

CHALLENGES AND STRATEGIES FOR INTEGRATING GREEN SKILLS INTO RENEWABLE ENERGY PROGRAMMES IN NIGERIAN COLLEGES OF EDUCATION

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Abstract

The integration of green skills into renewable energy programmes in Nigerian Colleges of Education is a critical prerequisite for developing a workforce capable of supporting sustainable development and implementing Nigeria's Energy Transition Plan. As institutions responsible for training Technical and Vocational Education and Training (TVET) teachers, Colleges of Education occupy a strategic position in shaping the competencies required for the emerging green economy. However, structured integration of renewable energy competencies within these institutions remains limited, creating a significant gap between national policy ambitions and educational practice. This study investigates the multifaceted challenges hindering such integration and proposes evidence-based strategic solutions grounded in empirical data. Three research questions guided the study: (i) What are the challenges hindering the integration of green skills into renewable energy programmes in Nigerian Colleges of Education? (ii) What is the current status of green skills integration in these institutions? and (iii) What strategies can effectively address these challenges? A convergent parallel mixed-methods design was adopted. The study population comprised lecturers and administrators from six purposely selected Colleges of Education in the South-South and South-West geopolitical zones of Nigeria. The survey instrument was a 35-item structured questionnaire administered to 120 respondents (89 lecturers and 31 administrators), which demonstrated high internal consistency (Cronbach's Alpha = 0.87). Qualitative data were collected through semi-structured interviews with 18 key informants and supplemented by systematic curriculum document analysis. Findings reveal key barriers including inadequate lecturer capacity in green technologies, rigid and prescriptive curricula, insufficient physical infrastructure, weak industry linkages, and persistent policy implementation gaps. The study proposes a multi-dimensional framework encompassing curriculum reform, targeted professional development, infrastructure investment, gender inclusion, and strengthened institutional collaboration with industry. The findings underscore the urgent need for systemic reforms to align teacher education with sustainability demands. This study contributes to the growing discourse on greening TVET in Nigeria and offers actionable, evidence-based recommendations for policymakers, institutional leaders, and development partners.

Keywords: Green skills; Renewable energy education; TVET; Colleges of Education; Nigeria; Sustainability

Introduction

Nigeria confronts a confluence of energy-related challenges that are simultaneously developmental, environmental, and economic in character. With approximately 85 million citizens lacking reliable access to electricity, one of the largest energy-poor populations in the world, the country's dependence on fossil fuels has deepened its vulnerability to global commodity price volatility while accelerating its contribution to greenhouse gas emissions (International Energy Agency [IEA], 2022). Against this backdrop, the Federal Government of Nigeria (2022) adopted a comprehensive Energy Transition Plan (ETP), setting an ambitious target of achieving net-zero greenhouse gas emissions by 2060. The ETP outlines a roadmap for transitioning to renewable energy sources, including solar, wind, and small hydropower, as central pillars of a sustainable energy future.

The success of this energy transition is contingent not only on policy frameworks and capital investment, but fundamentally on the availability of a skilled technical workforce. Renewable energy technologies require workers who possess both technical proficiencies such as solar photovoltaic installation, wind turbine maintenance, energy auditing, and grid integration and the transversal competencies needed to operate in complex, evolving technological environments (International Labour Organization [ILO], 2019). Building such a workforce demands a systematic and deliberate transformation of education and training systems at every level.

Technical and Vocational Education and Training (TVET) play a pivotal role in preparing this workforce. Within Nigeria's education architecture, Colleges of Education occupy a uniquely strategic position: they train the teachers who subsequently deliver technical and vocational knowledge at secondary and vocational levels across the country. The quality and relevance of education delivered in secondary schools and vocational training centres is therefore directly shaped by the competencies of teachers produced by Colleges of Education. Consequently, embedding green skills and renewable energy competencies within their programmes is a systemic necessity for Nigeria's energy transition.

Despite significant global advances in green education, Nigerian Colleges of Education have made limited progress in incorporating renewable energy and sustainability concepts into their curricula. Existing programme structures remain largely traditional, centred on conventional craft skills and general technology principles, with minimal engagement with emerging green technologies (World Bank, 2020). This creates a widening disconnect between teacher education and the evolving demands of both the labour market and national development priorities. As Busari (2025) notes, the absence of green skills in technology

education programmes means that a generation of TVET teachers is being produced without the competencies needed to educate future renewable energy technicians, installers, and practitioners.

This study focuses specifically on Colleges of Education in the South-South and South-West geopolitical zones of Nigeria regions characterised by significant industrial activity, petroleum infrastructure, and growing renewable energy investment, making the integration of green skills particularly pertinent. The South-South zone, encompassing states such as Rivers, Delta, Bayelsa, Cross River, Akwa Ibom, and Edo, is home to Nigeria's oil and gas heartland and faces acute environmental challenges associated with fossil fuel extraction. The South-West zone, including Lagos, Ogun, Oyo, Osun, Ondo, and Ekiti states, is the country's most economically active region and hosts the largest concentration of renewable energy enterprises and technology institutions. Both zones present urgent and contextually specific demands for green skills development.

This study pursues three specific objectives: (i) to identify and analyse the challenges hindering the integration of green skills into renewable energy programmes in Nigerian Colleges of Education; (ii) to examine the current status of such integration within these institutions; and (iii) to propose practical, context-sensitive strategies for effective implementation. Through a mixed-methods approach, the study generates both quantitative evidence on the prevalence and severity of barriers and qualitative insights into the institutional dynamics that shape them.

Literature Review

The Concept and Significance of Green Skills

Green skills are broadly defined by the International Labour Organization (ILO, 2019) as the technical knowledge, competencies, values, and attitudes required for the workforce to develop and support sustainable economic activity, including environmental protection and the management of natural resources. The concept encompasses a wide spectrum of competencies: at one end, highly technical skills such as the installation and maintenance of photovoltaic systems, wind energy equipment, and energy-efficient building systems; at the other, transversal competencies including systems thinking, environmental awareness, problem-solving, and adaptability to technological change.

Scholars have increasingly distinguished between 'new green occupations' entirely new job roles created by the green economy and the 'greening of existing occupations', which involves the transformation of traditional job profiles to incorporate sustainability-related

competencies (CEDEFOP, 2019; ILO, 2019). For Nigeria's TVET system, both dimensions are relevant: new occupations in solar installation and energy auditing are emerging rapidly, while existing trades such as electrical engineering, construction, and plumbing are being reshaped by sustainability requirements. Colleges of Education, as producers of TVET teachers, must prepare educators capable of addressing both dimensions.

The significance of green skills extends beyond environmental objectives. The International Renewable Energy Agency (IRENA, 2022) estimates that the renewable energy sector employed approximately 12.7 million people globally in 2021, with solar energy alone accounting for nearly 4 million jobs. In Nigeria, the SHINE Project (2025) estimates that the solar energy sector could generate over 250,000 skilled jobs by 2030, contingent on the development of adequate training infrastructure. Green skills are therefore central to both environmental sustainability and economic development, a dual imperative particularly salient in the South-South and South-West regions, where economic diversification away from petroleum dependence is a development priority.

Theoretical Framework: Greening TVET

This study is theoretically grounded in Majumdar's (2017) Greening TVET Framework, which conceptualises the integration of sustainability into vocational education across five interdependent dimensions: policy, curriculum, institution, community, and research. According to Majumdar (2017), sustainable transformation of TVET systems cannot be achieved through isolated interventions in any single dimension; rather, it requires coordinated reform across all five dimensions simultaneously. The framework is particularly useful for analysing the Nigerian context because it directs attention to both the structural conditions, policy frameworks and institutional capacity and the relational dimensions of TVET transformation, including community engagement and research connectivity.

Applied to Colleges of Education in the South-South and South-West zones, the framework suggests that green skills integration will be most effective when national policies mandate it, curricula are redesigned to embed it, institutions invest in the infrastructure and staffing to support it, communities and industries are engaged as partners, and research continuously informs and improves practice. The absence or weakness of any one of these dimensions creates systemic vulnerabilities that can undermine progress in the others.

Complementing Majumdar's framework, this study also draws on Ecological Systems Theory, which emphasises that learners and institutions exist within nested social, political, and economic systems (Bronfenbrenner, 1979, as cited in Barroso et al., 2021). This

perspective highlights that the integration of green skills in Colleges of Education cannot be understood solely as a matter of curriculum design or institutional will, but must be situated within the broader macro-level policy environment, the meso-level dynamics of institutional culture and resource allocation, and the micro-level practices of individual lecturers and students.

Global Context: Advances in Green TVET

At the global level, significant progress has been made in integrating sustainability into TVET systems. Germany's dual system of vocational education has progressively incorporated green competencies across virtually all vocational training programmes through a continuous process of occupational standards reform driven by tripartite social partnership between government, employers, and trade unions (Bundesministerium für Bildung und Forschung [BMBF], 2021). Australia's vocational education system has similarly integrated renewable energy units into a wide range of qualification pathways, supported by national Green Skills Agreements that mandate sustainability competencies across the TVET sector (Australian Department of Education, 2020).

UNESCO-UNEVOC (2021) has documented innovative practices in green TVET across diverse national contexts, including the integration of solar energy apprenticeships in Morocco, the development of green construction curricula in Indonesia, and the establishment of dedicated renewable energy technical schools in Bangladesh. These examples demonstrate that meaningful green TVET reform is achievable across different income levels and institutional contexts, provided that enabling conditions particularly policy commitment, funding, and industry engagement are in place.

African Context: Progress and Persistent Challenges

Across sub-Saharan Africa, the integration of green skills into TVET systems has gained increasing policy attention, though progress remains uneven. Kenya has made notable advances through the Technical and Vocational Education and Training Authority (TVETA), which has developed occupational standards for solar energy technicians and incorporated renewable energy modules into several national qualification frameworks (AfDB, 2020). South Africa's National Qualifications Framework includes environmental sustainability competencies across a range of vocational qualifications, supported by investment in dedicated renewable energy training facilities through private sector and international development partnerships (Ramsarup et al., 2021).

Nevertheless, the African Development Bank (AfDB, 2020) identifies persistent structural challenges across the continent, including chronic underfunding of TVET institutions, insufficient numbers of qualified TVET teachers and trainers, outdated equipment and laboratory facilities, and weak articulation between TVET programmes and labour market needs. Nigeria shares many of these challenges but also faces unique institutional constraints related to the federal structure of its education system and the regulatory complexity governing Colleges of Education.

The Nigerian Context: The Green Skills Gap in Southern Nigeria

Nigeria's TVET system is characterised by significant institutional fragmentation. Colleges of Education fall under the regulatory oversight of the National Commission for Colleges of Education (NCCE), which sets minimum academic standards and approves curricula. This regulatory architecture has historically impeded coordinated curriculum reform across the sector (World Bank, 2020). Studies by Eze and Akpan (2021) and Olaitan et al. (2020) document widespread misalignment between TVET programme content and contemporary industry requirements, including in the energy sector.

In the South-South zone, the dominance of the petroleum industry has historically marginalised investment in renewable energy training, despite the region's acute environmental challenges and emerging solar energy market (David & Daniels, 2025). The South-West zone, while more economically diversified, has seen renewable energy training concentrated in polytechnics and private sector institutes, leaving Colleges of Education largely disconnected from this development. The SHINE Project (2025) highlights the acute shortage of qualified solar energy trainers across both zones and underscores the urgent need to build institutional capacity within the TVET teacher education system. Busari (2025) similarly identifies the absence of green skills frameworks within Nigerian higher education institutions as a systemic gap requiring immediate policy attention.

Methodology

This study adopted a convergent parallel mixed-methods design (Creswell & Plano Clark, 2018), which enabled the simultaneous collection and independent analysis of both quantitative and qualitative data, with integration occurring at the interpretation stage. This design was selected because the complexity of the research problem understanding both the prevalence and the experiential dimensions of barriers to green skills integration warranted multiple modes of inquiry that could provide complementary forms of evidence. The

integration of quantitative survey data with qualitative interview findings and documentary evidence allowed for triangulation, enhancing the credibility and comprehensiveness of the conclusions.

The study population comprised lecturers and administrators in Colleges of Education across the South-South and South-West geopolitical zones of Nigeria. Six Colleges of Education were selected using purposive sampling based on three criteria: the presence of an active technology education department, geographic representation across both zones (three institutions per zone), and institutional willingness to participate. Participating South-South institutions were drawn from Rivers, Delta, and Cross River states; South-West institutions from Lagos, Ogun, and Oyo states.

A total of 120 respondents participated in the quantitative survey component, comprising technology education lecturers ($n = 89$) and departmental administrators ($n = 31$). For the qualitative component, 18 key informants were purposively selected to capture a range of relevant perspectives, including heads of technology education departments ($n = 6$), curriculum coordinators ($n = 4$), senior lecturers with industry experience ($n = 5$), and education administrators with policy responsibilities ($n = 3$). Purposive sampling was appropriate for this component as it enabled the selection of information-rich participants with direct relevance to the research questions (Patton, 2015).

Three data collection instruments were employed. The structured questionnaire (see Appendix A) comprised 35 items organised across five thematic clusters corresponding to the identified barrier categories: lecturer capacity, infrastructure, curriculum, industry linkages, and policy. Items were rated on a five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). Semi-structured interview guides (see Appendix B) were developed for each category of key informant, comprising open-ended questions designed to elicit detailed accounts of institutional experiences, perceptions of barriers, and perspectives on potential solutions. Curriculum and policy document analysis followed a structured review protocol examining NCCE Minimum Academic Standards, institutional programme documents, and relevant national policy frameworks.

The questionnaire demonstrated high internal consistency, with a Cronbach's Alpha coefficient of 0.87 across the full instrument. Individual subscales ranged from 0.81 to 0.89. Content validity was established through expert review by a panel of five specialists in TVET, curriculum studies, and renewable energy education. The interview guide was piloted with two participants external to the study sample and refined to improve question flow and clarity.

Qualitative credibility was further enhanced through member checking, whereby interview summaries were returned to six participants for validation.

Quantitative data were analysed using IBM SPSS Statistics (Version 26), employing descriptive statistics including frequencies, means, standard deviations, and percentage agreement rates. Qualitative data from interviews were transcribed verbatim and subjected to reflexive thematic analysis following the six-phase approach described by Braun and Clarke (2006). Document analysis followed a directed content analysis approach (Hsieh & Shannon, 2005), with findings used to contextualise and triangulate interview and survey data.

Ethical Considerations

Ethical approval was obtained from the relevant institutional research ethics committee prior to data collection. All participants provided written informed consent. Confidentiality was maintained throughout, with data stored securely and accessible only to the research team. The research adhered to the ethical principles of beneficence, non-maleficence, respect for persons, and justice.

Results

Respondent Profile

Of the 120 survey respondents, 74 (61.7%) were from South-South institutions and 46 (38.3%) from South-West institutions, reflecting the larger number of eligible lecturers in the South-South sample institutions. Male respondents constituted 68.3% (n = 82) and female respondents 31.7% (n = 38) of the sample. In terms of academic rank, 41.7% (n = 50) were senior lecturers, 33.3% (n = 40) were lecturers, and 25% (n = 30) were principal lecturers or chief lecturers. The majority of respondents (62.5%) had between 6 and 15 years of teaching experience, with 21.7% having more than 15 years.

Quantitative Findings: Challenges to Green Skills Integration

Table 1 presents the key challenges identified by survey respondents, showing percentage agreement scores (combined 'agree' and 'strongly agree' responses) and mean Likert scores for each barrier category. The results indicate that all five barrier categories are perceived as significant by the majority of respondents, with mean scores ranging from 4.0 to 4.5 on the five-point scale.

Table 1: Challenges to Green Skills Integration in Nigerian Colleges of Education (N = 120)

Challenge Category	% Agreement	Mean Score($\bar{X}$)	SD
Inadequate physical infrastructure and laboratory facilities	82%	4.5	0.61
Lecturer capacity gap in green technologies	78%	4.3	0.67
Weak industry and employer partnerships	70%	4.2	0.72
Policy implementation gaps at institutional level	68%	4.0	0.78
Rigid and prescriptive curriculum frameworks	65%	4.1	0.74

Infrastructure inadequacy emerged as the most widely recognised barrier, with 82% of respondents agreeing or strongly agreeing ($M = 4.5$, $SD = 0.61$). Notably, South-South institutions reported significantly higher infrastructure deficits than South-West counterparts, likely reflecting the historically centralised investment of federal resources in petroleum infrastructure rather than educational facilities in that zone. Lecturer capacity gaps were identified by 78% of respondents ($M = 4.3$, $SD = 0.67$), with similar patterns across both zones. Weak industry partnerships (70%; $M = 4.2$), policy implementation gaps (68%; $M = 4.0$), and curriculum rigidity (65%; $M = 4.1$) were also rated as highly significant barriers.

Qualitative Findings: Thematic Analysis

Thematic analysis of the 18 semi-structured interviews generated four overarching themes: (i) policy awareness and institutional disengagement; (ii) practical teaching constraints and resource poverty; (iii) gender imbalance and social barriers; and (iv) institutional inertia and resistance to change.

Theme 1: Policy Awareness and Institutional Disengagement. The majority of interviewed lecturers demonstrated limited familiarity with Nigeria's Energy Transition Plan and its implications for TVET teacher education. Participants from South-South institutions described a particularly acute disconnect, noting that institutional planning is dominated by concerns about petroleum industry partnerships rather than renewable energy readiness. Several informants observed that awareness of national energy policy among academic staff is largely absent at departmental level, consistent with findings by David and Daniels (2025) on the policy-practice gap in Nigerian TVET.

Theme 2: Practical Teaching Constraints and Resource Poverty. Interviewees consistently emphasised the absence of physical resources necessary for hands-on renewable energy instruction. The lack of solar panels, inverter systems, wind energy models, energy monitoring equipment, and updated textbooks was described as a fundamental obstacle across

both zones. One senior lecturer from a South-West College described attempting to teach solar energy concepts using diagrams alone, characterising this as a profound pedagogical limitation resulting in superficial student understanding. South-South participants additionally noted the irony of being located in energy-producing states yet lacking any renewable energy teaching equipment.

Theme 3: Gender Imbalance and Social Barriers. Gender imbalance emerged as a cross-cutting concern across both zones, with multiple participants noting that female students are significantly underrepresented in technical programmes. Participants from South-South institutions attributed this particularly to prevailing social norms in communities where technical education for women is culturally discouraged. South-West participants noted similar patterns, though with some evidence of emerging change driven by female role models in Lagos-based renewable energy enterprises. This finding resonates with the broader literature on gender in TVET (ILO, 2019).

Theme 4: Institutional Inertia and Resistance to Change. Several participants identified a culture of institutional inertia as a significant barrier. This manifested as resistance from established faculty members who perceived green skills integration as an additional burden, departmental reluctance to revise long-standing programme structures, and a general absence of strategic leadership around sustainability. One administrator from a South-South institution characterised the prevailing disposition as waiting for external directives rather than proactively identifying emerging educational needs, a form of institutional conservatism documented widely in the TVET reform literature (Ramsarup et al., 2021).

Document Analysis: Current Status of Green Skills Integration

Systematic analysis of curriculum documents revealed that green skills and renewable energy competencies are largely absent from formal curriculum frameworks across all six institutions. None of the participating Colleges of Education had a dedicated renewable energy programme or formally articulated green skills framework. In three South-West institutions, isolated references to solar energy or energy conservation appeared in elective modules but were not integrated into core learning outcomes. In the three South-South institutions examined, no reference to renewable energy was found in any current programme document, a particularly striking finding given the energy transition imperatives facing that region.

Discussion

The findings of this study reveal a pattern of systemic, multi-layered barriers to green skills integration in Nigerian Colleges of Education that is consistent with, and in several respects more severe than, the challenges documented in comparable TVET systems across sub-Saharan Africa (AfDB, 2020; Ramsarup et al., 2021). Interpreted through the lens of Majumdar's (2017) Greening TVET Framework, it is evident that institutions in both the South-South and South-West zones exhibit significant weaknesses across all five framework dimensions policy, curriculum, institution, community, and research.

Infrastructure inadequacy, identified as the most prevalent barrier, reflects a structural problem rooted in the chronic underfunding of Colleges of Education. The zone-level disparity in infrastructure challenges with South-South institutions reporting more severe deficits highlights how historical patterns of federal investment in petroleum infrastructure have simultaneously enriched the South-South economically while starving its educational institutions of capital resources needed for technical modernisation. This paradox, of resource-rich regions with resource-poor educational institutions, is a well-documented phenomenon in the literature on the 'resource curse' and human capital development (IEA, 2022).

Lecturer capacity gaps represent the most strategically critical challenge. The finding that 78% of respondents identified this barrier, with no significant difference between zones, suggests that the professional development of TVET lecturers in green technologies has been systematically neglected across the entire southern Nigeria TVET system. This creates a self-reinforcing skills deficit: without capable lecturers, student teachers cannot acquire green competencies; without skilled graduates entering the teaching profession, technical education at secondary and vocational levels continues without sustainability-oriented content (ILO, 2019; Eze & Akpan, 2021).

The rigidity of NCCE-governed curricula reflects a deeper structural tension between regulatory standardisation and educational responsiveness. While minimum academic standards serve important quality assurance functions, overly prescriptive frameworks impede the ability of institutions to adapt programmes to emerging industry needs (CEDEFOP, 2019). The absence of any explicit green skills dimension within current NCCE standards means that institutions lack both the mandate and the incentive to undertake curriculum reform. This is consistent with David and Daniels' (2025) analysis of the policy-curriculum disconnect in Nigerian TVET.

Weak industry linkages are particularly significant in the context of the South-West zone, where a relatively active renewable energy private sector exists but maintains limited

formal connections with Colleges of Education. The South-South zone presents a different dynamic: the dominant petroleum industry has historically been the primary partner for technical institutions, and renewable energy enterprises have yet to establish comparable relationships. Both zones would benefit from deliberate partnership brokering by the NCCE and relevant state government agencies to build the industry linkages that are foundational to quality TVET in the green economy (UNESCO-UNEVOC, 2021).

The gender imbalance identified across both zones, while not unique to the green skills context, assumes particular urgency given that the renewable energy sector offers significant employment opportunities for women, especially in areas such as solar energy sales, installation, and rural energy access (IRENA, 2022). The failure to address gender barriers in technical teacher education represents both an equity deficit and a missed economic opportunity. The evidence of emerging change in South-West institutions associated with female role models in Lagos-based renewable energy enterprises is a promising indicator that targeted institutional interventions can shift enrolment patterns.

The qualitative finding on institutional inertia aligns with wider scholarship on organisational change in education systems. Ramsarup et al. (2021) observe that TVET reform in sub-Saharan Africa is frequently undermined not by the absence of technical knowledge about what needs to change, but by the persistence of institutional cultures that prioritise stability over strategic transformation. Overcoming this inertia in both southern zones will require deliberate leadership development, incentive structures that reward curriculum innovation, and what Majumdar (2017) terms a 'culture of green' within educational institutions.

Conclusion and Implications

This study has demonstrated that the integration of green skills into renewable energy programmes in Nigerian Colleges of Education is both urgently necessary and currently inadequate. The convergent mixed-methods evidence generated establishes that significant structural, capacity, institutional, and policy barriers impede progress across institutions in the South-South and South-West geopolitical zones, and that these barriers operate across all dimensions of the Greening TVET Framework (Majumdar, 2017). The zone-level analysis reveals important contextual differences particularly the acute infrastructure deficits and petroleum industry dominance in the South-South, and the underutilised renewable energy industry connections in the South-West that should inform differentiated policy and institutional responses.

For national policymakers and the NCCE, the findings point to an urgent need for regulatory reform. The development of specific minimum academic standards for green skills integration in technology education programmes, aligned with Nigeria's Energy Transition Plan and international green skills frameworks, would provide the institutional mandate currently lacking across the sector. This should be complemented by targeted funding mechanisms, including dedicated capital grants for renewable energy laboratory development and ring-fenced allocations for lecturer professional development.

For institutional leaders in both zones, the findings underscore the importance of strategic commitment to sustainability as a core institutional value. Colleges of Education in the South-West, given their proximity to an active renewable energy industry in Lagos and surrounding states, are well-positioned to pioneer formal industry partnership frameworks that could serve as models for the sector. South-South institutions, confronting the specific challenges of petroleum industry dominance and environmental degradation, have a compelling case for dedicated state government and development partner support to build green TVET capacity as part of broader regional economic diversification strategies.

For development partners and international organisations, the study highlights both the scale of the challenge and the strategic leverage that targeted interventions can provide. Investment in trainer-of-trainers programmes, the co-development of contextualised curriculum materials, and the establishment of model renewable energy training facilities could serve as catalytic interventions that demonstrate the feasibility of green skills integration and build the evidence base for national scaling.

The study acknowledges limitations including the purposive sampling of six institutions, which limits generalisability. Future research employing larger, nationally representative samples across all geopolitical zones would strengthen the evidence base. Longitudinal research tracking the impact of specific interventions and studies exploring student teacher perspectives would further enrich understanding.

Recommendations

Based on the study findings, the following recommendations are proposed for relevant stakeholders:

- Curriculum Reform and Regulatory Update: The NCCE should revise Minimum Academic Standards for technology education to mandate renewable energy competencies as core programme components, with learning outcomes and assessment

criteria aligned with the ILO (2019) green skills framework and UNESCO-UNEVOC (2021) TVET sustainability guidelines.

- **Lecturer Capacity Building:** The NCCE and TETFund should jointly design a national Green TVET Teacher Professional Development Programme, including industry-based training components delivered in partnership with renewable energy companies active in both the South-South and South-West zones.
- **Infrastructure Investment:** Federal and state governments, in collaboration with development partners, should fund the establishment of renewable energy demonstration laboratories in all Colleges of Education, with standardised minimum equipment specifications and maintenance funding incorporated into recurrent budget allocations.
- **Industry and Community Partnerships:** Colleges of Education should develop formal collaboration frameworks with renewable energy industry associations, state energy commissions, and civil society organisations to facilitate curriculum co-design, guest instruction, student internships, and continuous occupational profile updates.
- **Gender Mainstreaming:** Institutions should implement targeted gender inclusion strategies encompassing scholarship schemes for female students, appointment of female academic staff in technical departments, and monitoring of gender-disaggregated enrolment data as a standard NCCE requirement.
- **Policy Communication:** The Federal Ministry of Education and NCCE should develop a systematic policy communication strategy to ensure that the implications of Nigeria's Energy Transition Plan are effectively communicated to Colleges of Education leaders and faculty, including annual green TVET forums and institutional sustainability audits.
- **Monitoring, Evaluation, and Research:** A national competency-based assessment framework for green skills should be developed and piloted in Colleges of Education. TETFund should designate green TVET as a priority research theme to build the evidence base for continuous improvement.

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Appendix A: Structured Questionnaire

Challenges and Strategies for Integrating Green Skills into Renewable Energy Programmes in Nigerian Colleges of Education Lecturer and Administrator Survey

Dear Respondent,

This questionnaire is part of a research study on the integration of green skills and renewable energy competencies in Colleges of Education in the South-South and South-West geopolitical zones of Nigeria. Your responses will be used solely for academic research purposes. Participation is voluntary and all information provided will be treated with strict confidentiality. Please do not write your name on this questionnaire. Thank you for your time and cooperation.

Section A: Demographic Information

Please tick (✓) the appropriate option or fill in the blank.

- A1.** Institution type:
 a. Federal College of Education
 b. State College of Education
- A2.** Geopolitical zone:
 a. South-South
 b. South-West
- A3.** Your role:
 a. Lecturer (Technology Education)
 b. Departmental Administrator
 c. Principal/Chief Lecturer
- A4.** Years of teaching/administrative experience:
 a. Less than 5 years
 b. 6–10 years
 c. 11–15 years
 d. More than 15 years
- A5.** Gender:
 a. Male
 b. Female
 c. Prefer not to say

Section B: Lecturer Capacity and Awareness

Please indicate your level of agreement with each statement using the scale below:

5 = Strongly Agree 4 = Agree 3 = Undecided 2 = Disagree 1 = Strongly Disagree

S/N	Statement	SA (5)	A (4)	U (3)	D (2)	SD (1)
B1	Lecturers in my department are adequately knowledgeable about renewable energy technologies.					
B2	Lecturers in my institution have received professional training in green skills or renewable energy.					
B3	There is a need for capacity building programmes for lecturers on green technologies.					
B4	I am aware of Nigeria's Energy Transition Plan (ETP) and its implications for TVET education.					
B5	Lecturers are supported to attend professional development workshops on renewable energy.					
B6	My institution has policies to encourage staff to acquire green skills competencies.					
B7	Most lecturers find it challenging to teach renewable energy topics due to limited knowledge.					

Section C: Infrastructure and Teaching Resources

S/N	Statement	SA (5)	A (4)	U (3)	D (2)	SD (1)
C1	My institution has functional renewable energy laboratories or demonstration facilities.					
C2	Adequate teaching materials and textbooks on renewable energy are available in my institution.					
C3	The absence of physical infrastructure is a major barrier to integrating green skills in our programmes.					
C4	My institution has access to solar panels, inverters, or other renewable energy equipment for teaching.					
C5	Funding constraints are a significant obstacle to infrastructure development for green skills.					
C6	State or federal government has provided recent support for renewable energy infrastructure in my College.					
C7	Development partners or international organisations have supported renewable energy facilities here.					

Section D: Curriculum and Policy

S/N	Statement	SA (5)	A (4)	U (3)	D (2)	SD (1)
D1	The current curriculum includes renewable energy or green skills as a core component.					
D2	The rigidity of the NCCE curriculum framework limits the integration of new green technology content.					
D3	There are clear national policy guidelines supporting the integration of green skills in Colleges of Education.					
D4	The NCCE Minimum Academic Standards need to be revised to incorporate renewable energy competencies.					
D5	My institution has a strategic plan that includes green skills integration as a priority.					
D6	Curriculum reform processes in my institution are too slow to respond to emerging green economy needs.					
D7	There is institutional support for lecturers who attempt to introduce green skills into their courses.					

Section E: Industry Linkages and Community Partnerships

S/N	Statement	SA (5)	A (4)	U (3)	D (2)	SD (1)
E1	My institution has formal partnerships with renewable energy companies.					
E2	Industry practitioners are invited to contribute to teaching or curriculum development in my department.					
E3	Students have opportunities for internships or work-based learning in renewable energy organisations.					
E4	Weak industry collaboration is a significant barrier to green skills integration in my institution.					
E5	There is engagement between my institution and state/federal energy agencies on TVET development.					
E6	The local renewable energy industry in this zone is interested in partnering with Colleges of Education.					
E7	Industry collaboration would improve the quality of renewable energy education in my institution.					

Section F: Gender and Inclusion

S/N	Statement	SA (5)	A (4)	U (3)	D (2)	SD (1)
F1	Female students are underrepresented in technology education programmes in my institution.					
F2	Social and cultural norms discourage female students from enrolling in technical programmes.					
F3	My institution has specific strategies to encourage female participation in technology education.					
F4	Gender imbalance in technical programmes affects the diversity of skills in the renewable energy sector.					
F5	The absence of female role models in technical faculty is a deterrent to female student enrolment.					
F6	Targeted gender inclusion policies would improve female participation in green skills programmes.					
F7	Physical workshop environments in technical programmes are welcoming and safe for female students.					

Section G: Open-Ended Questions

Please provide brief written responses to the following questions.

G1. In your opinion, what is the single most important step your institution could take to begin integrating green skills into its technology education programmes?

G2. What external support (from government, industry, or international partners) would most help your institution to develop renewable energy education?

G3. Are there any other challenges or opportunities related to green skills integration in your institution that you would like to highlight?

Thank you very much for completing this questionnaire. Your responses are invaluable to this research.

Appendix B: Semi-Structured Interview Guide**Key Informant Interview Guide for Heads of Department, Curriculum Coordinators,**

Senior Lecturers, and Education Administrators

Introduction to Participants: Thank you for agreeing to participate in this interview. This research investigates the challenges and strategies for integrating green skills and renewable energy competencies into technology education programmes in Colleges of Education across the South-South and South-West zones of Nigeria. This interview will last approximately 45–60 minutes. With your permission, the interview will be audio-recorded for accuracy in transcription. All information you provide will be treated with strict confidentiality, and you will not be identified by name in any publication arising from this research. You may withdraw at any time without consequence.

Part 1: Background and Institutional Context

1. Could you briefly describe your role in this institution and your experience in technology or vocational education?
2. How would you describe the current state of technology education programmes in your institution in relation to modern industry requirements?

3. To what extent are green skills or renewable energy topics currently addressed in your institution's technology education curriculum? Can you give specific examples?

Part 2: Awareness of Policy and National Frameworks

4. How familiar are you with Nigeria's Energy Transition Plan (2022) and its targets for renewable energy development by 2060? Has this informed any curriculum discussions in your department?

5. Are you aware of any NCCE guidelines or national policies that specifically address the integration of green skills or renewable energy into Colleges of Education curricula? If yes, how effectively have these been communicated and implemented at institutional level?

6. In your view, what role should national regulatory bodies such as the NCCE play in driving green skills integration in Colleges of Education?

Part 3: Challenges and Barriers

7. What do you consider to be the most significant challenges facing your institution in integrating renewable energy or green skills into its programmes? Please describe these from your direct experience.

8. How adequately equipped are lecturers in your institution to teach renewable energy topics? What are the gaps, and how did they arise?

9. How would you describe the adequacy of physical infrastructure laboratories, equipment, and materials for delivering renewable energy instruction in your institution?

10. In what ways does the current NCCE curriculum framework either support or constrain the integration of green skills and renewable energy content in your programmes?

11. How would you characterise the relationship between your institution and renewable energy industry stakeholders in your zone? Are there formal partnership mechanisms in place?

Part 4: Gender and Inclusion

12. How would you describe the gender balance among students enrolled in technology education programmes in your institution? What factors do you think contribute to the current situation?

13. Are there any institutional policies or practices specifically designed to encourage female participation in technical programmes? How effective have these been?

Part 5: Strategies and Solutions

14. What strategies do you believe would be most effective for overcoming the barriers to green skills integration in your institution? Are there examples from within or outside Nigeria that you find particularly instructive?

15. What types of support from government, development partners, or the private sector would most significantly enhance your institution's capacity to integrate renewable energy education?

16. If you had the authority to make three changes to curriculum, institutional practice, or policy to advance green skills integration in Colleges of Education, what would they be and why?

Part 6: Closing

17. Is there anything else you would like to share about the opportunities or challenges for green skills integration in your institution or in the broader context of Colleges of Education in this zone that we have not yet discussed?

Thank you sincerely for your time and for the valuable insights you have shared. This interview has been extremely helpful to our research. A summary of the key themes arising from your interview will be shared with you for member checking before any findings are published.