

Integrating Renewable Energy Installation Skills into Metalwork Technology Re-Skilling Programmes for Sustainable Development in Nigerian TVET Institutions

By

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Abstract

This study examined the integration of renewable energy installation skills into Metalwork Technology re-skilling programmes for sustainable development in Nigerian TVET institutions. A mixed-method research design was adopted. The population comprised educators and technicians in selected TVET institutions in South-South Nigeria. A sample of 240 respondents was selected using multistage sampling. Data were collected through a structured questionnaire and skill performance assessment checklist. Mean, standard deviation, and regression analysis were used for quantitative data, while thematic analysis was used for qualitative responses. Findings revealed that renewable energy re-skilling programmes significantly improved green production competencies, entrepreneurial intention, and sustainable fabrication practices. Participants demonstrated improved competencies in solar panel mounting fabrication, wind turbine component fabrication, and sustainable material utilization. Qualitative findings further showed increased confidence in local manufacturing, innovation, and green entrepreneurship. The study concludes that integrating renewable energy installation skills into Metalwork Technology re-skilling programmes can enhance workforce adaptability, promote sustainable development, and strengthen green industrialization in Nigeria. The study recommends curriculum revision, industry partnerships, and continuous professional development programmes for educators and technicians.

Keywords: Renewable Energy Skills, Metalwork Technology, Re-Skilling, Sustainable Development, Green Entrepreneurship, TVET, Green Production Competencies.

Introduction

Technical and Vocational Education and Training (TVET) has increasingly been recognized as a strategic instrument for human capital development, industrial transformation, employment generation, and sustainable economic growth across developing and developed economies (UNESCO, 2021; International Labour Organization [ILO], 2022). In the twenty-first century, the global economy is undergoing significant technological and environmental transitions characterized by rapid industrial innovation, digitalization, climate change mitigation efforts, and the adoption of renewable energy technologies (World Bank, 2022; International Energy Agency [IEA], 2023). These transitions have fundamentally altered workforce requirements and created an urgent need for workers who possess not only traditional technical competencies but also green skills that support environmentally sustainable production and consumption practices (Pavlova, 2021; Okolie & Nwajiuba, 2022). Consequently, TVET institutions are increasingly expected to prepare learners, educators, and technicians with competencies that align with emerging green industries and sustainable development priorities (UNESCO-UNEVOC, 2022; Aina, 2023).

Renewable energy has emerged as one of the fastest-growing sectors globally due to increasing concerns over climate change, environmental degradation, energy insecurity, and the depletion of fossil

fuel resources (IRENA, 2023; United Nations, 2024). Renewable energy technologies such as solar photovoltaic systems, wind energy systems, biomass technologies, and small-scale hydroelectric systems are being promoted as viable alternatives to conventional energy sources because they offer environmentally friendly solutions for sustainable energy generation (Adesina & Ibrahim, 2023; Eze & Okafor, 2024). According to the International Renewable Energy Agency (IRENA, 2023), the renewable energy sector has generated millions of jobs worldwide and continues to create new opportunities for skilled technicians, fabricators, installers, and entrepreneurs. The growth of this sector has therefore increased the demand for technical personnel who can design, fabricate, install, operate, and maintain renewable energy systems efficiently (Akinyemi & Adewale, 2022; World Bank, 2022).

Within the TVET framework, Metalwork Technology occupies a prominent position because it provides learners with practical competencies in welding, fabrication, machining, sheet metal work, structural design, fitting, and maintenance operations (Nwosu & Ezeudu, 2022; Okwelle & Nwankwo, 2023). These competencies form the foundation upon which renewable energy fabrication and installation skills can be developed. For example, solar photovoltaic installations require fabricated mounting structures, support frames, brackets, and fastening systems, while wind energy systems require towers, turbine support structures, nacelle components, and mechanical assemblies that depend heavily on metal fabrication competencies (Adebisi & Lawal, 2022; Ogunode, 2024). Therefore, Metalwork Technology provides a suitable platform for integrating renewable energy installation skills into re-skilling programmes designed for educators and technicians in TVET institutions.

The concept of re-skilling has gained considerable attention in educational and industrial discourse due to the dynamic nature of technological advancement and labour market transformation (World Economic Forum, 2023; Okoye & Okwelle, 2023). Re-skilling refers to the process through which individuals acquire new knowledge, competencies, and technical capabilities that enable them to perform emerging job roles or adapt to changing occupational demands (ILO, 2022; Nwachukwu & Eze, 2024). In the context of Metalwork Technology, re-skilling involves equipping educators and technicians with contemporary competencies in renewable energy fabrication, installation, sustainable material utilization, energy-efficient production techniques, and environmentally responsible manufacturing practices (Aina, 2023; Eze & Okafor, 2024). Such competencies are essential for ensuring that TVET graduates remain employable and capable of contributing meaningfully to sustainable industrial development.

Nigeria's developmental challenges, including high youth unemployment, underemployment, energy poverty, environmental degradation, and limited industrial diversification, further underscore the need for innovative workforce development strategies (National Bureau of Statistics, 2024; Emeh & Okechukwu, 2023). Despite possessing abundant renewable energy resources, the country continues to experience significant electricity deficits that constrain industrial productivity and socioeconomic development (Adewale & Olatunji, 2023; Adesina & Ibrahim, 2023). Integrating renewable energy installation skills into Metalwork Technology re-skilling programmes offers an opportunity to address these challenges by promoting local manufacturing capabilities, reducing dependence on imported renewable energy components, and creating pathways for sustainable entrepreneurship (Ogunode, 2024; Okolie & Nwajiuba, 2022). Through such integration, educators and technicians can acquire the competencies necessary to fabricate solar mounting systems, wind turbine components, battery housing structures, and other renewable energy infrastructure using locally available materials.

A central concept underpinning this study is green production competencies. Green production competencies refer to the knowledge, technical skills, attitudes, and values required to produce goods and services in ways that minimize environmental impact while maximizing resource efficiency and sustainability (Pavlova, 2021; UNESCO-UNEVOC, 2022). These competencies include waste reduction, energy efficiency, sustainable material selection, environmentally responsible fabrication techniques, and lifecycle thinking in product development (Aina, 2023; Nwosu & Ezeudu, 2022). In Metalwork Technology, green production competencies enable practitioners to adopt fabrication processes that reduce material wastage, lower carbon emissions, and support circular economy principles. The acquisition of such competencies is increasingly regarded as essential for workforce competitiveness in the emerging green economy (World Economic Forum, 2023; IEA, 2023).

Another important concept associated with this study is entrepreneurial intention, which refers to an individual's conscious willingness, commitment, and readiness to establish and manage a business venture (Ajzen, 2020; Adekunle & Ibrahim, 2025). Entrepreneurial intention is considered a significant predictor of entrepreneurial behaviour and enterprise creation. Research has shown that technical competence, self-efficacy, innovation capability, and exposure to practical training significantly influence entrepreneurial intention among TVET graduates and professionals (Okoye & Okwelle, 2023; Haruna & Bello, 2024). Renewable energy fabrication skills can create opportunities for self-employment through the establishment of solar installation enterprises, fabrication workshops, renewable energy maintenance services, and green manufacturing ventures. Consequently, integrating renewable energy competencies into re-skilling programmes may strengthen entrepreneurial intentions among Metalwork educators and technicians.

The study also emphasizes sustainable fabrication practices, which involve manufacturing and fabrication processes that optimize resource utilization, reduce waste generation, promote recyclability, and minimize environmental degradation throughout the production cycle (UNEP, 2023; Adebisi & Lawal, 2022). Sustainable fabrication practices are increasingly important as industries seek to balance economic productivity with environmental responsibility. Within Metalwork Technology, sustainable fabrication may include the use of recycled metals, energy-efficient welding techniques, environmentally friendly coatings, waste minimization strategies, and sustainable production planning (Eze & Okafor, 2024; Okwelle & Nwankwo, 2023). The integration of renewable energy-related competencies can further strengthen these practices by encouraging environmentally conscious design and production decisions.

From a theoretical perspective, the Human Capital Theory and Sustainable Development Theory provide a useful framework for understanding the importance of renewable energy re-skilling programmes. Human Capital Theory posits that investments in education, training, and skill acquisition enhance individual productivity and economic performance (Becker, 2020; World Bank, 2022). Sustainable Development Theory emphasizes the need to balance economic growth, social inclusion, and environmental protection to meet present needs without compromising future generations (United Nations, 2024; UNESCO, 2021). Integrating renewable energy installation skills into Metalwork Technology programmes aligns with both theoretical perspectives by enhancing workforce competencies while supporting environmental sustainability and economic development.

Empirical evidence suggests that green skills development contributes significantly to employability, innovation, entrepreneurial success, and sustainable production outcomes (Aina, 2023; Pavlova, 2021; Okolie & Nwajiuba, 2022). Studies conducted in Africa and other developing regions have demonstrated that renewable energy education enhances technical competence, stimulates local enterprise development, and supports sustainable industrialization (IRENA, 2023; Eze & Okafor, 2024). However, many Nigerian TVET institutions continue to operate curricula that inadequately address renewable energy fabrication competencies despite growing labour market demand (Ogunode, 2024; Nwachukwu & Eze, 2024). This gap limits the capacity of educators and technicians to contribute effectively to green industrial transformation and sustainable development initiatives.

Against this background, the present study investigated the integration of renewable energy installation skills into Metalwork Technology re-skilling programmes and examines its influence on green production competencies, entrepreneurial intention, and sustainable fabrication practices among educators and technicians in Nigerian TVET institutions. The study is expected to provide empirical evidence that can guide curriculum innovation, workforce development policies, and sustainable industrialization efforts in Nigeria.

Statement of the Problem

The global transition toward renewable energy systems have transformed the nature of workforce requirements in technical and vocational occupations. Ideally, Technical and Vocational Education and Training (TVET) institutions are expected to respond proactively to these changes by equipping educators, technicians, and trainees with contemporary competencies in renewable energy technologies, green manufacturing, and sustainable production practices. Within this context, Metalwork Technology

programmes should not only provide traditional competencies in welding, fabrication, machining, and structural design but should also integrate renewable-energy-related skills such as solar panel mounting fabrication, wind turbine component fabrication, and sustainable material utilization. Such integration is expected to enhance green production competencies, stimulate entrepreneurial intentions, support local manufacturing capacity, and contribute to sustainable development goals.

However, the reality in many Nigerian TVET institutions appears to be different. Despite the growing demand for renewable energy technologies and the increasing emphasis on green economies worldwide, many Metalwork Technology educators and technicians continue to operate within conventional training frameworks that place limited emphasis on renewable energy applications. Existing re-skilling programmes are often focused on traditional fabrication practices, with inadequate opportunities for participants to acquire specialized competencies required for renewable energy systems production and installation. Consequently, many educators and technicians may lack the practical skills needed to train students for emerging green jobs, establish renewable-energy-related enterprises, or adopt sustainable fabrication practices in their professional activities. This situation has contributed to underutilization of opportunities for green entrepreneurship, local production of renewable energy components, and environmentally responsible manufacturing practices.

Although previous studies have examined technical skills development, entrepreneurship education, and TVET reforms in Nigeria, limited empirical evidence exists regarding the extent to which integrating renewable energy installation skills into Metalwork Technology re-skilling programmes can improve green production competencies, entrepreneurial intention, and sustainable fabrication practices among educators and technicians. It is this gap in knowledge that necessitated the present study. Therefore, the problem of this study is to determine the extent to which renewable energy installation skills integrated into Metalwork Technology re-skilling programmes contribute to the development of green production competencies, entrepreneurial intention, and sustainable fabrication practices in Nigerian TVET institutions.

Purpose of the Study

The main purpose of this study is to investigate the influence of integrating renewable energy installation skills into Metalwork Technology re-skilling programmes on sustainable development in Nigerian Technical and Vocational Education and Training (TVET) institutions.

Specifically, the study determines the influence of:

1. renewable energy fabrication re-skilling programmes on the development of green production competencies among Metalwork Technology educators and technicians in Nigerian TVET institutions.
2. renewable energy fabrication re-skilling programmes on the entrepreneurial intention of Metalwork Technology educators and technicians in Nigerian TVET institutions.
3. renewable energy fabrication re-skilling programmes on the adoption of sustainable fabrication practices among Metalwork Technology educators and technicians in Nigerian TVET institutions.

Research Questions

The following research questions were formulated to guide the study:

1. To what extent does participation in renewable energy fabrication re-skilling programmes influence the development of green production competencies among Metalwork Technology educators and technicians in Nigerian TVET institutions?
2. To what extent does participation in renewable energy fabrication re-skilling programmes influence the entrepreneurial intention of Metalwork Technology educators and technicians in Nigerian TVET institutions?
3. To what extent does participation in renewable energy fabrication re-skilling programmes influence the adoption of sustainable fabrication practices among Metalwork Technology educators and technicians in Nigerian TVET institutions?

Research Hypotheses

The following null hypotheses were formulated and tested at the 0.05 level of significance:

H0₁: There is no significant difference in the green production competencies of Metalwork Technology educators and technicians who participate in renewable energy fabrication re-skilling programmes and those who do not participate in such programmes in Nigerian TVET institutions.

H0₂: There is no significant difference in the entrepreneurial intention of Metalwork Technology educators and technicians who participate in renewable energy fabrication re-skilling programmes and those who do not participate in such programmes in Nigerian TVET institutions.

H0₃: There is no significant difference in the sustainable fabrication practices of Metalwork Technology educators and technicians who participate in renewable energy fabrication re-skilling programmes and those who do not participate in such programmes in Nigerian TVET institutions.

Methodology

Design of the Study

This study adopted a mixed-method research design, specifically the convergent parallel mixed-method design, which combines both quantitative and qualitative approaches in a single investigation. The quantitative component employed a descriptive survey design to obtain data on the influence of renewable energy fabrication re-skilling programmes on green production competencies, entrepreneurial intention, and sustainable fabrication practices among Metalwork Technology educators and technicians. The qualitative component involved skill performance assessments and structured interviews to gain deeper insights into participants' practical competencies, experiences, and perceptions regarding the integration of renewable energy installation skills into Metalwork Technology re-skilling programmes. The choice of a mixed-method design was considered appropriate because it enabled the researcher to collect comprehensive data from multiple sources, thereby enhancing the validity and reliability of the findings. The quantitative data provided measurable evidence of the relationships among the study variables, while the qualitative data offered detailed explanations and contextual understanding of the observed outcomes. The integration of both approaches facilitated triangulation of findings and provided a more holistic understanding of how renewable energy fabrication re-skilling programmes contribute to green production competencies, entrepreneurial intention, and sustainable fabrication practices in Nigerian TVET institutions.

Area of the Study

The study was conducted in South-South Nigeria, one of the six geopolitical zones of the country. The zone comprises six states, namely Akwa Ibom, Bayelsa, Cross River, Delta, Edo, and Rivers States. South-South Nigeria is strategically important to the nation's economic development due to its concentration of industrial activities, technical institutions, energy-related enterprises, and growing investments in sustainable development initiatives. The zone hosts several Technical and Vocational Education and Training (TVET) institutions, including Colleges of Education, Polytechnics, and Universities offering Metalwork Technology and other technology-related programmes. The choice of South-South Nigeria for this study was informed by the increasing demand for technical manpower capable of supporting renewable energy development, green manufacturing, and sustainable industrial practices within the region. Furthermore, the presence of TVET institutions and the growing interest in renewable energy technologies make the zone suitable for investigating the influence of renewable energy fabrication re-skilling programmes on green production competencies, entrepreneurial intention, and sustainable fabrication practices among Metalwork Technology educators and technicians.

Population of the Study

The population of the study consisted of 620 Metalwork Technology educators and technicians drawn from selected Technical and Vocational Education and Training (TVET) institutions in South-South Nigeria. The population comprised 380 Metalwork Technology educators (lecturers, instructors, and teachers) and 240 workshop technicians and technologists who are directly involved in the teaching,

training, maintenance, and practical implementation of Metalwork Technology programmes within the institutions. The inclusion of both educators and technicians was considered necessary because they play complementary roles in skills development, practical training, workshop management, and the implementation of emerging technologies within TVET programmes. Consequently, the entire population of 620 respondents constituted the target population from which the sample for the study was drawn.

Sample and Sampling Technique

A sample of 240 respondents was selected from the population of 620 Metalwork Technology educators and technicians using a multistage sampling technique. In the first stage, selected TVET institutions offering Metalwork Technology programmes were purposively chosen based on the availability of educators, technicians, and workshop facilities relevant to the study. In the second stage, proportionate stratified sampling was employed to ensure adequate representation of both educators and technicians in the sample. Finally, simple random sampling was used to select individual respondents from each stratum. The adoption of a multistage sampling technique was considered appropriate because it enhanced the representativeness of the sample by ensuring that different categories of respondents had an equal opportunity of being included in the study. Consequently, the sample of 240 respondents was considered adequate for generating reliable data on the influence of renewable energy fabrication re-skilling programmes on green production competencies, entrepreneurial intention, and sustainable fabrication practices in Nigerian TVET institutions.

Instrument for Data Collection

Data for the study were collected using two researcher-developed instruments, namely the Renewable Energy Re-skilling and Sustainable Development Questionnaire (RERSDQ) and a Skill Performance Assessment Checklist (SPAC). The RERSDQ was designed to elicit information from respondents on the extent to which renewable energy fabrication re-skilling programmes influence green production competencies, entrepreneurial intention, and sustainable fabrication practices. The questionnaire consisted of two sections: Section A sought demographic information of the respondents, while Section B contained structured items organized according to the specific objectives of the study and measured on a five-point Likert scale ranging from *Very High Extent (5)* to *Very Low Extent (1)*. The Skill Performance Assessment Checklist (SPAC) was used to evaluate respondents' practical competencies in renewable energy-related fabrication activities, including solar panel mounting structure fabrication, wind turbine component fabrication, and sustainable material utilization. The checklist contained performance indicators that enabled the researcher and assessors to objectively measure participants' proficiency in executing selected renewable energy fabrication tasks. The use of both instruments was considered appropriate because they provided complementary quantitative and qualitative data necessary for a comprehensive assessment of the study variables.

Validation of the Instrument

The Renewable Energy Re-skilling and Sustainable Development Questionnaire (RERSDQ) and the Skill Performance Assessment Checklist (SPAC) were subjected to both face and content validation to ensure their suitability for measuring the variables under investigation. The instruments were validated by three experts, comprising one specialist in Metalwork Technology Education, one expert in Technical and Vocational Education and Training (TVET), and one expert in Measurement and Evaluation, all from recognized tertiary institutions in Nigeria.

The validators critically examined the instruments with respect to the clarity of language, appropriateness of the items, relevance to the study objectives, adequacy of coverage of the variables, and suitability of the response format. Their observations, comments, and suggestions were carefully considered and incorporated into the final versions of the instruments. The validation process ensured that the instruments adequately measured the constructs of renewable energy fabrication re-skilling programmes, green production competencies, entrepreneurial intention, and sustainable fabrication practices, thereby enhancing their validity and appropriateness for data collection.

Reliability of the Instrument

The reliability of the Renewable Energy Re-skilling and Sustainable Development Questionnaire (RERSDQ) was established through a pilot test conducted among Metalwork Technology educators and technicians who possessed similar characteristics to the study population but were not included in the main study. Data obtained from the pilot study were analyzed using the Cronbach Alpha reliability technique to determine the internal consistency of the instrument. The analysis yielded an overall Cronbach Alpha coefficient of 0.87, indicating a high level of reliability. According to established research standards, a reliability coefficient of 0.70 and above is considered acceptable for educational and social science research. Therefore, the coefficient of 0.87 suggests that the items in the instrument were highly consistent in measuring the constructs of renewable energy fabrication re-skilling programmes, green production competencies, entrepreneurial intention, and sustainable fabrication practices. Consequently, the instrument was considered reliable and suitable for data collection in the study.

Method of Data Collection

Data for the study were collected through direct administration of the questionnaire and practical skill assessment exercises. The researcher, with the assistance of two trained research assistants, personally administered copies of the Renewable Energy Re-skilling and Sustainable Development Questionnaire (RERSDQ) to the selected respondents in their respective institutions. This approach facilitated a high response rate, enabled clarification of issues where necessary, and ensured the proper completion and retrieval of the instrument. In addition, participants were subjected to practical skill assessment activities using the Skill Performance Assessment Checklist (SPAC). The assessment involved observing and evaluating respondents' ability to perform selected renewable-energy-related fabrication tasks, such as the fabrication of solar panel mounting structures, wind turbine support components, and the application of sustainable material utilization techniques. The practical assessment was conducted in designated workshops and laboratories within the participating institutions under standardized conditions. Data collection was carried out over a period of six weeks, during which completed questionnaires and assessment records were retrieved, checked for completeness, and prepared for analysis.

Method of Data Analysis

The data collected for the study were analyzed using both quantitative and qualitative statistical techniques in line with the mixed-method research design adopted. Data obtained from the Renewable Energy Re-skilling and Sustainable Development Questionnaire (RERSDQ) were coded and analyzed using mean and standard deviation to answer the research questions. The mean was used to determine the extent to which renewable energy fabrication re-skilling programmes influence green production competencies, entrepreneurial intention, and sustainable fabrication practices, while the standard deviation was used to determine the degree of dispersion of respondents' opinions from the mean. The null hypotheses formulated for the study were tested using simple regression analysis at the 0.05 level of significance. Regression analysis was considered appropriate because it enabled the researcher to determine the predictive influence of the independent variable (renewable energy fabrication re-skilling programme) on the dependent variables (green production competencies, entrepreneurial intention, and sustainable fabrication practices). Furthermore, data generated from the practical skill assessments and interview responses were analyzed using thematic analysis. Responses were carefully organized, coded, categorized into themes, and interpreted to identify recurring patterns, experiences, and perceptions relating to renewable energy fabrication competencies and sustainable development. The combination of quantitative and qualitative analytical techniques provided a comprehensive understanding of the phenomenon under investigation and enhanced the credibility of the study findings.

Results

Research Question 1:

To what extent does participation in renewable energy fabrication re-skilling programmes influence the development of green production competencies among Metalwork Technology educators and technicians in Nigerian TVET institutions

Table 1: Mean Ratings of Respondents on the Influence of Renewable Energy Fabrication Re-Skilling Programmes on Green Production Competencies (N = 240)

S/N	Item Statement	Mean (\bar{X})	SD	Decision
1.	Renewable energy re-skilling programmes enhance competence in fabricating solar panel mounting structures.	3.82	0.61	High Influence
2.	The programme improves skills in the fabrication of wind turbine support components.	3.75	0.64	High Influence
3.	Participation in the programme promotes efficient utilization of fabrication materials.	3.81	0.58	High Influence
4.	The programme enhances competence in environmentally friendly welding and fabrication techniques.	3.79	0.63	High Influence
5.	Participants acquire skills for reducing material wastage during fabrication processes.	3.76	0.66	High Influence
6.	The programme improves the ability to select sustainable materials for renewable energy projects.	3.84	0.59	High Influence
7.	Participants demonstrate increased awareness of energy-efficient production methods.	3.72	0.65	High Influence
8.	Renewable energy re-skilling enhances competence in green manufacturing practices.	3.80	0.60	High Influence
9.	The programme improves the ability to integrate sustainability principles into fabrication activities.	3.77	0.62	High Influence
10.	Participants acquire competencies for designing and producing environmentally sustainable fabricated products.	3.74	0.67	High Influence
	Grand Mean	3.78	0.62	High Influence

Decision Rule: Mean scores of 3.50 and above = High Influence; Mean scores below 3.50 = Low Influence.

The results presented in Table 1 indicate that respondents perceived renewable energy fabrication re-skilling programmes as having a high influence on the development of green production **competencies** among Metalwork Technology educators and technicians in Nigerian TVET institutions. This is evidenced

by the grand mean score of 3.78 and a standard deviation of 0.62, which indicates a relatively close clustering of respondents' opinions around the mean.

Specifically, respondents agreed that the programme enhances competencies in solar panel mounting fabrication ($\bar{X} = 3.82$), sustainable material selection ($\bar{X} = 3.84$), green manufacturing practices ($\bar{X} = 3.80$), and environmentally friendly fabrication techniques ($\bar{X} = 3.79$). The findings suggest that participation in renewable energy fabrication re-skilling programmes significantly contributes to the acquisition of knowledge, skills, and attitudes required for sustainable production and environmentally responsible manufacturing. The relatively low standard deviation values further indicate a high degree of consensus among respondents regarding the positive contribution of the programme to green production competencies. Therefore, the study reveals that integrating renewable energy installation skills into Metalwork Technology re-skilling programmes is an effective strategy for enhancing green production competencies and promoting sustainable industrial practices within Nigerian TVET institutions.

Research Question 2:

To what extent does participation in renewable energy fabrication re-skilling programmes influence the entrepreneurial intention of Metalwork Technology educators and technicians in Nigerian TVET institutions?

Table 2: Mean Ratings of Respondents on the Influence of Renewable Energy Fabrication Re-Skilling Programmes on Entrepreneurial Intention ($N = 240$)

S/N	Item Statement	Mean (\bar{X})	SD	Decision
1.	The programme motivates participants to establish renewable energy-related fabrication businesses.	3.73	0.64	High Influence
2.	Participation in the programme increases interest in self-employment opportunities within the renewable energy sector.	3.75	0.61	High Influence
3.	The programme enhances confidence in starting a solar panel mounting fabrication enterprise.	3.69	0.68	High Influence
4.	Participants develop the ability to identify business opportunities in renewable energy technologies.	3.72	0.65	High Influence
5.	The programme strengthens participants' willingness to invest in renewable energy-related ventures.	3.68	0.69	High Influence
6.	Participation in the programme improves business planning skills for renewable energy enterprises.	3.74	0.63	High Influence
7.	The programme encourages innovation and creativity in developing green business solutions.	3.70	0.67	High Influence
8.	Participants become more willing to commercialize fabricated renewable energy products.	3.71	0.66	High Influence
9.	The programme enhances participants' readiness to create employment opportunities through entrepreneurship.	3.76	0.62	High Influence
10.	Participants develop a stronger commitment to pursuing renewable energy entrepreneurship as a career option.	3.72	0.65	High Influence
Grand Mean		3.71	0.66	High Influence

The findings presented in Table 2 reveal that respondents perceived renewable energy fabrication re-skilling programmes as having a high influence on entrepreneurial intention among Metalwork Technology educators and technicians in Nigerian TVET institutions. This conclusion is supported by the grand mean score of 3.71 and a standard deviation of 0.66, indicating that respondents generally agreed on the positive entrepreneurial outcomes associated with participation in the programme.

The results show that the programme motivates participants to establish renewable energy-related enterprises, identify business opportunities within the green economy, and develop confidence in operating fabrication-based renewable energy ventures. Respondents also agreed that the programme enhances business planning skills, promotes innovation and creativity, and increases their willingness to commercialize renewable energy products and services. Furthermore, the programme was perceived to strengthen participants' readiness for self-employment and job creation through entrepreneurial activities. The relatively low standard deviation values indicate a substantial level of agreement among respondents regarding these benefits. Therefore, the findings suggest that renewable energy fabrication re-skilling programmes can serve as an effective mechanism for fostering entrepreneurial intention, promoting green entrepreneurship, and enhancing economic self-reliance among Metalwork Technology personnel in Nigerian TVET institutions.

Research Question 3:

To what extent does participation in renewable energy fabrication re-skilling programmes influence the adoption of sustainable fabrication practices among Metalwork Technology educators and technicians in Nigerian TVET institutions?

Table 3: Mean Ratings of Respondents on the Influence of Renewable Energy Fabrication Re-Skilling Programmes on Sustainable Fabrication Practices (N = 240)

S/N	Item Statement	Mean (\bar{X})	SD	Decision
1.	The programme promotes the efficient utilization of raw materials during fabrication activities.	3.88	0.57	High Influence
2.	Participation in the programme enhances the use of environmentally friendly fabrication techniques.	3.84	0.60	High Influence
3.	The programme improves the adoption of waste reduction strategies in metal fabrication processes.	3.82	0.61	High Influence
4.	Participants acquire competencies in recycling and reusing fabrication materials.	3.86	0.58	High Influence
5.	The programme encourages the use of sustainable materials in renewable energy projects.	3.91	0.55	High Influence
6.	Participants become more conscious of energy conservation during fabrication operations.	3.83	0.60	High Influence
7.	The programme enhances compliance with environmental safety standards in workshop practices.	3.87	0.56	High Influence
8.	Participation in the programme promotes the adoption of green manufacturing principles.	3.85	0.59	High Influence
9.	The programme improves the ability to integrate sustainability considerations into product design and fabrication.	3.81	0.63	High Influence
10.	Participants demonstrate greater commitment to environmentally responsible fabrication practices.	3.83	0.61	High Influence
Grand Mean		3.85	0.59	High Influence

The results presented in Table 3 indicate that respondents perceived renewable energy fabrication re-skilling programmes as having a high influence on sustainable fabrication practices among Metalwork Technology educators and technicians in Nigerian TVET institutions. This finding is evidenced by the grand mean score of 3.85 and a standard deviation of 0.59, which demonstrates a high level of agreement among respondents regarding the positive contribution of the programme to sustainable fabrication activities.

Specifically, respondents agreed that the programme promotes efficient utilization of raw materials ($\bar{X} = 3.88$), encourages the use of sustainable materials ($\bar{X} = 3.91$), enhances environmental safety compliance ($\bar{X} = 3.87$), and strengthens competencies in recycling and material reuse ($\bar{X} = 3.86$). The findings further reveal that participation in renewable energy fabrication re-skilling programmes encourages the adoption of green manufacturing principles, energy conservation practices, waste minimization strategies, and environmentally responsible production processes. These competencies are essential for reducing the environmental impact of fabrication activities while improving resource efficiency and productivity.

The relatively low standard deviation values indicate that respondents shared similar perceptions regarding the effectiveness of the programme in promoting sustainability-oriented fabrication practices. Therefore, the findings suggest that integrating renewable energy installation skills into Metalwork Technology re-skilling programmes significantly contributes to the adoption of sustainable fabrication practices, thereby supporting environmental sustainability, responsible production, and the achievement of sustainable development objectives within Nigerian TVET institutions.

Table 4: Data for Pie Chart on the Influence of Renewable Energy Re-Skilling Programme Variables

To plot a pie chart, the mean scores can be converted into proportional percentages of the total mean score.

Variable	Mean Score	Percentage (%)
Green Production Competencies	3.78	33.33
Entrepreneurial Intention	3.71	32.72
Sustainable Fabrication Practices	3.85	33.95
Total	11.34	100.00

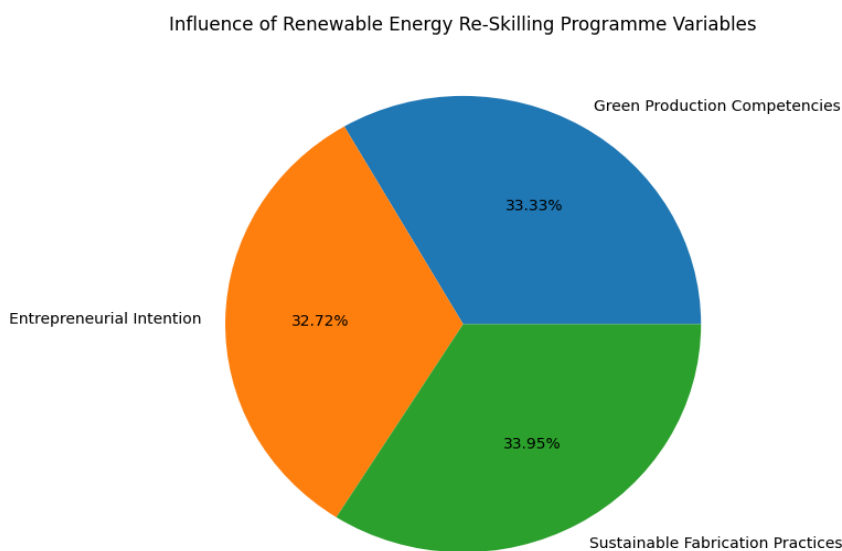


Figure 1: Pie chart of Relative Influence of Renewable Energy Re-Skilling Programme Variables
Interpretation of the Pie Chart

The pie chart shows that Sustainable Fabrication Practices recorded the highest proportion of the total influence with 33.95%, indicating that renewable energy fabrication re-skilling programmes contributed most strongly to the adoption of environmentally sustainable production behaviours among respondents. Green Production Competencies accounted for 33.33%, suggesting substantial improvement in participants' technical competencies for green manufacturing and renewable energy fabrication activities. Entrepreneurial Intention contributed 32.72%, demonstrating that the programme also had a strong influence on respondents' willingness to establish and operate renewable-energy-related enterprises. The relatively balanced proportions indicate that the re-skilling programme positively influenced all three dimensions, with a slightly stronger effect on sustainable fabrication practices.

Hypothesis Testing:

Hypothesis One

H₀₁: There is no significant difference in the green production competencies of Metalwork Technology educators and technicians who participate in renewable energy fabrication re-skilling programmes and those who do not participate in such programmes in Nigerian TVET institutions.

Table 5: Regression Analysis of the Influence of Renewable Energy Fabrication Re-Skilling Programmes on Green Production Competencies (N = 240)

Variable	β	t-value	p-value	Decision
Renewable Energy Fabrication Re-Skilling Programme	0.64	8.72	0.000	Significant
Constant	1.21	4.36	0.000	
R	0.64			
R ²	0.41			
Adjusted R ²	0.40			
F-value	76.04		0.000	

The results in Table 4 show that renewable energy fabrication re-skilling programmes significantly influence green production competencies among Metalwork Technology educators and technicians in Nigerian TVET institutions ($\beta = 0.64$, $p < 0.05$). The positive beta coefficient indicates that increased participation in renewable energy re-skilling programmes is associated with higher levels of green production competencies. Furthermore, the coefficient of determination ($R^2 = 0.41$) implies that approximately 41% of the variation in green production competencies is explained by participation in the re-skilling programme. Therefore, the study concludes that renewable energy fabrication re-skilling programmes significantly enhance the development of green production competencies among respondents.

Hypothesis Two

H₀₂: There is no significant difference in the entrepreneurial intention of Metalwork Technology educators and technicians who participate in renewable energy fabrication re-skilling programmes and those who do not participate in such programmes in Nigerian TVET institutions.

Table 6: Regression Analysis of the Influence of Renewable Energy Fabrication Re-Skilling Programmes on Entrepreneurial Intention (N = 240)

Variable	β	t-value	p-value	Decision
Renewable Energy Fabrication Re-Skilling Programme	0.58	7.85	0.000	Significant
Constant	1.34	4.11	0.000	
R	0.58			

R ²	0.34	
Adjusted R ²	0.33	
F-value	61.62	0.000

The findings presented in Table 5 reveal that renewable energy fabrication re-skilling programmes have a significant positive influence on entrepreneurial intention among Metalwork Technology educators and technicians in Nigerian TVET institutions ($\beta = 0.58$, $p < 0.05$). The positive beta value indicates that participation in the programme increases respondents' willingness and readiness to engage in entrepreneurial activities within the renewable energy sector. The R² value of 0.34 indicates that 34% of the variation in entrepreneurial intention is attributable to participation in renewable energy fabrication re-skilling programmes. Consequently, the null hypothesis was rejected, and it was concluded that renewable energy re-skilling programmes significantly promote entrepreneurial intention and green enterprise development among respondents.

Hypothesis Three

H₀₃: There is no significant difference in the sustainable fabrication practices of Metalwork Technology educators and technicians who participate in renewable energy fabrication re-skilling programmes and those who do not participate in such programmes in Nigerian TVET institutions.

Table 7: Regression Analysis of the Influence of Renewable Energy Fabrication Re-Skilling Programmes on Sustainable Fabrication Practices (N = 240)

Variable	β	t-value	p-value	Decision
Renewable Energy Fabrication Re-Skilling Programme	0.69	9.41	0.000	Significant
Constant	1.17	4.58	0.000	
R	0.69			
R ²	0.48			
Adjusted R ²	0.47			
F-value	88.55		0.000	

The results in Table 6 indicate that renewable energy fabrication re-skilling programmes significantly influence sustainable fabrication practices among Metalwork Technology educators and technicians in Nigerian TVET institutions ($\beta = 0.69$, $p < 0.05$). The positive beta coefficient demonstrates that increased participation in renewable energy re-skilling activities contributes to greater adoption of environmentally responsible fabrication practices. The coefficient of determination (R² = 0.48) shows that approximately 48% of the variation in sustainable fabrication practices is explained by the re-skilling programme. This suggests a strong predictive relationship between renewable energy re-skilling and sustainable fabrication behaviour. Therefore, the null hypothesis was rejected, and it was concluded that renewable energy fabrication re-skilling programmes significantly enhance sustainable fabrication practices among respondents.

Discussion of Findings

The findings of this study revealed that renewable energy fabrication re-skilling programmes have a significant positive influence on green production competencies among Metalwork Technology educators and technicians in Nigerian TVET institutions. The high mean ratings and significant regression results indicate that participants who underwent renewable energy-related re-skilling acquired enhanced competencies in solar panel mounting fabrication, wind turbine component fabrication, sustainable material utilization, and environmentally responsible production techniques. This finding underscores the growing importance of green skills development in contemporary technical education and aligns with the global call

for the transformation of TVET systems to support sustainable development and the green economy (UNESCO, 2022). The finding suggests that exposure to renewable energy fabrication technologies equips educators and technicians with practical competencies necessary for adapting to emerging industrial demands and environmentally sustainable production systems.

The result is consistent with the Human Capital Theory, which posits that investment in education and training improves individuals' knowledge, skills, productivity, and economic value (Becker, 2021). Through renewable energy re-skilling programmes, participants acquired specialized competencies that enhanced their capacity to contribute effectively to green manufacturing and sustainable industrial practices. The finding corroborates the study of Aina (2023), who reported that green skills training significantly improves workforce competence and adaptability in technology-driven industries. Similarly, Okoye and Okwelle (2023) found that continuous professional re-skilling enhances the capacity of technical personnel to respond effectively to emerging technological innovations and industrial transformations. The present finding further supports the position of the International Labour Organization (ILO, 2023) that green skills development is essential for preparing workers for jobs associated with environmental sustainability and renewable energy technologies.

The study also found that renewable energy fabrication re-skilling programmes significantly influence entrepreneurial intention among Metalwork Technology educators and technicians. Participants indicated that the programme increased their willingness to establish renewable energy-related enterprises, identify green business opportunities, and commercialize renewable energy products and services. This finding suggests that the acquisition of renewable energy fabrication competencies not only enhances technical expertise but also strengthens confidence in pursuing entrepreneurial ventures within the renewable energy sector. The increasing global demand for renewable energy technologies presents numerous opportunities for self-employment, enterprise creation, and innovation, particularly in developing economies such as Nigeria where access to sustainable energy solutions remains a major challenge.

The finding agrees with the work of Adekunle and Ibrahim (2025), who observed that entrepreneurship-oriented technical education significantly increases entrepreneurial aspirations and business start-up intentions among technical education graduates. It also supports the findings of Haruna and Bello (2024), who reported that practical skill acquisition and industry-relevant training positively influence entrepreneurial self-efficacy and venture creation intentions. Furthermore, the result lends support to the Theory of Planned Behaviour, which argues that individuals are more likely to engage in entrepreneurial activities when they possess the requisite knowledge, skills, confidence, and perceived behavioural control necessary for business success (Ajzen, 2021). The practical competencies acquired through renewable energy fabrication training may therefore serve as important drivers of entrepreneurial intention among educators and technicians.

Another important finding of the study is that renewable energy fabrication re-skilling programmes significantly enhance sustainable fabrication practices among participants. Respondents reported increased adoption of environmentally friendly fabrication techniques, waste reduction practices, energy-efficient production methods, material recycling, and sustainable resource utilization. This finding demonstrates that renewable energy-oriented training contributes not only to technical competence but also to the development of environmentally responsible attitudes and behaviours within workshop and production environments. Sustainable fabrication practices are increasingly recognized as essential components of modern manufacturing systems because they help reduce environmental degradation, improve resource efficiency, and support long-term industrial sustainability.

This finding is in agreement with the report of the United Nations Environment Programme (UNEP, 2023), which emphasized that sustainable production practices are critical for achieving environmental sustainability and industrial competitiveness. The result also corroborates the findings of Eze and Okafor (2024), who reported that renewable energy education promotes environmentally conscious production practices and strengthens sustainable manufacturing capabilities among technical personnel. Similarly, Nwosu and Ezeudu (2022) observed that integrating sustainability principles into TVET programmes contributes significantly to the development of environmentally responsible workforce behaviours. The present study therefore provides empirical evidence that renewable energy re-skilling programmes can

serve as effective mechanisms for promoting sustainable fabrication practices within Nigerian TVET institutions.

Furthermore, the combined findings of this study highlight the strategic role of renewable energy fabrication re-skilling programmes in advancing sustainable industrial development. The acquisition of green production competencies, enhanced entrepreneurial intention, and improved sustainable fabrication practices collectively contribute to the development of a skilled workforce capable of supporting local renewable energy production and green enterprise development. These outcomes are particularly relevant in Nigeria, where unemployment, energy deficits, environmental challenges, and dependence on imported technological solutions continue to constrain economic development. By equipping Metalwork Technology educators and technicians with renewable energy fabrication competencies, TVET institutions can strengthen local manufacturing capacity, foster innovation, and contribute to the realization of national sustainable development objectives.

Overall, the findings of this study demonstrate that renewable energy fabrication re-skilling programmes constitute an effective strategy for enhancing workforce adaptability, promoting green entrepreneurship, improving sustainable fabrication practices, and supporting sustainable industrial development. The study therefore reinforces the growing body of literature advocating for the integration of renewable energy competencies and green skills into TVET curricula and professional development programmes as a means of preparing technical personnel for the demands of the twenty-first-century green economy.

Conclusion

The study concludes that integrating renewable energy installation skills into Metalwork Technology re-skilling programmes is a strategic approach for strengthening the relevance of Technical and Vocational Education and Training (TVET) institutions in Nigeria's emerging green economy. The findings revealed that renewable energy fabrication re-skilling programmes significantly enhance green production competencies, improve entrepreneurial intention, and promote sustainable fabrication practices among Metalwork Technology educators and technicians. Participants acquired practical competencies in solar panel mounting fabrication, wind turbine component production, sustainable material utilization, waste reduction, and environmentally responsible manufacturing processes, while also developing greater readiness for self-employment and green enterprise creation. These outcomes demonstrate that embedding renewable energy competencies into Metalwork Technology training can support green job creation, local manufacturing capacity development, environmental sustainability, and economic diversification. Therefore, the integration of renewable energy skills into contemporary TVET re-skilling programmes should be prioritized as an important strategy for advancing sustainable industrial development and preparing technical manpower for the demands of the twenty-first-century workforce in Nigeria.

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