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RENEWABLE ENERGY SKILLS ACQUISITION, CURRICULUM INTEGRATION AND EMPLOYABILITY READINESS AMONG TECHNOLOGY EDUCATION STUDENTS IN NORTH-CENTRAL NIGERIA

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ABSTRACT
The global transition towards sustainable energy systems has increased the demand for a technically competent workforce capable of installing, operating, maintaining and managing renewable energy technologies. Consequently, technology education institutions have an important responsibility to equip students with relevant practical competencies that support employment and entrepreneurship in the emerging green economy. This study examines renewable energy skills acquisition, curriculum integration and employability readiness among technology education students in North-Central Nigeria. A descriptive survey research design was adopted. The population comprised 2,075 undergraduate and postgraduate technology education students from five public universities, while a sample of 335 students was selected through proportionate stratified random sampling. Data were collected using a 40-item researcher-developed instrument titled Renewable Energy Skills Development among Technology Education Students Questionnaire (RESDTESQ). The instrument was validated by three experts, while the Cronbach's alpha coefficients for its eight clusters ranged from 0.742 to 0.819. Mean and standard deviation were used to answer the research questions, while chi-square was used to test the hypothesis at the 0.05 level of significance. The results showed a low level of renewable energy skills (grand mean = 2.1486) and a low extent of curriculum integration (grand mean = 1.9981), while overall employability readiness was rated at a high extent (2.5196), and no significant association was found between skills acquisition and employability readiness, $\chi^2(1) = 1.418$, $p = .234$. The study offers a basis for strengthening competency-based renewable energy education, improving curriculum relevance and enhancing graduates' preparedness for employment in the renewable energy sector.

Keywords: Renewable energy, skills acquisition, technology education, curriculum integration, employability readiness, North-Central Nigeria

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Introduction

The increasing global demand for sustainable energy has made renewable energy technologies important components of contemporary economic development, environmental protection and energy security. Technologies such as solar photovoltaic systems, wind energy, hydropower and biomass provide alternative sources of energy while creating opportunities for technological innovation, industrial development and employment generation. The transition towards cleaner energy systems, however, requires not only financial investment and technological infrastructure but also a skilled workforce capable of supporting the installation, operation and maintenance of renewable energy facilities (International Energy Agency [IEA], 2023; International Renewable Energy Agency [IRENA] & International Labour Organization [ILO], 2026). The development of appropriate technical skills is particularly important because renewable energy technologies require specialised competencies. These include photovoltaic system design, electrical installation, battery management, inverter configuration, energy auditing, equipment testing, troubleshooting, preventive maintenance and adherence to electrical safety standards. The availability of individuals with these competencies can contribute to the effective deployment of renewable energy systems and the development of associated technical enterprises.

In Nigeria, renewable energy development has considerable relevance to national energy security, electricity access and economic diversification. The National Renewable Energy and Energy Efficiency Policy recognises the importance of renewable energy resources, including solar, wind, hydropower and biomass, in expanding energy access and supporting sustainable economic development (Federal Government of Nigeria, 2015). The Revised National Energy Policy also identifies renewable energy as an important component of Nigeria's long-term energy strategy (Energy Commission of Nigeria, 2022). Technology education institutions are strategically positioned to prepare students for emerging technical occupations associated with this transition. Through relevant curriculum content, laboratory instruction, workshop activities, industrial attachment and competency-based assessment, these institutions can develop students' ability to apply technical knowledge to practical occupational tasks.

However, theoretical knowledge alone may not adequately prepare students for renewable energy employment. Students need opportunities to work with actual equipment, perform supervised installations, interpret electrical diagrams, conduct measurements and identify technical faults. Where practical instruction is inadequate, graduates may experience difficulties translating classroom knowledge into workplace competence. The International Labour Organization (2019) emphasises that the transition towards environmentally sustainable economies requires appropriate skills development, reskilling and continuous professional learning. Similarly, UNESCO-UNEVOC (2017) identifies curriculum modernisation, institutional capacity, teacher development and collaboration with relevant stakeholders as important elements of greening technical and vocational education.

North-Central Nigeria provides a relevant setting for examining renewable energy skills development. The region comprises Benue, Kogi, Kwara, Nasarawa, Niger and Plateau States, together with the Federal Capital Territory, Abuja. The selected universities provide an institutional context for investigating the extent to which technology education programmes prepare students for renewable energy-related occupational opportunities. Renewable energy competencies may provide graduates with opportunities in solar installation, battery and inverter maintenance, energy consultancy, electrical services, renewable energy project support and technical entrepreneurship (Oluka & Onyebuenyi, 2017). Nevertheless, employability depends

on several factors, including the relevance of training, practical experience, professional competence, workplace adaptability and prevailing labour-market conditions. It is therefore necessary to examine the competencies students acquire, the extent to which renewable energy content is incorporated into technology education programmes and the relationship between renewable energy skills acquisition and perceived employability readiness.

Renewable energy skills acquisition refers to the process through which individuals develop the technical knowledge, practical abilities and occupational competencies required to work effectively with renewable energy technologies. These competencies encompass the identification of system components, installation of equipment, electrical connections, system configuration, performance testing, fault diagnosis and preventive maintenance. In solar photovoltaic technology, for example, students are expected to understand energy demand estimation, photovoltaic module selection, battery sizing, charge-controller configuration, inverter operation and electrical protection. Skills acquisition is most effective when theoretical instruction is combined with supervised practical experience (Arilesere & Jacob, 2026). The ILO (2019) explains that the transition towards environmentally sustainable economic activities requires education and training systems to respond to changing occupational requirements. This suggests that technology education programmes should continually update their instructional content to reflect emerging technical competencies.

Curriculum integration refers to the incorporation of relevant renewable energy knowledge, practical activities and assessment procedures into technology education programmes. Such integration may take place through dedicated renewable energy courses, electrical technology modules, laboratory exercises, student projects, industrial attachment and interdisciplinary technical assignments. Effective curriculum integration requires more than the inclusion of renewable energy topics in course descriptions. It should provide opportunities for students to interact with relevant equipment, perform practical activities and develop competencies that correspond to occupational requirements. UNESCO-UNEVOC (2017) identifies curriculum modernisation, teacher capacity development and institutional support as important considerations in developing education systems that respond to green economic opportunities, while Busari (2025) emphasised curriculum restructuring, lecturer development and competency-based learning as important requirements for integrating green skills into university technology education programmes.

Employability readiness refers to the knowledge, competencies, attitudes and personal attributes that prepare individuals to obtain and perform occupational responsibilities effectively. Within the renewable energy sector, employability readiness may include technical installation skills, equipment maintenance, electrical safety, troubleshooting, problem-solving, communication, teamwork and familiarity with workplace procedures. The development of technical competencies can improve students' preparedness for occupational responsibilities. However, employability is influenced by more than technical knowledge. Work experience, professional certification, industry demand, communication skills and access to employment opportunities may also affect graduate outcomes (Orji & Uche, 2021). The ILO (2019) identifies the importance of aligning education and training with the changing requirements of environmentally sustainable occupations. Consequently, the relationship between renewable energy skills acquisition and employability readiness should be investigated empirically rather than assumed.

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Statement of the problem

The increasing adoption of renewable energy technologies has created a demand for individuals with relevant technical and practical competencies. Technology education programmes are expected to respond to this demand by preparing students to undertake installation, operation, maintenance and troubleshooting activities associated with renewable energy systems (IRENA & ILO, 2026). Despite the growing relevance of renewable energy, the extent to which students acquire the necessary competencies through university-based technology education programmes requires empirical investigation. Inadequate laboratory facilities, limited practical exposure, insufficient specialist instruction and weak curriculum integration may restrict opportunities for students to develop occupationally relevant skills (Udoka & Owodiong, 2024). Furthermore, the inclusion of renewable energy topics in course outlines does not necessarily guarantee that students can perform the practical tasks required in the workplace. Effective skills development requires appropriate instructional equipment, qualified lecturers, practical exercises and meaningful industry engagement.

There is consequently a need to establish the level of renewable energy competencies possessed by technology education students, determine the extent of renewable energy curriculum integration and examine whether acquired skills are associated with students' perceived readiness for employment. Busari (2025) showed that the integration of green skills into Nigerian university technology education programmes still requires curriculum restructuring, lecturer development and institutional funding, but did not measure the competencies students actually possess. The problem addressed by this study is the insufficient empirical evidence concerning renewable energy skills acquisition, curriculum integration and employability readiness among technology education students in selected public universities in North-Central Nigeria.

Aim and objectives of the study

The main purpose of this study was to examine renewable energy skills acquisition, curriculum integration and employability readiness among technology education students in North-Central Nigeria. Specifically, the study sought to:

1. assess the level of renewable energy skills possessed by technology education students;
2. examine the extent to which renewable energy education is integrated into technology education programmes; and
3. determine the relationship between renewable energy skills acquisition and students' employability readiness.

Research questions

The following research questions guided the study:

1. What level of renewable energy skills do technology education students possess in North-Central Nigeria?
2. To what extent is renewable energy education integrated into technology education programmes in the selected universities?
3. What relationship exists between renewable energy skills acquisition and students' employability readiness?

Hypothesis

The following null hypothesis was formulated and tested at the 0.05 level of significance:

H_{01}: There is no statistically significant association between renewable energy skills acquisition and employability readiness among technology education students in North-Central Nigeria.

Theoretical framework

This study is anchored primarily on Human Capital Theory, associated with Becker (1993). Human Capital Theory explains that investments in education, training and skills development enhance individuals' productive capacities and may improve their employment prospects and economic opportunities. Applied to renewable energy education, the theory suggests that students who acquire relevant technical competencies through formal instruction and practical experience may become better prepared to undertake renewable energy-related occupational activities. The theory also provides a basis for understanding the importance of institutional investment in laboratories, equipment, teaching personnel and industry-based learning. However, the relationship between human capital development and employment is influenced by broader economic and labour-market conditions. Therefore, possessing technical skills does not automatically guarantee employment (Marginson, 2019).

The study examines three interconnected variables. Renewable energy skills acquisition covers installation, operation, maintenance, testing, troubleshooting and safety competencies; curriculum integration covers renewable energy course content, practical exercises, laboratory activities, projects and industrial exposure; and employability readiness covers students' perceived preparedness for renewable energy employment and related occupational responsibilities. The framework proposes that curriculum integration provides opportunities for skills acquisition, while acquired competencies may be associated with improved employability readiness. These relationships are subject to empirical investigation (Becker, 1993; UNESCO-UNEVOC, 2017).

Methodology

The study adopted a descriptive survey research design. This design was considered appropriate because it enabled the collection of information from technology education students concerning their renewable energy competencies, curriculum experiences and perceived employability readiness (Siedlecki, 2020). The study was conducted in North-Central Nigeria, comprising Benue, Kogi, Kwara, Nasarawa, Niger and Plateau States, together with the Federal Capital Territory, Abuja. The population comprised 2,075 undergraduate and postgraduate technology education students enrolled in five selected public universities, namely Rev. Fr. Moses Orshio Adasu University, Makurdi, Benue State; Joseph Sarwuan Tarka University, Makurdi, Benue State; University of Jos, Plateau State; Federal University of Technology, Minna, Niger State; and University of Ilorin, Kwara State. The population figure was obtained from departmental and registry records for the 2025/2026 academic session.

A sample of 335 students was selected from the population of 2,075 using proportionate stratified random sampling. Each university constituted a stratum, and the sample was allocated in proportion to the population of eligible students in each institution (Siedlecki, 2020). Data were collected using a researcher-developed questionnaire titled Renewable Energy Skills Development among Technology Education Students Questionnaire (RESDTESQ). The instrument contained 40 items. Section A obtained demographic and institutional information, while Section B contained the items, arranged in eight clusters, that addressed the research variables. Responses were measured using the four-point rating scale shown in Table 1, and a mean score of 2.50 was adopted as the decision threshold.

Table 1: Rating Scale and Decision Intervals

Response	Score	Mean interval	Decision
Very High Extent	4	3.50 to 4.00	Very High
High Extent	3	2.50 to 3.49	High
Low Extent	2	1.50 to 2.49	Low
Very Low Extent	1	1.00 to 1.49	Very Low

Source: Researchers' instrument.

The instrument was subjected to face and content validation by three experts from the Faculty of Technology and Industrial Studies, Rev. Fr. Moses Orshio Adasu University. A pilot test was conducted with 20 technology education students from two universities outside the study area, namely the University of Nigeria, Nsukka, and Ebonyi State University. The Cronbach's alpha coefficients for the eight clusters ranged from 0.742 to 0.819, with an overall coefficient of 0.961. Taber (2018) cautions that very high alpha values may indicate that items are measuring the same thing in slightly different words rather than showing a better instrument. Two research assistants were trained on the purpose of the study, questionnaire administration and the procedures for collecting completed instruments. A total of 335 copies of the questionnaire were administered, and respondents were given up to two days to complete them. The researcher and the research assistants then retrieved the completed copies. The renewable energy skills acquisition and employability readness with 166 very low extent and those 145 very high extent in their groupings with influence institutional factors on skills acquisitions with students skills acquisition on lowly extent on 204 and those on highly extent 107.

Mean and standard deviation were used to answer the research questions. Chi-square was used to test the null hypothesis at the 0.05 level of significance. This is because the respondents that have renewable energy skills acquisition and those that does not possess, and those with employability readness and those without. The chi-square test of independence is suited to examining the association between two categorical variables, so continuous or ordinal scores must first be grouped into categories before it is applied (McHugh, 2013).

Results

Research question One: What level of renewable energy skills do technology education students possess in North-Central Nigeria?

Table 2: Mean Ratings and Standard Deviations of Students' Renewable Energy Skills

Skill indicator	Mean	SD	Decision
Solar photovoltaic system installation	2.4148	1.3506	Low
Identification and selection of system components	2.3666	1.3250	Low
Battery and inverter installation and maintenance	2.3537	1.3478	Low
Electrical testing and troubleshooting	1.3762	0.9554	Very Low
Renewable energy system safety	2.2315	1.3974	Low
Grand mean	**2.1486**	**0.70**	**Low**

Source: Field Survey, 2026.

The grand mean of 2.1486 falls below the predetermined decision threshold of 2.50, suggesting a low level of reported renewable energy skills acquisition. Solar photovoltaic system installation recorded the highest mean of 2.4148, while electrical testing and troubleshooting

recorded the lowest mean of 1.3762, which falls within the very low interval. The results suggest that students require additional opportunities to develop practical competencies in photovoltaic installation, component selection, battery management, inverter configuration, electrical testing and safety procedures. This finding has important implications for technology education institutions because renewable energy competencies require practical application rather than theoretical knowledge alone. The ILO (2019) emphasises that developing a workforce for environmentally sustainable occupations requires appropriate technical training and continuous skills development.

Research question Two: To what extent is renewable energy education integrated into technology education programmes in the selected universities?

Table 3: Mean Ratings and Standard Deviations of Renewable Energy Curriculum Integration

Curriculum indicator	Mean	SD	Decision
Inclusion of renewable energy topics in courses	2.1929	1.3252	Low
Availability of practical sessions	2.4019	1.3569	Low
Use of renewable energy projects in assessment	1.4727	1.0679	Very Low
Access to relevant laboratory equipment	1.6913	1.1946	Low
Industrial attachment involving renewable energy	2.2315	1.3858	Low
Grand mean	**1.9981**	**0.69**	**Low**

Source: Field Survey, 2026.

The grand mean of 1.9981 indicates a low extent of renewable energy curriculum integration. This result suggests that renewable energy content and associated practical activities may not be sufficiently embedded in the selected technology education programmes. The low rating for renewable energy projects and laboratory equipment particularly warrants attention because students require opportunities to apply theoretical concepts to practical technical assignments. UNESCO-UNEVOC (2017) emphasises the importance of modernising technical education curricula and strengthening institutional capabilities to prepare learners for green occupations. Universities should therefore consider integrating dedicated renewable energy modules, laboratory exercises, practical projects and industry-based learning into their technology education programmes.

Research question Three: What relationship exists between renewable energy skills acquisition and students' employability readiness?

Table 4: Descriptive Ratings of Renewable Energy Skills and Employability Readiness

Indicator	Mean	SD	Decision
Confidence in undertaking entry-level renewable energy tasks	2.3376	1.4296	Low
Readiness to undertake installation and maintenance work	2.2572	0.9113	Low
Ability to diagnose common system faults	3.4405	0.9749	High
Preparedness for renewable energy industry employment	2.1768	1.4450	Low
Overall employability readiness	**2.5196**	**0.56**	**High**

Source: Field Survey, 2026.

The findings show that the overall employability readiness score was 2.5196, indicating a high extent of perceived readiness based on the study's decision benchmark. However, the individual indicators reveal differences in students' perceived competencies. Ability to diagnose common system faults recorded a mean of 3.4405, indicating a high extent, while confidence in undertaking entry-level renewable energy tasks (2.3376), readiness for installation and maintenance work (2.2572) and preparedness for renewable energy industry employment (2.1768) were rated low. The descriptive mean scores alone do not establish whether a statistically significant association exists, and that determination depends on the hypothesis test (McHugh, 2013).

Test of hypothesis

H_{01}: There is no statistically significant association between renewable energy skills acquisition and employability readiness among technology education students in North-Central Nigeria.

Table 5: Chi-Square Test of the Relationship between Renewable Energy Skills Acquisition and Employability Readiness

Statistic	Result
Chi-square value	1.418
Degrees of freedom	1
Sample size analysed	166
Significance level	0.05
p-value	.234
Decision	Fail to reject H_{01}

Source: Field Survey, 2026.

The result indicates that the calculated chi-square value was 1.418 at one degree of freedom, with a p-value of .234, which is greater than the 0.05 level of significance. Since $p > .05$, the null hypothesis was not rejected, and there was no statistically significant relationship between renewable energy skills acquisition and employability readiness. This finding suggests that the study did not establish a statistically significant association between the two variables in the analysed sample. However, it should not be interpreted as proof that renewable energy skills are irrelevant to employability. The result may be influenced by measurement procedures, sample size, categorisation of variables and other employment-related factors (McHugh, 2013).

Discussion of findings

The first finding is that the low grand mean for skills acquisition (2.1486) indicates that students perceived their technical competencies as weak, which points to the need for additional practical instruction and competency-based assessment. This finding is consistent with Udoka and Owodiong (2024), who identified solar panel installation, electrical engineering drawing, energy efficiency and troubleshooting as important competencies for students preparing for participation in a sustainable green economy, and with Arilesere and Jacob (2026), who found that both theoretical competencies and practical skills are essential for technical and vocational education graduates who install solar energy systems. The very low rating for electrical testing and troubleshooting is particularly important, because these are among the practical skills that solar technicians and technologists rate as most highly required.

Second, the curriculum integration results provide information about students' exposure to renewable energy content and practical learning opportunities. The low level of integration

(grand mean = 1.9981) suggests the need for curriculum review, improved laboratory facilities and stronger engagement with renewable energy industries. This agrees with Busari (2025), who emphasised curriculum restructuring, lecturer professional development and appropriate institutional resources for integrating green competencies into Nigerian university technology education programmes, and with Hamza et al. (2020), who found that environmental, economic and social factors, including energy and waste in buildings, should guide the greening of technical college programmes in Nigeria.

Third, the test of Hypothesis One did not establish a significant association between skills acquisition and employability readiness, $\chi^2(1) = 1.418$, $p = .234$. This suggests that employability depends on factors beyond technical skill, such as work experience, certification and labour-market conditions, although the association does not by itself establish a causal effect. Orji and Uche (2021) argued that the Students Industrial Work Experience Scheme should be optimised to build the employability skills of Nigerian tertiary students, which supports the view that workplace exposure matters alongside classroom competence. Marginson (2019) also cautioned that education does not translate directly into employment outcomes, because status, labour-market structure and other factors intervene.

These issues are consistent with the broader position of the ILO (2019), which emphasises the importance of skills development in preparing workers for the transition towards environmentally sustainable economies. The high rating for the ability to diagnose common system faults alongside the very low rating for electrical testing and troubleshooting should be read with caution, because the two items describe closely related tasks; the difference may reflect the wording of the items or students' familiarity with identifying faults compared with carrying out tests, and it should be checked against the questionnaire (Taber, 2018).

Conclusion

This study examined renewable energy skills acquisition, curriculum integration and employability readiness among technology education students in North-Central Nigeria. The study recognises that preparing students for renewable energy employment requires relevant curriculum content, qualified instructors, functional laboratory facilities and sufficient practical learning opportunities (ILO, 2019). The results revealed low levels of reported renewable energy competencies and of renewable energy integration into the students' programmes. No significant association was found between renewable energy skills acquisition and employability readiness, which suggests that technical skills alone do not determine students' perceived readiness for employment. The descriptive survey design relies substantially on respondents' reported experiences and perceptions, and the study covers five selected public universities, so future research should incorporate practical competency tests, employer assessments, graduate follow-up and comparisons between institutions with different levels of renewable energy curriculum integration (Siedlecki, 2020).

Recommendations

Based on the findings, the following recommendations are proposed:

1. Curriculum review: Universities should periodically review technology education curricula to incorporate current renewable energy technologies, installation procedures, safety requirements and industry-relevant competencies.
2. Practical skills development: Institutions should provide regular supervised training in photovoltaic installation, battery management, inverter configuration, electrical testing and system troubleshooting.

3. Laboratory improvement: University management should provide functional renewable energy laboratories equipped with photovoltaic panels, batteries, inverters, charge controllers, measuring instruments and safety devices.
4. Industry collaboration: Universities should establish partnerships with renewable energy companies to facilitate industrial attachment, practical demonstrations, internships and workplace learning.
5. Competency-based assessment: Students should demonstrate practical competence through structured tasks and performance checklists, in addition to written examinations.
6. Employability support: Career services and departments should provide technical portfolios, entrepreneurship exposure and opportunities for students to demonstrate their skills to prospective employers.
7. Graduate tracking: Institutions should periodically examine graduate employment, self-employment and further training to determine how well their programmes prepare students for the labour market.

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