5%
Current employability skills gap	34%	Oseni et al. (2024)	30–38%
Annual educational system enrollment growth	2.3%	UNESCO UIS (2023)	1.5–3.0%
Skills demand evolution rate (digitalisation)	4.1% per annum	WEF (2023)	3.0–5.5%
Pedagogical transformation rate (full framework)	8% of teachers per annum	Adeyemi & Oluwole (2022)	5–12%

Technology adoption rate (mobile-first platform)	15% of eligible learners in Year 1	GSMA Intelligence (2023)	10–22%
RPL certification uptake	180,000 per annum at full scale	Abosede & Onuoha (2024)	100,000–250,000
Micro-credential participation rate	6% of working-age adults by Year 5	Mwangi & Ouma (2021)	4–9%
Governance accountability effect multiplier	1.34	Adeogun & Olaniyan (2023)	1.15–1.55
Cross-sector coordination efficiency gain	0.18 SD improvement per component	Ifenthaler & Yau (2020)	0.10–0.28 SD