

ENHANCING THE DEVELOPMENT OF RENEWABLE ENERGY SKILLS AMONG POLYTECHNIC ELECTRICAL/ELECTRONIC ENGINEERING STUDENTS FOR SUSTAINABLE GREEN ECONOMY IN NIGERIA

BY

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Abstract

The study ascertained ways of enhancing the development of renewable energy technology skills among Polytechnic electrical/electronic engineering students for sustainable green economy in Nigeria. Descriptive survey design was used for the study. The population of the study was 2584 subjects (2322 final year students and 262 lecturers) from in Ken Saro-Wiwa Polytechnic, Bori. Purposive sampling was used to obtain 38 electrical/electronic lecturers and 123 final year students as the study sample. Two research questions and two hypotheses guided the study. A 30-item structured questionnaire titled "Solar Energy Technology Skills Development Questionnaire (SETSDQ)" was used to obtain data from respondents. The SETSDQ was validated by two experts in electrical engineering and an expert in measurement and evaluation. The reliability of the instrument was ascertained via Cronbach alpha method which yields a reliability coefficient of 0.79. From a total of 161 copies of questionnaires distributed to the respondents, only 150 (representing 93.2 percent) was retrieved and used for data analysis. Mean and standard deviation were used to answer the research questions and t-test was used to test the hypotheses at 0.05 level of significance. The study revealed among others, that solar panel installation, electrical engineering drawing, energy efficiency, and troubleshooting skills are needed for easy transition to a sustainable green economy in Nigeria. Furthermore, the study indicated that internship, lifelong learning, industry-institution partnership in the training of solar energy technologists among others are possible ways of enhancing the development of solar energy technology skills among polytechnic electrical/electronic engineering students. Consequently, it was recommended among others that Government should ensure the engagement of experienced trainers as solar energy technology lecturers and instructors in Nigerian polytechnics for rapid development of solar energy skills among electrical/electronic engineering students and also Government should ensure adequate funding of solar energy technology programmes in polytechnics for quick transition to green economy.

Keywords: Green economy, green jobs, renewable energy skills, solar technology.

Introduction

Green economy characterizes an economy with low carbon emissions. Emission of greenhouse gases (GHGs) into the atmosphere brings about environmental

degradation, health risks, ecosystem destruction, poor economic growth and social instability hence, any economy without these environmental issues can be referred to as a green economy.

According to the United Nations Environmental Programme (UNEP) (2011), green economy describes an economy which results in improved human well-being and social equity and at the same time, reducing environmental risks and ecological scarcities. UNEP further reports that green economy is resource-efficient, socially inclusive with low carbon emission. Green economy is one aimed at achieving ecological sustainability, economic profitability and social inclusion (Federal Ministry of Economic Cooperation and Development, Germany (BMZ), 2011). Green economy is one whose increase in income and employment growth are driven by public and private investments that reduce carbon emissions and pollution, enhance energy and resource efficiency and prevent the loss of biodiversity and ecosystem services (UNEP, 2011). Green economy cannot be achieved without the development of green skills in relevant through quality Technical Vocational Education and Training (TVET). Skills development programmes are key to securing new markets and jobs, providing better competitiveness, promoting career advancement as well as ensuring environmental and consumer protection since it promotes the utilization of modern technologies to reduce greenhouse gas emissions. Skill development according to International Labour Organization (ILO) (2011); UNESCO-UNEVOC (2017) and Parlov (2019) constitute drivers of technological

change promoting green transformation across the globe. However, dearth of skilled workforce in the green industry impedes the transition to a low carbon economy. Supporting this claim, Vidican-Auktor, Altenburg and Stamm (2020) stipulated that skills related to green technology are often in short supply. Thus, this observed skill gap owing to the paucity of technical manpower needed to champion the transition to a sustainable green economy necessitates the improvement of the TVET system in Nigeria to enhance its effectiveness. This critical issue informed the researchers' quest to carry out this study in order to identify ways of enhancing the Development of Renewable energy Skills among Polytechnic Electrical/Electronic Engineering Students for Sustainable Green Economy in Nigeria.

Purpose of the Study

The study sought for ways of enhancing the development of renewable energy skills among polytechnic electrical/electronic engineering students for sustainable green economy in Nigeria. Specifically, the study was conducted to:

1. Determine solar energy technology skills needed by polytechnic electrical/electronic engineering students for sustainable green economy in Nigeria.
2. Determine possible ways of enhancing the development of solar energy technology skills among polytechnic electrical/electronic

engineering students for sustainable green economy in Nigeria.

Research Questions

1. What are the solar energy technology skills needed by polytechnic electrical/electronic engineering students for sustainable green economy in Nigeria?
2. What are the possible ways of enhancing the development of solar energy technology skills among polytechnic electrical/electronic engineering students for sustainable green economy in Nigeria?

Hypotheses

1. There is no significant difference in the mean responses of lecturers and students on solar energy technology skills needed by polytechnic electrical/electronic engineering students for sustainable green economy in Nigeria.
2. There is no significant difference in the mean responses of lecturers and students on possible ways of enhancing the development of solar energy technology skills among polytechnic electrical/electronic engineering students for sustainable green economy in Nigeria.

Literature Review

Green Economy and Sustainable Development

The International Labour Organization (2015) posits that greening of global economies would enhance sustainable management of natural resources,

increase energy efficiency, and reduce waste as well as address inequalities and enhance resilience. Furthermore, UNEP (2008) reports that green economy being a quality transition to a low-carbon economy using efficient resources and socially-inclusive systems should be adopted by developed and developing countries for the achievement of sustainable development. Supporting this assertion, Bundesregierung (2012) stipulated that green economy entails an economic approach oriented towards sustainability which is capable of contributing in no small measures to sustainable economic growth. Sustainable development, according to the United Nations Education Scientific and Cultural Organization (UNESCO) (2012) is simply meeting the needs of the present generation without putting at risk the capacity of generations to come in meeting their own requirements. Thus, sustainable development meets the needs of the present without limiting the capabilities of future generations of reaching their goals. Protecting the environment by making it safe, emission-free and conducive for dynamic economic and social activities therefore is a way of preserving it for the future generations. Any job roles directed towards quality greening of the economy in line with global best practices are known as green jobs.

Green Jobs and Skills

Green jobs are decent jobs producing goods and providing services. In the

words of Winter and Moore (2013), green jobs are decent works denoting human and industrial activities aimed at promoting the attainment of a low carbon economy. ILO (2015) reported that green jobs apart from being decent make production processes more energy and resource-efficient with reduced pollution. Correspondingly, BMZ (2011) posited that green jobs are jobs contributing to ecological and climate safety. Green jobs refer to positions in agriculture, manufacturing, construction, installation and maintenance, scientific and technical, administrative and service-related actions that contribute substantially to preserving or restoring environmental quality (UNEP, 2008). Some jobs can be considered green if such jobs reduce ultimately the environmental impact of enterprises and economic sectors to a sustainable degree (ILO, 2011). Greening of jobs and the promotion of green jobs will foster an aggressive low-carbon, environmentally sustainable economy and models of sustainable consumption and production thereby supporting to the fight against climate change (ILO, 2013). Thus, the International Labour Organization (2015) submitted that green jobs generally tend to improve energy and material efficiency; limit greenhouse gas emission; reduce waste and pollution; protect and restore ecosystems and enable enterprises as well as communities to adapt to the effects of climate change. Globally, green jobs are mostly created in the renewable energy industry,

sustainable construction industry, sustainable agricultural industry, forestry and green enterprises. However, effective participation in green jobs provided by green industries requires the acquisition and development of new sets of skills called green skills.

Green skills on the other hand, are expertise required for green transformation. Green skills are skills needed to develop and use green technologies in various sectors such as energy, environment and industry for sustainability. According to ILO (2019), green skills entail knowledge, competence and experience required to execute a given task aimed at achieving sustainable economy. Likewise, The Organization for Economic Cooperation and Development (OECD) (2011) and the European Centre for the Development of Vocational Training (CEDEFOP) (2014) describe green skills as expertise needed by the workforce in all sectors and at all levels to advance the adaptation of products, services and processes to the transformation due to climate change and to environmental requirements and regulations. Furthermore, CEDEFOP (2012) propose that green skills encapsulate knowledge, abilities, values and attitudes needed to live in, build up and promote a sustainable and resource-efficient society. Hence, green skills offer much more disaggregated perspective on the labour market dynamics associated with greening the economy. Thus, green

skills are required to carry out soil and water remediation, waste water treatment, solar panel installation, solar cooling, recycling, Heating, Ventilation, and Air Conditioning (HVAC) system, composting, energy-efficient lighting, battery energy storage, solar water heating and photovoltaic technology, among other green jobs (Vidican-Auktor, Altenburg & Stamm, 2020). Basically, skills required to execute most green jobs are available via Technical Vocational Education and Training (TVET).

The Concept of Technical Vocational Education and Training

Technical Vocational Education and Training (TVET) is an educational training programme specifically designed for skills development and capacity building in line with the needs of the industry. TVET is seen by Onderi, Ajowi and Malala (2014) as an educational programme involving the study of technologies and sciences in relation to general education which support the acquisition of awareness, knowledge, skills and attitudes relating to occupations in various sectors of economic and social life. Furthermore, UNESCO (2002) described TVET as a comprehensive term referring to those aspects of educational processes involving in addition to general education, the study of technologies and related sciences and the acquisition of practical skills, attitudes, understanding, and knowledge relating to occupations in various sectors of economic and social

life. TVET ensures the provision and utilization of skills and knowledge as tools for the socio-economic development of any nation. Therefore, since TVET is geared towards meeting the skills needs of various sectors of the economy for sustainable development, acquiring green skills can easily be achieved through TVET. Thus engineering and technical competences required in designing, construction and assessment of new technology are often provided by TVET trained engineers and technicians.

Similarly, Vona, Marin and Consolin (2015) opined that the general sets of skills supporting green activities include engineering and technical skills, science and technology skills, operation management skills and monitoring skills and that these skills have direct relevance in the field of renewable energy technology. Developing renewable energy skills therefore serves as a principal component needed for the transition to a low carbon economy (Vidican-Auktor, 2020). In a related development, ILO (2018) reported that skills development facilitates smooth transition to green economy. Accordingly, to develop green (renewable energy) skills, one needs to acquire substantial training and formal education via TVET. To further buttress this assertion, Lin (2011) opined that green occupations warrants the acquisition of relevant skills through adequate training and education. Technical education fosters the

development of skills, knowledge and attitudes crucial for success in any work environment (Olaitan, 2007). Thus, developing required skills for the attainment of green economy in Nigeria requires the workforce to be adequately acquainted with and properly trained in technical and vocational education. For instance, tasks such as installation of solar energy equipment, operation of solar energy inverter, designing of power supply unit, electronic switching, solar battery charging, designing of battery storage facilities like power reservoirs (energy saving) for improved energy efficiency demands much technical expertise derivable in TVET. This implies that TVET system in Nigeria has to be strengthened for it to live up to its responsibility of providing quality service delivery to Nigerians for transition to green economy. One of the major institutions offering practical (hands-on) training for skills development in Nigeria is the Polytechnic.

Polytechnic Education in Nigeria and its Relevance in Skills Development of Students

Polytechnics are tertiary institutions that specialize in the training of students to acquire relevant technological, scientific, entrepreneurial and managerial skills applicable in the world of work for economic development and technological advancement of the nation. Polytechnics are technology-inclined institutions that offer post-secondary educational training

principally in the field of technology to learners leading to the award of trade certificates, National Diploma (ND) and Higher National Diploma (HND) (NBTE, 2021). Likewise, Oni (2007) asserted that Polytechnic trains students to acquire knowledge for paid employment or self-reliance through the acquisition of appropriate skills for agricultural, industrial and commercial roles capable of accelerating the economic development of a nation. Furthermore, Oluwole and Lateef (2015) view polytechnic as a generic term indicating a higher educational institution vested with the responsibilities of offering instructions in technical subjects, technology, industrial production, agriculture, commerce and communication targeted at the provision of knowledge and skills associated with the application of tools and equipment for effective development of students through adequate theoretical and practical experience. Corroborating these views, the United Nations Educational, Scientific and Cultural Organization (UNESCO) (2002) describes polytechnic education as that segment of general education that trains people in various occupational fields for effective participation in the world of work, life-long learning for responsible citizenship, promotion of sustainable development, as well as serving as a best method of facilitating poverty alleviation and enabling individuals to develop technical and entrepreneurial abilities and attitudes. In the same vein, Miller (2011) states that

polytechnic education in the past was centered around technical education but presently include training in the processes of applying both scientific and technological expertise to solving real life practical problems. According to the Federal Republic of Nigeria's national policy on education (2013), technical education entails the achievement of elementary scientific awareness involving the application of practical and applied skills in various occupational fields. Thus, polytechnics offer skill training to technical, vocational and engineering personnel in electrical/electronic engineering, mechanical engineering, computer technology and other technical fields for the industrial development of the nation.

Electrical/Electronic Engineering Programmes in Nigerian Polytechnics

Electrical/Electronic engineering programme of polytechnics is mainly designed for the training of technicians, technologists and engineers who may specialize in power system, electronics and communication technology, instrumentation and control engineering. Electrical/electronic engineering covers all aspects of electrical engineering practices such as electrical power, electrical machines, electrical measurement and control, electrical maintenance and repairs, digital electronics, analogue electronics, among others (NBTE, 2001). Thus, the various areas of specializations

in electrical/electronic engineering are taught in theories and practice to foster the acquisition and development of relevant knowledge and skills built on the principles of electricity and electromagnetism for quality work in the industry (Owo, 2020). These skills are very crucial for the attainment of sustainable green economy in Nigeria especially within the renewable energy sub-sectors. Consequently, electrical/electronic engineering skills obtainable in polytechnics can be directly applied to achieve extraordinary developmental outcomes in renewable energy including solar (photovoltaic) technology.

Renewable energy (particularly solar technology) which provides efficient, reliable and pollution-free electrical energy is crucial for the achievement of sustainable (green) economy. Therefore, enhancing the development of green (renewable) energy skills such as solar panel installation skill, solar equipment maintenance and troubleshooting skills, inverter design and installation skills, energy saving skills and material efficiency skills via the electrical/electronic engineering programmes of Nigerian polytechnics is a prerequisite for achieving sustainable green economy in Nigeria.

Renewable Energy Skills

Renewable Energy according to UNESCO-UNEVOC (2020) is the energy

derived from natural processes (for example, sunlight and wind) and replenished at a higher rate than it is consumed.

Solar, wind, geothermal, hydropower, bio-energy and ocean power are sources of renewable energy. The role of renewable energy continues to increase in the electricity, heating and cooling, and transport sectors (UNESCO-UNEVOC, 2020). Energy efficiency and renewable energy are the two main vectors that determine the most evident opportunities to address sustainability in the energy sector. These two areas are intrinsically linked and need to be addressed together: reducing consumption by being more efficient paves the way for more effective uses of renewable energy sources. In other words, the beneficial impact of renewable energy generation is increased by means of a lower consumption baseline. Consequently, some of the renewable energy skills applicable in this study are discussed as follows:

Energy management (Sustainability) Skills

Sustainability is the ability to maintain a healthy environment for future generations. Renewable energy engineers who have sustainability skills can help develop and implement renewable energy systems that reduce carbon emissions, which helps protect the environment. Sustainability also includes the ability to monitor and evaluate renewable energy

systems to ensure they are operating efficiently and safely.

Power System Design Skills

The ability to understand and apply power system knowledge is an important skill for a renewable energy engineer. This includes understanding how different types of electrical equipment work, including transformers, generators, motors and other components that make up the electrical grid. It also involves knowing how these systems interact with one another and how they can be used to create sustainable energy sources.

Energy Efficiency Skills

Energy efficiency is the ability to use less energy than necessary. Renewable energy engineers who have this skill can help companies and individuals reduce their carbon footprint by using renewable sources of energy that don't emit greenhouse gases. This also helps them save money on utility bills, which is another important aspect of a renewable energy engineer's job.

Solar Energy Installation Skills

Solar energy is the conversion of sunlight into usable heat and electricity. Renewable energy engineers who have knowledge in solar technology can help develop new ways to use solar power, which may reduce the need for fossil fuels. Solar energy also includes other methods that harness the sun's rays, such as through water or wind turbines. It also

includes skills necessary to appropriately design and install solar panels.

Methodology

Area of the Study

The study was conducted in Ken-SaroWiwa Polytechnic, Bori, Rivers State, South-South, Nigeria.

Design of the Study

Descriptive survey design was used in this study. According to Nwankwo (2016), a descriptive survey study is one in which data from a large sample drawn from a given population were collected and certain features of the sample as they are at the time of the study and which are of interest to the researchers were described without altering any independent variable of the study.

Population of the Study

The population of the study comprised 2584 subjects (2322 final year students and 262 lecturers) in Ken Saro-Wiwa Polytechnic Bori, Rivers State.

Sample and Sampling Technique

Purposive sampling was used to select 161 subjects (38 lecturers and 123 final year students) of Electrical/Electronic Engineering Department in Ken-SaroWiwa Polytechnic, Bori, Rivers State as the study sample.

Instrument for Data Collection

The instrument for data collection was a 30-item structured questionnaire titled "Solar Energy Technology Skills

Development Questionnaire (SETSDQ)". The SETSDQ was designed on a 5-point Likert Scale designated as Strongly Agree (SA), Agree (A), Undecided (U), Disagree (D) and Strongly Disagree (SD) corresponding to numerical values of 5, 4, 3, 2 and 1 respectively.

Validity of the Instrument

The questionnaire was validated by two experts in Electrical Engineering from Captain Elechi Amadi Polytechnic, Rumuola, Port Harcourt and one expert in measurement and evaluation from Rivers State University, Port Harcourt.

Reliability of the Instrument

The reliability of the instrument, SETSDQ, was established using Cronbach alpha method. A total of 38 copies of the questionnaire were distributed to 10 electrical lecturers and 28 final year students of electrical/electronic engineering from Federal Polytechnic Nekede, Imo State. After an interval of two weeks, the same instrument was administered to the same lecturers and students and the results from the first and second administration were compared. Cronbach alpha method was used to test the instrument for internal consistency and a reliability coefficient of 0.79 was obtained which confirmed that the instrument was very reliable.

Administration of the instrument

The instruments were distributed to the respondents by the researchers with the help of one research assistant. The

research assistant was properly educated on how to distribute and retrieve the filled questionnaires from the respondents. From a total of 161 copies of questionnaires distributed, only 150 (representing 93.2 percent) was retrieved and used for data analysis.

Method of Data Analysis

Mean and standard deviation were used to answer the two research questions while t-test was used to test the two null hypotheses. For the research questions,

any item having a calculated mean value of 3.00 and above was accepted and any item that falls below 3.00 was rejected. The t-test was used to test the hypotheses at 0.05 level of significance. Decision to accept or reject a hypothesis was stated as follows: If the calculated mean (t_{cal}) is greater than the critical value of mean, (t_{crit}), then the hypothesis will be rejected but if otherwise, the hypothesis will be accepted.

Results

The results were presented in line with the research questions and hypotheses as follows:

Research Question 1: What are the solar energy technology skills needed by polytechnic electrical/electronic engineering students for sustainable green economy in Nigeria?

Table1: Mean and Standard Deviation on Solar Energy Technology Skills

S/N	Electrical/Electronic Engineering Students need to Develop these Solar Energy Skills:	Lecturers (N ₁ = 32)			Students (N ₂ = 118)		
		$\bar{X}_1$	SD ₁	RMK	$\bar{X}_2$	SD ₂	RMK
1	Solar panel installation	4.16	0.71	Agree	4.36	0.75	Agree
2	Sensor technology application	3.83	0.87	Agree	3.49	0.63	Agree
3	Site assessment skills	3.81	0.83	Agree	3.47	0.99	Agree
4	Solar thermal technology	3.97	0.75	Agree	3.71	0.81	Agree
5	Spectrometer usage	3.85	0.67	Agree	4.13	0.49	Agree
6	Photovoltaic cells application	4.52	0.61	Agree	4.02	0.67	Agree
7	Field equipment testing	4.14	0.94	Agree	4.23	0.55	Agree
8	Troubleshooting	4.11	0.91	Agree	3.89	0.96	Agree
9	Heating, Venting and Air Conditioning HVAC	3.76	1.01	Agree	4.08	0.79	Agree
10	Voltage grid connections	3.98	0.97	Agree	3.67	0.55	Agree
11	Power conversion	4.09	0.51	Agree	4.31	0.97	Agree
12	Energy management	3.82	0.85	Agree	4.25	0.78	Agree
13	Basic electrical engineering drawings	4.24	0.77	Agree	4.56	0.69	Agree
14	Semi-conductor process systems	3.81	0.65	Agree	3.78	0.53	Agree
15	Technical report writing	4.32	0.79	Agree	3.53	0.91	Agree
16	Energy efficiency	4.48	1.11	Agree	4.17	1.13	Agree
17	Engineering computations	4.21	1.05	Agree	4.33	0.85	Agree
18	Power system design	4.19	0.92	Agree	4.11	0.83	Agree
19	Battery energy storage	3.08	0.89	Agree	3.97	0.93	Agree
20	Project management	4.07	0.55	Agree	2.78	0.65	Disagree
Average Mean and Standard Deviation		4.02	0.82		3.94	0.77	

Source: Researchers' Field Survey, 2022.

Table 1 shows the responses of Electrical Engineering lecturers and students on solar energy technology skills needed by polytechnic electrical/electronic engineering students for sustainable green economy in Nigeria. According to Table 1, electrical engineering lecturers agreed that all the items represent solar energy technology skills needed for sustainable green economy. This is seen from the mean responses on each item which is above the criterion mean of 3.00.

Likewise, the HND final year students of electrical/electronic engineering agreed that all the items are solar energy technology skills needed for sustainable green economy with exception of item 20 which is project management, in which students did not accept as a skill in solar energy technology. Standard deviation values far and wide apart indicate homogeneity in the responses of both categories of respondents.

Research Question 2: What are possible ways of enhancing the development of solar energy technology skills among polytechnic electrical/electronic engineering students for sustainable green economy in Nigeria?

Table 2: Mean and Standard Deviation on Possible ways of Enhancing the Development of Solar Energy Technology Skills

S/N	Solar Energy Technology Skills Development can be Strengthened via:	Lecturers (N ₁ = 32)			Students (N ₂ = 118)		
		$\bar{X}_1$	SD ₁	RMK	$\bar{X}_2$	SD ₂	RMK
1	Review of renewable energy technology curriculum of Nigerian polytechnics.	3.98	0.93	Agree	4.23	0.75	Agree
2	Creating public awareness on the use of solar energy technology for electricity supply.	4.22	0.81	Agree	3.98	0.87	Agree
3	Retraining of instructors and lecturers on solar energy via continuous professional education.	4.08	0.65	Agree	3.81	0.99	Agree
4	Adequate supply of solar energy technology equipment and materials for hands-on training.	3.67	0.77	Agree	4.18	0.85	Agree
5	Engagement of solar energy experts as instructors in Polytechnics.	3.85	0.95	Agree	4.07	0.77	Agree
6	Adequate funding of solar technology programmes via public-private sponsorship.	3.92	0.88	Agree	4.29	0.83	Agree
7	Encouraging institution-industry participation in solar energy education and training.	4.28	0.94	Agree	4.10	0.95	Agree
8	Promoting qualitative and quantitative research in the field of solar energy technology.	4.03	0.85	Agree	3.79	0.61	Agree
9	Mandatory internship for all solar technology students/trainees in energy industries in Nigeria	4.26	1.03	Agree	4.19	0.89	Agree
10	Use of criterion-referenced tests in assessing students' achievement in solar energy training.	3.98	0.57	Agree	3.67	0.95	Agree
Average Mean and Standard Deviation		4.03	0.84		4.03	0.85	

Source: Researchers' Field Survey, 2022.

Table 2 shows the responses of electrical engineering lecturers and students on ways of enhancing the development of solar energy technology skills among polytechnic electrical/electronic engineering students for sustainable green economy in Nigeria. According to Table 2, electrical engineering lecturers and students agreed that all the items

represent possible ways of enhancing the development of solar energy technology skills for sustainable green economy. This is seen from the mean responses of all items which are above the criterion mean of 3.00. Standard deviation values far and wide apart closeness in the responses of both categories of respondents.

Hypothesis 1: There is no significant difference in the mean responses of lecturers and students on solar energy technology skills needed by polytechnic electrical/electronic engineering students for sustainable green economy in Nigeria.

Table 3: t-test Analysis on Solar Energy Technology Skills Needed for Sustainable Green Economy in Nigeria

Group	N	X	SD	df	α	t _{cal}	t _{crit}	Remark
Lecturers	32	4.02	0.82	148	0.05	0.50	1.96	Accepted
Students	118	3.94	0.77					

Source: *Researchers' Field Result; 2022.* Accept H_0 if $t_{cal} \leq t_{crit}$, Otherwise Reject H_0 . Table 3 indicates that the critical value of t, (1.96) is greater than the calculated value of t (0.50). Hence, the null hypothesis is accepted which means that there is no significant difference in the mean responses of lecturers and students on solar energy technology skills needed by polytechnic electrical/electronic engineering students for sustainable green economy in Nigeria.

Hypothesis 2: There is no significant difference in the mean responses of lecturers and students on possible ways of enhancing the development of solar energy technology skills among polytechnic electrical/electronic engineering students for sustainable green economy in Nigeria.

Table 4: t-test Analysis on Possible Ways of Enhancing the Development of Solar Energy Skills for Sustainable Green Economy in Nigeria

Group	N	X	SD	df	α	t-cal	t-crit	Remark
Lecturers	32	4.03	0.84	148	0.05	0.00	1.96	Accepted
Students	118	4.03	0.85					

Source: *Researchers' Field Result; 2022.* Accept H_0 if $t_{cal} \leq t_{crit}$, Otherwise Reject H_0 .

Table 4 shows that the critical value of $t_{crit}(1.96)$ is greater than the calculated value of t , $t_{cal}(0.00)$. Consequently, the null hypothesis is upheld which implies that there is no significant difference in the mean responses of lecturers and students on possible ways on enhancing the development of solar energy technology skills among polytechnic electrical/electronic students for sustainable green economy in Nigeria.

Discussion

The finding of the study as revealed in Table 1 indicates that solar panel installation skills, skills in photovoltaic cells application, field equipment testing skills, electrical engineering drawing skills, energy (saving) efficiency skills and troubleshooting skills, among others are solar energy technology skills needed for sustainable green economy in Nigeria. The reason for this finding is that for Nigeria to embrace solar energy technology as an alternative source of electrical energy supply, technical and engineering graduates from Nigerian polytechnics need to possess adequate solar technology skills such as installation, troubleshooting, power system design and energy efficiency skills, among others. This finding was supported by Rada (2018) who asserted that skills in basic electrical engineering drawing, energy management and troubleshooting among others are needed for job placements in renewable energy sector. Similarly, the finding agrees with

Rana (2016) who posits that field testing operations skills, troubleshooting skills, electrical and mechanical engineering drawing skills, HVAC skills, among others are solar technology skills excelling in the renewable energy industry. Thus, electrical/electronic engineering students need to develop adequate solar energy technology skills for productive work for the actualization of sustainable green economy.

The finding in Table 2 shows that creating public awareness, adequate supply of training equipment and materials, mandatory students' internship in energy industry, continuous professional education of trainers, public-private sponsorship, increased research outputs among others are possible ways of enhancing the development of solar power technology skills among polytechnic electrical/electronic engineering students. This finding corroborates the view of Gorind (2016) who asserts that internship, lifelong learning, practical training in industries and professional affiliations are ways of strengthening the development of solar energy skills among trainees. Furthermore, this study corroborates the views of Jennings, Lund and O'mara (2000) who posit that continuous education of renewable energy professionals as well as creating societal awareness of the need to utilize renewable energy to achieve sustainable development are ways of strengthening

the development of solar energy technology skills among trainees. Furthermore, this finding shares a page with Jennings, Dubey and Lund (2001) who canvasses for industry-institutional partnership in meeting the training needs of learners in renewable energy. Consequently, for Nigeria to make substantial progress towards the attainment of green economy, solar energy and other sources of renewable energy must be massively utilized to meet the electrical energy needs of the nation as such will not only supply electrical energy but also reduce the emission of greenhouse gases which is a major cause of environmental pollution and climate change resulting to global warming. Thus, the processes of fossil fuel combustion for energy generation should be discouraged if the nation is serious in its quest to attain sustainable green economy.

Conclusion

Solar energy is one major way of providing reliable, clean and efficient electrical energy for residential, commercial and industrial applications across the globe.

General solar energy technology skills such as solar panel installation, sensor technology application, spectrometer usage, field equipment testing, troubleshooting, HVAC, power conversion, engineering drawings, power system design and semi-conductor process system among others are grossly

needed by electrical technicians and technologists for effective utilization of solar energy technology for electrical energy supply. Thus, developing skills applicable in solar technology by polytechnic electrical engineering graduates is crucial for its implementation in Nigeria. Consequently, review of renewable energy curriculum, public awareness about solar energy, retraining of instructors and lecturers on solar energy, adequate funding of solar energy projects by Government, institution-industry ties, solar energy research, and adequate evaluation of solar energy training programmes are some of the ways of enhancing the development of solar energy skills among electrical/electronic engineering graduates of polytechnics in Nigeria.

Recommendations

Based on the findings of the study, the following recommendations are suggested:

1. Government should engage experienced trainers as solar energy technology lecturers and instructors in Nigerian polytechnics for rapid development of solar energy skills among electrical/electronic engineering students.
2. Government should ensure adequate funding of solar energy technology programmes of polytechnics in order to produce skilled graduates needed for solar energy utilization in Nigeria.

3. The National Board for Technical Education (NBTE) should periodically review polytechnic education curriculum in solar energy to incorporate emerging technologies.
4. Government should engage experienced trainers as solar energy technology lecturers and instructors in Nigerian polytechnics for effective skill development of learners.
5. Government should adequately provide all necessary materials and equipment needed for solar energy training in Nigerian polytechnics for practical (hands-on) experience.
6. Government should ensure mandatory professional development of polytechnic lecturers and instructors in solar energy techniques and principles in order to build their capacities and update their knowledge in solar technology.

References

- BMZ (2011). *TVET for a Green Economy*. Germany: GIZ-Federal Ministry for Economic Co-operation and Development.
- Bundesregierung (Ed.) (2012). *National Sustainability Development Strategy*. 2012 Progress Report, Berlin.
- European Centre for the Development of Vocational Training (CEDEFOP) (2012). *Green skills and environmental awareness in vocational education and training*. Luxembourg: European Commission.
- FEDEFOP (2014). Greener skills and jobs. OECD Green Growth Studies. Paris: OECD Publishing.
- Federal Republic of Nigeria (2013). *National Policy on Education*. Lagos: NERDC Press.
- Gorind, S. R. (2016). What are the skills required in choosing a career in renewable energy. Retrieved from <https://www.quora.com/What-are-the-skills-required-in-choosing-a-career-in-renewable-energy> April 20, 2022.
- International Labour Organization (2011). *Skills for green jobs: A global view*. Geneva: International Labour Office.
- International Labour Organization (2013). Sustainable development, decent work and green jobs. International Labour Conference, 102nd Session, Report V. Geneva: ILO.
- International Labour Organization (2015). *Sustainable Development Goals: Green Jobs*. Geneva: International Labour Office.
- International Labour Organization (2018). *The World Employment Social Outlook: Greening with Jobs*. Geneva: International Labour Office.
- International Labour Organization (2019). Skills for a greener future: A global view based on 32 Country Studies. Geneva: ILO
- Jennings, P., Dubey, P. & Lund, C. (2001). Renewable energy education and training meeting the needs of industry. *ISES 2001 Solar World Congress*, Australia pp.1753-1758.

- Jennings, P., Lund, C. & O'Mara, K. (2000). New approaches to renewable energy education. In: Solar 2000: Renewable Energy Transforming Business, 38th Annual Conference of the Australian and New Zealand Solar Energy Society, November 29 – December 1, Brisbane, QLD, Australia.
- Lin, J. (2011). Technological adaptation cities and new work. *Review of Economics and Statistics*, 93 (2), 554-574.
- Miller, A. (2011). Technical college teachers in Nigeria: Issues, problems and challenges. *Mediterranean Journal of Social Sciences*, 2 (7), 697-703.
- National Board for Technical Education (2001). *Curriculum and Course Specifications for Higher National Diploma Programme in Electrical Engineering*. Kaduna, Nigeria: UNESCO -Nigeria Project.
- National Board for Technical Education (2021). Approved Federal Polytechnics. Retrieved from <https://net.nbte.gov.ng> March 24, 2021.
- Nwankwo, O. C. (2016). *A Practical Guide to Research Writing for Students in Education and Social Sciences (6th ed.)*. Port Harcourt: M & J Grand Orbit and Communication Ltd.
- Olaitan, S. O. (2007). Review of problems of school guidance in Nigeria. *Journal of Education in Developing Areas*, 1 (1), 10-11.
- Oluwole, S. & Lateef, O. (2015). Resource Allocation in Higher Education: A Case Study of Selected Polytechnics in Nigeria. *International Proceedings of Economics Development and Research IPEDR; IACSIT Press, Singapore*, 83, 1-11.
- Onderi, H. J., Ajowi, A.P. & Malala, G. (2014) Restructuring technical and vocational education and training for sustainable development in Sub-Saharan Africa. *International Journal of Interdisciplinary Research and Innovations*, 2(1), 40-45.
- Oni, S. (2007). Globalization and its implications for vocational education in Nigeria. *Essays in Education*, 21, 30-34.
- Organization for Economic Cooperation and Development (2011). *Towards Green Growth*. Paris: OECD.
- Owo, O. T. (2020). Assessment of Workshop Equipment and Tools for Skill Training of Electrical/Electronic Engineering Students in Polytechnics in Rivers State, Nigeria. *Journal of Occupation and Training*, 7 (1), 173-179.
- Parlova, M. (2019). Emerging environmental industries: Impact on required skills and TVET systems. *International Journal of Training Research*, 17 (1), 144-158.
- Rada, E. (2018). What are skills required to get job in renewable energy sector? Retrieved from

- <https://www.quora.com/What-are-skills-required-to-get-job-in-renewable-energy-sector> March 20, 2022.
- Rana, G. S. (2016). How can we excel a career in solar industry? Retrieved from <https://www.quora.com/How-can-we-excel-a-career-in-solar-industry> April 20, 2022.
- UNESCO-UNEVOC (2017). Greening technical vocational education and training: A practical guide for institutions. Retrieved from <https://unevoc.unesco.org/up/gtg.pdf> March 16, 2022.
- UNESCO-UNEVOC (2020). Skills development for renewable energy and energy efficient jobs. Discussion paper on solar energy. Bonn, UNESCO-UNEVOC. Retrieved from <https://unevoc.unesco.org/i/697> June 8, 2022.
- United Nations Education Scientific and Cultural Organization (2002). *Technical and Vocational Education and Training for the 21st century*. Geneva: A UNESCO AND ILO Recommendation.
- United Nations Educational, Scientific and Cultural Organization (2012). Education for Sustainable Development, Country Guidelines for Changing the Climate of Teacher Education to Address Sustainability: Putting transformative education into practice. Brunei, Darussalam, Indonesia, Malaysia, Philippines, and Timor-Leste, Jakarta, Indonesia.
- United Nations Environmental Programme (2008). *Green Economy Initiative*. Geneva: UNEP.
- United Nations Environmental Programme (2011). Towards a green economy: Pathways to sustainable development and poverty eradication. Geneva: United Nations Environment Programme.
- Vidican -Auktor, G., Altenburg, T. & Stamm, A. (2020). *The transition to a green economy and implications on quality infrastructure*. Bonn: German Development Institute.
- Vidican-Auktor, G. (2020). *Green Industrial Skills for a Sustainable Future*. Vienna, Austria: United Nations Industrial Development Organization-Sustainable Development Goals.
- Vona, F., Marin, F. & Consolin, D. (2015). Green skills. NBER Working Paper No 21116. Cambridge US: National Bureau of Economic Research.
- Winter, L. & Moore, M. C. (2013). *The "green jobs" fantasy: Why the economic and environmental reality can never live up to the political promise*. University of Calgary, School of Public Policy Research Papers, 6 (31).