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Bridging Skills Mismatch in Nigeria's TVET System: Integrating Industry 4.0 Competencies for Entrepreneurial Readiness

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Abstract

The accelerating impact of the Fourth Industrial Revolution (Industry 4.0) has heightened the demand for a digitally competent and innovative workforce. In Nigeria, however, a persistent mismatch exists between industry-required competencies and the training provided through Technical and Vocational Education and Training (TVET). Although TVET is expected to produce job-ready graduates and entrepreneurs, its curricula remain outdated and disconnected from the realities of automation, artificial intelligence (AI), and smart manufacturing. This study uniquely explores how integrating Industry 4.0 competencies can reposition Nigeria's TVET system for entrepreneurial competitiveness in sub-Saharan Africa, addressing a major gap in contextualizing digital-era skills within African TVET reform. Anchored in human capital, systems, and innovation diffusion theories, the study adopts a documentary research design, drawing evidence from policy documents, scholarly literature, and industry reports. Findings reveal that 65% of employers identify digital illiteracy among TVET graduates as a key barrier to employment, highlighting the urgency of integrating digital skills into training programmes. The study further uncovers weak institutional-industry linkages, poor infrastructure, and limited investment in STEM and technical innovation as major constraints. It recommends urgent reforms, including the infusion of AI literacy, data analytics, robotics, and cyber-physical systems into core curricula, complemented by hands-on and experiential learning approaches. Fostering critical thinking, creativity, and adaptability is equally vital. The study concludes that aligning TVET with Industry 4.0

imperatives is crucial for bridging the skills gap, reducing youth unemployment, and enhancing Nigeria's global competitiveness.

Keywords: Skills Development, Innovation Ecosystem, STEM Education, Master Craft, Industrial Adaptability.

Introduction

The quest for inclusive economic development and sustainable job creation in Nigeria has placed increasing emphasis on the revitalization of technical and vocational education and training (TVET) as a strategic vehicle for workforce preparation and entrepreneurial development. Historically, TVET has been tasked with equipping individuals with practical, occupation-specific skills to meet the immediate demands of the labour market. However, since Nigeria's independence, the TVET system has struggled to assert its relevance due to underinvestment, stigmatization, weak policy implementation, and outdated curricula (Okoli, Ejiofor, Ali & Nwakile, 2020; Ladan, 2023). The emergence of the Fourth Industrial Revolution (4IR), characterized by automation, artificial intelligence (AI), robotics, Internet of Things (IoT), and smart manufacturing, has further complicated the situation, magnifying existing skills gaps and exposing deep structural deficiencies in Nigeria's education-to-employment value chain (World Economic Forum, 2020; Apata, Adeniyi, Ajiwoju, Adeosun, 2025; Tunmibi & Ekeh, 2025).

The global transition towards an innovation-driven and technology-based economy has significantly redefined the competencies required for gainful employment and successful entrepreneurship. Skills such as AI literacy, digital problem-solving, data analytics, cyber-physical system management, and creativity are becoming non-negotiable for thriving in the new economy (UNESCO-UNEVOC, 2021; Chiamogu & Chiamogu, 2025). Yet, Nigeria's TVET system remains largely anchored on traditional pedagogies, offering limited integration of science, technology, engineering and mathematics (STEM), master craft and technological innovation competencies that are vital to preparing future-ready entrepreneurs. This misalignment occurs when the skills acquired through formal education or training diverge from the needs of employers or the productive demands of the economy (ILO, 2022).

The issue of skills mismatch is both complex and multi-dimensional. It is not merely a technical gap but a manifestation of systemic disconnects between policy formulation, institutional practices, industry demands, and global economic transitions. Scholars have identified several dimensions of this mismatch: vertical mismatch (over- or under-qualification), horizontal mismatch (field-of-study incongruence), and qualitative mismatch (inadequate practical or soft skills) (McGuinness, Pouliakas & Redmond, 2018). In Nigeria, this problem is particularly acute

in the TVET sector, where many graduates lack not only technical competence but also the innovation mindset and entrepreneurial skills needed to create value in emerging economic sectors (Oviawe, 2020).

Despite ongoing reforms and increased policy attention, Nigeria's TVET system remains poorly aligned with the demands of Industry 4.0, resulting in persistent vertical, horizontal, and qualitative skills mismatches that undermine employability, limit innovation capacity, and constrain entrepreneurial readiness. The continued disconnect between curriculum content, pedagogical practices, and industry requirements reveals a systemic gap that must be addressed to build a future-ready workforce capable of driving inclusive economic growth. The general objective of this study is to examine how the integration of Industry 4.0 competencies into Nigeria's TVET curricula can bridge the persistent skills mismatch and enhance entrepreneurial readiness. This focus is not only timely but critical for addressing the youth unemployment crisis, which currently hovers above 40% in some regions (NBS, 2022). With a growing youthful population and a fast-evolving digital economy, Nigeria stands at a pivotal moment where bridging this gap can unlock transformative opportunities in employment, enterprise development, and national competitiveness.

To illuminate the rationale for this study, the human capital theory provides a foundational analytical framework. Propounded by Becker (1993), the theory posits that investment in education and skills development enhances productivity, economic growth, and individual earning potential. This study extends this theory to the context of technological disruption, arguing that the quality and relevance of human capital, especially in vocational and technical domains, must evolve in tandem with industry requirements. Complementarily, the systems theory is applied to understand the TVET ecosystem as an interconnected structure comprising institutions, policies, pedagogies, industry players and learners. Disruptions in any part of the system, especially in curriculum relevance and industry collaboration, impede the effective functioning of the whole.

Moreover, the study draws insights from the innovation diffusion theory (Rogers, 2003), which explains how new ideas, technologies, and practices spread within a social system. The reluctance or delay in adopting Industry 4.0 competencies within Nigeria's TVET system can be linked to institutional inertia, lack of capacity, and insufficient awareness among policymakers and educators. Hence, integrating these analytical perspectives allows for a more holistic understanding of the dynamics of skills mismatch and the strategic pathways to curriculum reform and system modernization.

In sum, the situational and historical realities of Nigeria's TVET system, coupled with the fast-evolving demands of Industry 4.0, necessitate a critical examination of how to bridge the enduring skills mismatch. By anchoring the study on robust theoretical foundations and situating it within the broader discourse on human capital and economic transformation, this research provides a compelling rationale for policy, institutional, and curricular reforms aimed at preparing future-ready entrepreneurs for Nigeria's digital economy.

Review of Related Literature

Conceptualizing TVET and Skills Mismatch in Nigeria

Technical and Vocational Education and Training (TVET) is recognized globally as a critical driver of economic productivity, job creation, and technological innovation. According to UNESCO (2016), TVET encompasses "education, training and skills development relating to a wide range of occupational fields, production, services, and livelihoods." However, the disconnect between what TVET institutions teach and what industries require has resulted in persistent skills mismatches; defined as the gap between the skills employers seek and those possessed by job seekers (ILO, 2022).

The concept of *skills mismatch* has gained prominence in global labour and education discourses, particularly with the advent of the Fourth Industrial Revolution (4IR), which has altered the structure of production and employment. Skills mismatch refers to the discrepancy between the qualifications and competencies offered by job seekers and those required by employers (ILO, 2022). In Nigeria, this is most apparent within the Technical and Vocational Education and Training (TVET) sector, where structural, pedagogical, and curricular deficits hinder the system's capacity to respond to industrial demands (Okolie, Igwe & Elom, 2019; Apata et al., 2025; Chiamogu & Chiamogu, 2025). Despite its stated mandate to prepare learners for employability and entrepreneurship, the Nigerian TVET system has struggled to maintain relevance due to outdated instructional content, inadequate infrastructure, and limited digital integration (Okoli et al., 2020). These challenges are worsened by a lack of strategic alignment with Industry 4.0, which demands skills in STEM**,** AI**,** robotics**,** automation**,** data science, and smart manufacturing competencies that are either absent or underdeveloped in most Nigerian technical institutions (UNIDO, 2021; UNESCO-UNEVOC, 2021).

In Nigeria, the problem is particularly glaring due to systemic neglect, poor curriculum development, limited stakeholder engagement, and outdated training equipment (Okolie et al., 2019; Chiamogu & Chiamogu, 2025). The general workforce lacks hands-on exposure to critical skills in automation, digital literacy, and STEM-related competencies that are now essential in the Industry 4.0 era (Aina, 2021).

Dynamics and Dialectics of TVET Policy, Coordination and Implementation

Despite various national policies aimed at revitalizing TVET such as the National Policy on Education (2014) and National Skills Qualification Framework (NSQF), coordination and implementation have remained fragmented. The National Board for Technical Education (NBTE)**,** the apex body responsible for standard-setting in polytechnics and technical colleges, has made efforts to revise curricula through Competency-Based Training (CBT). However, its interventions are often constrained by poor funding, lack of autonomy at institutional levels, and minimal industry involvement (Uwaifo, 2010; NBTE, 2020).

Industry participation in curriculum development and student internship schemes remains marginal, with most partnerships being ad hoc or donor-driven rather than strategic or policy-based (Oviawe, 2020). Additionally, funding from agencies like Tertiary Education Trust

Fund **(**TETFund) and**,** Industrial Training Fund **(**ITF) are frequently insufficient, misallocated, or delayed, further undermining TVET's ability to modernize and innovate (Ayonmike et al., 2015).

Thematic Demands of Industry 4.0: STEM, AI, IoT, Robotics, and Master Craft

The Fourth Industrial Revolution (4IR) is reshaping global production systems, demanding new skills in areas like Artificial Intelligence (AI), Internet of Things (IoT), smart manufacturing, data analytics, robotics, and mechatronics (Schwab, 2016). These technologies are no longer optional in industrial ecosystems but critical prerequisites for national competitiveness. In Nigeria, the lack of institutional capacity to integrate such skills into TVET programmes has limited the ability of graduates to respond to these shifts (UNIDO, 2021). A recent pilot project by Siemens Nigeria in collaboration with the German Chamber of Commerce found that only 18% of Nigerian polytechnic students could operate programmable logic controllers (PLCs), a core automation tool in modern factories (Siemens Report, 2020). Similarly, the Nigerian Economic Summit Group (NESG) (2022) reports that many manufacturing firms now require AI-based predictive maintenance capabilities, yet only 3 out of 55 TVET institutions surveyed offered AI-related contents in their curriculum.

Furthermore, master craft skills, long heralded in Nigeria's informal economy, are not being adequately integrated into formal training systems. Despite the National Skills Development Programme (NSDP), many of these initiatives operate in silos, without strong articulation pathways into higher education or technological innovation hubs (ITF, 2021).

Curricula, Skills Gap, and Industrial Demands: A Critical Nexus

TVET curricula in Nigeria are often overloaded with theory and under-resourced in practice. The NBTE has attempted to update the curriculum to include entrepreneurship, yet this has not translated into innovative or digital entrepreneurship skills required for Industry 4.0. Okwelle (2014) argues that the disconnect between curriculum content and industry needs is due to limited institutional research, rigid accreditation processes, and weak mechanisms for real-time curriculum review.

A survey by the Manufacturers Association of Nigeria (MAN) in 2021 indicated that over 65% of employers found polytechnic graduates deficient in basic computational thinking, design thinking, and data interpretation; skills fundamental to smart production environments. In Kaduna State, a case study by Yusuf and Ajibola (2020) showed that only one out of six government technical colleges had functioning information communication technologies (ICT) or internet of things (IoT) laboratories, with most relying on outdated electrical wiring and mechanical drawing exercises for practical sessions.

Contributions and Constraints of NBTE and Allied Agencies

The NBTE, established in 1977, has played a crucial role in defining minimum standards for technical education and introducing frameworks like CBT and the National Occupational

Standards (NOS). However, its ability to enforce compliance, drive innovation, and lead technological transformation is limited by bureaucratic inertia and underfunding (Okoro & Bello, 2015). Other relevant agencies include:

- **TETFund**, which provides institutional support through research and infrastructure grants, but has historically focused on universities rather than polytechnics or technical colleges.
- **ITF**, which runs vocational training centres but often lacks coordination with national TVET policies.
- **Nigerian Skills Qualification Framework (NSQF)**, designed to harmonize skills development across sectors, but still poorly understood by employers and educators (NSQF Secretariat, 2019).

Structural, Pedagogical and Curricular Deficiencies: Empirical Cases

The systemic issues in TVET delivery are both structural and pedagogical. Structurally, many technical colleges operate with dilapidated infrastructure, inadequate power supply, and unqualified instructors. Pedagogically, most teaching methods remain didactic, with limited student-centred or project-based learning approaches. Curricularly, the slow pace of curriculum renewal hinders the timely adoption of global best practices.

For instance, at the Federal Polytechnic, Ado-Ekiti, a curriculum reform initiative launched in 2018 to incorporate 3D printing and AI modules stalled due to lack of skilled instructors and laboratory facilities (Adediran & Ogunleye, 2021). Similarly, the Federal Science and Technical College as well as other technical colleges and institutions in Anambra State, established to drive local innovation, do not have access to IoT kits or coding tools needed to prepare students for tech-based entrepreneurship (Uche & Emechebe, 2020).

The literature clearly underscores that bridging the skills mismatch in Nigeria's TVET system requires a holistic and multi-stakeholder approach. Integrating Industry 4.0 competencies, rooted in STEM, master craft, and digital innovation; into TVET curricula is no longer a theoretical aspiration but an urgent national imperative. This integration must be backed by curriculum reform, industry partnership, adequate funding, and innovative pedagogies to produce future-ready entrepreneurs capable of thriving in Nigeria's evolving industrial setting.

Theoretical and Analytical Framework

A robust theoretical and analytical framework is essential for understanding and explaining the underlying causes, manifestations, and solutions to the skills mismatch crisis within Nigeria's Technical and Vocational Education and Training (TVET) system. This study is anchored on three interrelated theoretical perspectives: human capital theory**,** systems theory**,** and innovation diffusion theory; which together provide multidimensional lens for analyzing how the integration of Industry 4.0 competencies can enhance entrepreneurial readiness in Nigeria.

a) **Human Capital Theory**: Developed by Schultz (1961) and expanded by Becker (1993), Human Capital Theory posits that investments in education and skill acquisition increase individual productivity and contribute to national development. Within the TVET context, it underscores the economic rationale for aligning vocational education with the changing structure of production in the digital era. For Nigeria, TVET must equip learners with Industry 4.0 competencies such as artificial intelligence (AI), robotics, data analytics, and cyber-physical systems, to drive innovation and self-employment. As Becker (1993) argues, education that fails to align with productive economic systems becomes an economic liability. Thus, the integration of digital and entrepreneurial skills within TVET represents a strategic investment in national productivity and competitiveness.
b) **Systems Theory:** Originating from Bertalanffy (1968), Systems Theory views institutions as interconnected subsystems that function effectively only through coherence and feedback. Applied to TVET, it highlights the interdependence among curriculum design, pedagogy, policy, funding, industry collaboration, and student outcomes. Nigeria's TVET ecosystem suffers from systemic fragmentation; where curricular reform occurs in isolation from labour market needs, and poor coordination exists among agencies like NBTE, ITF, and industry stakeholders (Okoli et al., 2020). Systems Theory, therefore, operationalizes Human Capital Theory by providing the *mechanism* through which educational investments (as posited by Human Capital Theory) can be effectively coordinated and translated into tangible economic outcomes. In essence, while Human Capital Theory explains *why* investment in skills is necessary, Systems Theory explains *how* such investment must be organized across institutional subsystems to yield desired results.
c) **Innovation Diffusion Theory**: Rogers' (2003) innovation diffusion theory (IDT) explains how and at what rate new ideas or technologies are adopted within a social system. In Nigeria's TVET system, many institutions fall within the "late majority" or "laggard" adopter categories due to weak infrastructure, bureaucratic inertia, and limited incentives for technological innovation (Tunmibi & Ekeh, 2025). IDT complements Systems Theory by addressing the *behavioural and organizational dynamics* that influence reform adoption; clarifying why even well-designed systems often resist change. It also provides strategies such as pilot projects, innovation champions, and early adopter networks; to accelerate the diffusion of Industry 4.0 competencies within TVET institutions.

Integrating the Theories

Together, these frameworks form a dynamic and complementary structure for understanding and addressing Nigeria's TVET challenges:

a) **Human Capital Theory** establishes the *economic rationale* for skills development.
b) **Systems Theory** provides the *organizational architecture* for implementing those skills effectively.

c) **Innovation Diffusion Theory** explains the *rate and pattern of adoption* of digital innovations across TVET institutions.

Conceptual Model Description

The proposed conceptual model (see *Figure 1*) illustrates the interconnection among the three theories:

1. **Inputs (Human Capital Investment):** Education, training, and skill acquisition policies targeting Industry 4.0 competencies.
2. **Processes (Systems Alignment):** Institutional coordination among TVET agencies, industries, and government ensuring curriculum relevance, infrastructure support, and policy coherence.
3. **Outputs (Innovation Adoption):** Diffusion of Industry 4.0 technologies, digital literacy, and entrepreneurial skills across TVET institutions.
4. **Outcomes (Entrepreneurial Readiness):** Emergence of digitally skilled, innovative, and self-reliant graduates driving economic transformation and competitiveness.

Thus, the model posits that effective human capital investment (HCT) achieves maximum impact only when supported by coherent system structures (ST) and sustained by innovation adoption dynamics (IDT)**.** Together, these drive TVET modernization and entrepreneurial readiness within Nigeria's evolving digital economy.

This model illustrates the interrelationship among Human Capital Theory (HCT), Systems Theory (ST), and Innovation Diffusion Theory (IDT) as applied to the Nigerian TVET context.

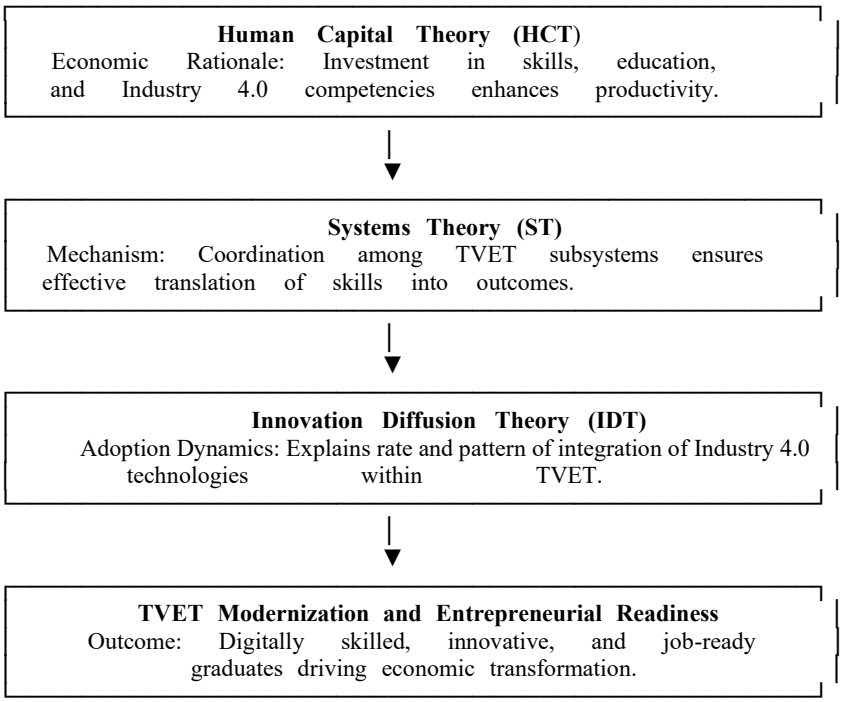


Figure 1: Conceptual Model Linking Industry 4.0 Competencies, TVET Modernization, and Entrepreneurial Readiness

The model demonstrates a linear and reinforcing relationship among the three theories. Human Capital Theory provides the foundational justification for investing in skills; Systems Theory operationalizes this investment through institutional coordination and policy alignment; and Innovation Diffusion Theory accelerates the adoption of Industry 4.0 practices. Together, they drive TVET modernization and entrepreneurial readiness in Nigeria's digital economy.

Materials and Methods

This study adopts a documentary research design, a qualitative approach that involves the systematic collection, evaluation, interpretation, and synthesis of secondary data from existing documents. This design is suitable for exploring the structural, curricular, and policy dimensions of Nigeria's Technical and Vocational Education and Training (TVET) system in relation to Industry 4.0 competencies and entrepreneurial readiness. It facilitates a broad and critical analysis of policy frameworks, institutional practices, and comparative models without the constraints of field-based data collection (Bowen, 2009).

Data Sources and Selection Criteria

Documents were purposefully selected based on four criteria to ensure credibility, relevance, and analytical depth**:**

1. **Policy relevance** – documents directly addressing TVET reform, Industry 4.0 integration, or national human capital development strategies.
2. **Publication date** – materials published between 2010 and 2025, to reflect contemporary developments in digital and vocational education.
3. **Institutional authority** – sources from reputable and authoritative bodies such as the Federal Ministry of Education, National Board for Technical Education (NBTE), Industrial Training Fund (ITF), and global agencies (UNESCO, ILO, UNIDO, WEF).
4. **Analytical value** – empirical or conceptual depth that contributes to understanding the TVET–Industry 4.0–entrepreneurship nexus.

Data were drawn from:

a) National and institutional policy documents (e.g., *National Policy on Education*, NBTE curriculum guidelines, NSQF framework);
b) Strategic plans and reports of NBTE, ITF, and the Federal Ministry of Education;
c) International publications (UNESCO-UNEVOC, ILO, WEF, UNIDO);
d) Peer-reviewed journal articles, books, government white papers, and empirical studies on TVET, STEM, and entrepreneurial skills development.

Data Analysis and Thematic Categorization

A thematic content analysis approach was employed to identify recurring patterns, relationships, and reform needs within the TVET system. The documents were coded and categorized into themes aligned with the study objectives, interpreted through the lenses of human capital theory**,** systems theory**,** and innovation diffusion theory.

Table 1: Data Sources, Analytical Focus, and Emergent Themes

Data Source	Analytical Focus	Emergent Themes
National policy documents (NPE, NSQF, NBTE Guidelines)	Curricular alignment and skills standards	Nature and dimensions of skills mismatch
NBTE, ITF, and FME reports	Policy formulation and institutional coordination	Policy coherence and systemic capacity gaps
UNESCO, ILO, UNIDO, WEF reports	Comparative global frameworks	Integration of Industry 4.0 competencies
Academic publications and empirical studies	Theoretical grounding and case evidence	Entrepreneurial readiness and innovation orientation

Flow of Analysis

1. **Document identification** → based on relevance and credibility criteria.
2. **Content evaluation** → screening for policy, institutional, and curricular insights.
3. **Thematic synthesis** → coding around five core themes.
4. **Theory-guided interpretation** → aligning findings with HCT, ST, and IDT frameworks.
5. **Analytical integration** → generating reform pathways for Industry 4.0-ready TVET.

This flow diagram illustrates the five sequential stages of data analysis in the study, from document identification to analytical integration, showing how each step builds toward developing reform pathways for an Industry 4.0-ready TVET system in Nigeria.

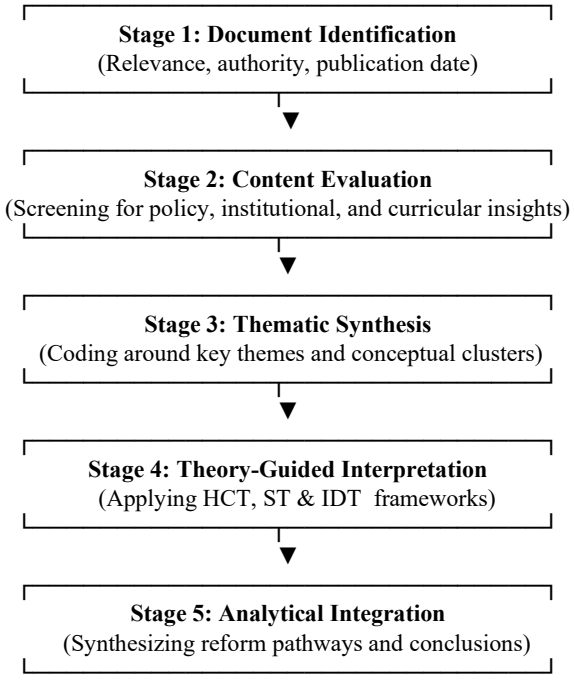


Figure 2: Flow Diagram of the Data Analysis Process

The process is iterative and reflexive, allowing feedback from theoretical interpretation to inform theme refinement and final integration. This approach ensures analytical coherence and validity in deriving policy-relevant insights.

Limitations and Future Considerations

This study relies exclusively on secondary data, which may carry inherent biases in institutional reporting or selective publication. The absence of primary data (such as interviews or surveys) limits the depth of stakeholder perspectives. Future studies could incorporate quantitative indicators, such as graduate employment rates, employer satisfaction indices, or digital literacy benchmarks, to enhance empirical robustness and triangulate findings.

Results, Discussion and Analysis of Findings: Incidences of Skills Mismatch in Nigeria

a) **Outdated Curricula and Disconnected Learning:** A significant contributor to the skills mismatch is the reliance on obsolete curricula in most public TVET institutions. For instance, the curriculum for Electrical Engineering in many polytechnics still emphasizes analog systems, basic electrical circuits, and relay logic, while industries have shifted to digital systems, programmable logic controllers (PLCs), IoT-driven automation, and renewable energy technologies. Most polytechnic students report difficulties in adapting to internships at automation firms because the institution's curricular lacked exposure to tools like MATLAB, SolidWorks, and AI-driven design platforms used in industry (Adeoye, 2023). Curricula lag have hampered students' competitiveness in contemporary technical education training in Nigeria.

b) **Inadequate Integration of STEM and Master Craft Skills:** Although TVET should equip students with both theoretical STEM knowledge and practical mastery, many institutions emphasize only one dimension. Welding and fabrication students of several public polytechnics in Nigeria, for example, often lack the foundational math and digital design skills needed to work with computer-aided design/manufacturing (CAD/CAM) systems or laser cutters now common in manufacturing hubs. In Aba, Abia State, known for its indigenous leather and tailoring industry, most artisans lack formal TVET training. Attempts to upskill them through traditional polytechnic programmes have failed because these programmes do not incorporate digital fabrication, e-commerce, or design thinking—core skills required to innovate and market globally (Chukwuma, 2022).

c) **Limited Industry-TVET Collaboration:** Many TVET institutions operate in isolation from the industries they are meant to serve. The absence of industry representation in curriculum design leads to misalignment between training and job requirements. The Industrial Training Fund (ITF) 2022 report noted that over 60% of Nigerian employers struggle to fill entry-level roles despite high graduate turnout, primarily due to lack of relevant technical or soft skills. In contrast, private institutions like Semicolon Africa in

Lagos co-create curricula with software firms and expose students to real-life tech projects, significantly increasing their employability in startups and multinationals.

d) **Pedagogical Deficiencies:** Teaching methods in most public TVET institutions are still largely didactic, with minimal emphasis on experiential learning. This stifles the development of creative and entrepreneurial capabilities. In many public TVET institutions, students in Mechatronics Engineering complained during accreditation that their programme involved more chalkboard lectures than lab-based simulations. Lecturers lacked exposure to tools like Python, Arduino, or Tensor Flow, critical for modern automation tasks (NBTE Report, 2021). In contrast, Covenant University, though not a TVET institution, incorporates project-based learning and entrepreneurship in STEM fields, yielding job creators rather than job seekers.

e) **Infrastructure Deficit:** Without access to modern laboratories and workshops, digital libraries, or simulation software, TVET institutions cannot meaningfully implement Industry 4.0 content even if introduced into the curriculum. The Digital Literacy Initiative by TETFund piloted in select polytechnics failed to scale because of inadequate internet bandwidth, obsolete computers, and lack of technical support staff. Students trained in digital entrepreneurship could not sustain the experience post-grant due to weak infrastructure (TETFund Review, 2022).

f) **Weak Policy Implementation and Coordination:** Policies such as the National Skills Qualification Framework (NSQF) and the National Occupational Standards (NOS) exist on paper but are poorly implemented due to inter-agency rivalry and weak monitoring. NBTE introduced a skill accreditation framework in 2018 to align TVET outputs with global standards. However, most polytechnics still focus on diploma-based outputs without integrating occupational standards, and many TVET instructors remain unaware of NSQF requirements (NBTE Evaluation Report, 2021).

g) **Youth Unemployment Despite Certification:** Despite holding diplomas and trade qualifications, many Nigerian youths remain unemployed or underemployed due to irrelevance of skills acquired. A 2023 NBS Labour Force Survey revealed that nearly 42% of youth with National Diplomas from polytechnics are either unemployed or working in unrelated sectors such as street trading or transport. This outcome contradicts the intent of vocational training and underscores the chronic gap between training outcomes and labour market demands.

h) **Private Sector Models as Emerging Best Practice:** Private training hubs like Decagon Institute, Utiva, and AltSchool Africa have demonstrated how industry-focused training, especially in tech and entrepreneurship, can bridge the skills gap. Decagon partners with companies like Microsoft and Access Bank to train full-stack developers in six months, combining digital skills, soft skills, and financial literacy. Their graduates often receive job offers before programme completion, showcasing how strategic collaboration and modular curricula work better than traditional TVET approaches.

Comparative Insight from Other African Countries

Experiences from other African countries show that Nigeria's TVET challenges mirror wider continental realities but also offer practical lessons. Rwanda, for instance, did not just integrate coding and robotics on paper: its TVET schools now run community-based innovation labs where students assemble simple robots, program drones for agricultural mapping, and learn digital fabrication using 3D printers. These hands-on initiatives, supported by the Rwanda TVET Board (RTB), have produced graduates who easily transition into local tech startups and public-sector digital service units. In **K**enya, reforms led by the Technical and Vocational Education and Training Authority (TVETA) have transformed several public TVET colleges into digital hubs; at Kisumu National Polytechnic, for example, students use virtual welding simulators and industry-coded competency modules co-designed with manufacturing firms. Ghana's National TVET Qualifications Framework (NTVETQF) has also made a tangible impact by harmonizing certificates across ministries and training centers, allowing apprentices from informal sectors: such as carpentry clusters in Kumasi; to upgrade their skills and obtain nationally recognized qualifications. Together, these examples show that progress comes from deliberate actions: coherent policies backed by funding, strong digital infrastructure, and constant engagement with industry. Comparing Nigeria's progress with these cases underscores the need for a more coordinated, innovation-driven TVET ecosystem that links curriculum, pedagogy, certification, and real workplace experience.

Synthesis and Implications

These cases and examples validate the following:

a) The skills mismatch in Nigeria's TVET system is both systemic and symptomatic of deeper institutional, infrastructural, and policy deficiencies.
b) The absence of experiential learning, digital tools, industry involvement, and modern STEM integration hinders the development of entrepreneurial readiness.
c) Innovative, private-sector-led models offer insights into what a reformed, Industry 4.0-aligned TVET system should look like.

The discussed findings, when contextualized within Nigeria's industrial realities and the demands of the Fourth Industrial Revolution, reveal the urgent need for a curriculum overhaul, public-private partnerships, digital infrastructure development, and educator retraining. Addressing the skills mismatch is not only about reforming what is taught but also how, where, and with whom learning happens.

Table 2: Summary of Findings on Skills Mismatch and TVET Reform Needs in Nigeria

Finding	Description & Discussion	Implication/Analysis
Outdated TVET Curricula	Most TVET institutions in Nigeria still rely on curricula that emphasize traditional technical skills, with little or no inclusion of Industry 4.0 competencies such as AI, IoT, robotics, and smart manufacturing.	This curriculum lag contributes to vertical and qualitative skills mismatches. Graduates are underprepared for the demands of modern industries, undermining their employability and entrepreneurial capacity.
Weak Integration of STEM and Master Craft Skills	STEM subjects and advanced craft-based skills are poorly integrated into TVET programmes. The emphasis remains on rote technical training rather than cross-disciplinary problem-solving or innovation.	The lack of STEM-oriented, innovation-driven education hinders the development of adaptive, digitally literate, and creative entrepreneurs needed for a knowledge economy.
Inadequate Digital Infrastructure	Many TVET institutions lack the infrastructure necessary to support digital learning and training in Industry 4.0 tools (e.g., simulation labs, AI toolkits, robotics kits).	Without foundational infrastructure, even well-revised curricula cannot be effectively implemented, reinforcing systemic inequities in skills delivery.
Limited Industry-TVET Collaboration	There is minimal partnership between TVET institutions and industries in curriculum design, internship placements, and skill certification.	This disconnection leads to horizontal mismatch—students are trained in areas irrelevant to market needs. Industry-academic collaboration is essential for real-world skills development.
Fragmented Policy Coordination	Policies from NBTE, ITF, Ministry of Education, and other regulatory bodies often operate in silos, with little coherence or shared objectives.	The lack of a unified national skills development framework hampers the responsiveness of TVET to emerging technological trends and entrepreneurial training.
Pedagogical Deficiencies	Teaching methods remain largely didactic and theory-based, with limited experiential, hands-on, or project-based learning.	Entrepreneurial readiness requires critical thinking, creativity, collaboration, and adaptability—skills not adequately cultivated through outdated pedagogy.
Low Capacity for Curriculum Innovation	Many TVET educators lack training or awareness of Industry 4.0 technologies. There is no formal mechanism for continuous professional development.	Teachers are key change agents. Without upskilling, they cannot transmit relevant skills to students. This further widens the innovation adoption gap (Rogers, 2003).
High Youth Unemployment Linked to Skills Mismatch	Youth unemployment remains high despite increasing numbers of TVET graduates. Employers cite "lack of relevant skills" as a key reason for unemployability.	This validates the central argument of Human Capital Theory (Becker, 1993) that economic productivity is a function of skill relevance and quality.
Emerging Best Practices in Private and Specialized Institutions	Some private polytechnics and innovation hubs (e.g., Andela, Covenant University, Semicolon Africa) are integrating tech-driven training aligned with Industry 4.0.	These institutions serve as models for scaling curriculum reforms, showcasing the potential of agile, industry-led TVET interventions.
Policy Efforts Exist but Lack Implementation Drive	National strategies such as the National Skills Qualification Framework (NSQF) and the Nigerian Education Research and Development Council (NERDC) reform plans recognize the need for Industry 4.0 alignment, but implementation is weak.	The gap between policy intent and execution reinforces the need for systemic overhaul and coordination—echoing Systems Theory (Bertalanffy, 1968).

Recommendations and Policy Implications

This section presents actionable recommendations and corresponding policy implications based on the study's key findings. In light of the structural, curricular, pedagogical, and institutional gaps within Nigeria's TVET system; especially its misalignment with Industry 4.0 competencies, these proposals are intended to guide policymakers, educators, industry stakeholders and development partners in repositioning TVET as a driver of entrepreneurial readiness and national competitiveness.

Grounded in the study's theoretical frameworks: human capital theory, systems theory and innovation diffusion theory; the recommendations aim to promote a more adaptive, inclusive and innovation-oriented TVET environment. The accompanying policy implications offer strategic direction for government agencies and regulatory bodies seeking to reform skills development, reduce youth unemployment, and align education with emerging industrial demands.

a) Curriculum Reform for Industry 4.0 Alignment: TVET curricula should be urgently overhauled to integrate Industry 4.0 competencies such as artificial intelligence (AI), robotics, Internet of Things (IoT), smart manufacturing, data analytics, and cybersecurity. This should be accompanied by a strong emphasis on STEM education, digital skills, and entrepreneurial training. The National Board for Technical Education (NBTE) must mandate and supervise a nationwide review of all National and Higher National Diploma programmes with input from industry stakeholders. The curriculum reform must be competency-based and modular, allowing adaptability to emerging technologies.
b) Strengthen Public-Private Sector Collaboration: Forge robust partnerships between TVET institutions and industries for curriculum co-design, internships, mentorship, and industrial attachments. Industries should play a formal role in training design, implementation, and assessment. The Federal Ministry of Education, through NBTE, should establish Industry Advisory Boards within each polytechnic and technical college to institutionalize industry participation and ensure the relevance of training to labour market needs.
c) Invest in Digital and Technical Infrastructure: Massive investment in digital laboratories, fabrication hubs, simulation software, smart classrooms, and broadband connectivity in TVET institutions is essential to make Industry 4.0 training feasible and practical. Funding agencies like TETFund, NITDA, and World Bank Skills Development Projects should prioritize digital infrastructure grants and equipment financing for accredited TVET institutions, with clear monitoring and sustainability plans.
d) Continuous Professional Development for TVET Educators: TVET instructors must undergo regular training on Industry 4.0 technologies, STEM teaching methods, entrepreneurship, and project-based learning to bridge the capacity gap in curriculum delivery. NBTE should collaborate with bodies like ITF, C-STEmp, and international development partners to design and implement a National Digital Upskilling Framework for all TVET educators, linked to professional advancement and recertification.

e) Adopt Dual Training and Experiential Learning Models: Integrate dual training approaches combining classroom instruction with structured industrial exposure, apprenticeship models, and entrepreneurial incubation for learners. The National Skills Qualification Framework (NSQF) should be scaled up to embed experiential learning as a core requirement for all vocational qualifications, supported by regulatory incentives for participating industries.
f) Establish Innovation and Entrepreneurship Hubs in TVET Institutions: TVET institutions should establish innovation hubs and enterprise incubation centres where students can develop products, test ideas, and receive support for startups. Government and private sector-led innovation funding (e.g., through Bank of Industry**,** SMEDAN**,** NESP**,** and AfDB Youth Entrepreneurship Funds**)** should be made available to polytechnics and technical colleges to finance entrepreneurial ecosystems.
g) Promote Policy Coherence and Inter-Agency Synergy: Improve coordination among NBTE, ITF, NERDC, National Planning Commission, and relevant ministries to ensure coherent and synergistic policies for TVET reform. The Federal Government should establish a National Skills Council to harmonize all TVET and Industry 4.0-related policy actions, monitor implementation, and ensure alignment with Nigeria's industrial development goals and youth employment strategies.
h) Institutionalize Labour Market Intelligence Systems: Develop a national system to track emerging job trends, employer skill requirements, and graduate employability outcomes. The Ministry of Labour, in collaboration with NBS and industry associations, should operationalize a Labour Market Observatory to inform TVET curriculum planning, policy direction, and national manpower forecasting.
i) Reduce TVET Stigmatization and Rebrand Technical Careers: Launch nationwide awareness campaigns to reposition TVET as a viable and prestigious path to innovation, enterprise, and professional success. The Ministry of Information and Orientation should lead a "Skilled Nigeria" campaign in partnership with NBTE, UNESCO-UNEVOC, and youth organizations to change public perception and increase enrolment in technical fields.
j) Encourage Private Sector-Led TVET Innovations: Provide policy and fiscal incentives to private organizations and startups involved in innovative, tech-driven vocational education (e.g., Andela, Utiva, Semicolon). Through tax credits, matching grants, and public-private partnerships, government can mainstream successful private models into national TVET policy and expand access to relevant training for underserved populations.

Bridging the skills mismatch in Nigeria's TVET system is not merely an educational reform; it is an economic and national development imperative. Aligning TVET curricula, pedagogy, and infrastructure with the realities of the Fourth Industrial Revolution is key to transforming youth potential into innovation, reducing unemployment, and positioning Nigeria as a competitive player in the global digital economy. Achieving this requires strategic collaboration**,** strong political will**,** and robust implementation frameworks**.**

Conclusion

This paper has critically examined the persistent skills mismatch in Nigeria's TVET system within the context of Industry 4.0 imperatives. It has established that despite TVET's strategic role in preparing the workforce for employment and entrepreneurship, significant gaps remain between training outcomes and the evolving demands of the digital and industrial economy. These gaps are evident in outdated curricula, weak industry linkages, infrastructural deficits, and limited exposure to emerging technologies such as artificial intelligence, robotics, data analytics, and smart manufacturing.

The study reaffirms that aligning TVET with Industry 4.0 competencies is essential to cultivating entrepreneurial readiness and building a resilient, future-ready workforce. Bridging this gap requires a deliberate and collaborative effort involving curriculum reform, investment in digital infrastructure, industry partnership, and capacity building for educators. As Nigeria confronts high youth unemployment and increasing global competition, the revitalization of its TVET system must become a national priority. The insights shared in this paper offer a compelling call to action for policymakers, educators, researchers, and industry stakeholders attending this conference to engage in meaningful dialogue and forge partnerships that will drive TVET transformation for sustainable development and economic competitiveness.

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The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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