



Photovoltaic Cell Wiring and Maintenance Skills Needed by Electrical/Electronic Technology Graduates for Self Reliance in Northern Nigeria

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ABSTRACT

This study aimed to identify the essential photovoltaic cell wiring and maintenance skills required by graduates of Electrical/Electronic Technology (EET) Education for achieving self-reliance in northern Nigeria. Two research questions were formulated, and two hypotheses were posited to guide the study. Employing a descriptive survey research design, the study involved a population of fifty-two (52) respondents, comprising twenty-nine (29) EET lecturers, six (6) EET technologists, and seventeen (17) PVC installers. Given the small and specific population, no sampling was conducted; instead, all respondents were included. The data collection instrument, named the "Photovoltaic Wiring and Maintenance Skills (PVC-WMS) Needed Questionnaire," was developed by the researcher, validated by experts in electrical/electronic technology education, and pilot-tested at the University of Nigeria, Nsukka. The instrument demonstrated high reliability, with a Cronbach's Alpha coefficient of 0.93. Statistical Package for the Social Sciences (SPSS) version 23 was employed for data analysis, utilizing mean and standard deviation to address the research questions, while one-way ANOVA was applied to test the null hypotheses at a 0.05 level of significance. The study's findings revealed a high demand for photovoltaic wiring and maintenance skills among graduates for achieving self-reliance. However, no significant differences were observed among respondents concerning the importance of these skills for Electrical/Electronic Technology graduates. Based on these results, the study recommended that the government should consider curriculum revisions to incorporate practical skills acquisition, including photovoltaic cell wiring and maintenance. Additionally, universities should develop comprehensive and standardized training programs for these skills, incorporating adaptable training modules. The promotion of standardization in training and certification for photovoltaic cell systems was emphasized, along with the creation of focused training programs that emphasize practical components to keep trainees abreast of evolving technologies.

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INTRODUCTION

Technology Education (TE) is a type of education that prepares its graduates to possess

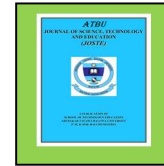
technical skills and knowledge in their various areas of specialization for self-reliance and national economic development. The Federal

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Republic of Nigeria (FRN) defines TE as post-secondary education that imparts the necessary skills and knowledge required leading to the production of skilled human resources relevant to the needs of the labor market. Specifically, the broad aim of TE is the production of an enterprising and self-reliant technicians and technologist.

Also, TE in Nigeria was established to pursue the following goals to include; providing courses of instruction and training in engineering, technologies, applied science, business and management, leading to the production of skill graduates; providing technical knowledge and entrepreneurial skills necessary for agricultural, commercial and economic development; give training and impart the necessary entrepreneurial skills for the production of technicians, technologists and other skilled graduates who shall be enterprising and self-reliant; train graduates who can apply scientific knowledge to solve environmental problems for the convenience of man; and give exposure on professional studies in the technologies (FRN,2013). Electrical/Electronic being among the application scientific knowledge that be possessed for self-reliance.

Specifically, according to Arya, et al., (2023) electrical/electronic is the process of applying scientific knowledge in the design, selection of materials, construction, operation, and maintenance of electrical/electronic products. In the view of Chinyere, and Afeez (2022) electrical/electronic technology is the study of techniques, materials, devices, and electrical/electronic principles. The electrical/electronic technology education program is one of the courses offered in universities in Nigeria. It is designed to prepare its graduates as technologists in the following areas of electrical/electronic maintenance of equipment and appliances, electric power and machine installations, maintenance and installation of domestic, commercial, and industrial wiring.

Unfortunately, the rates of teeming graduate unemployment is hugely increasing at an alarming rate among all graduates including electrical/electronic technology education

graduates as being reported by the National Bureau of Statistics (NBS, 2022) on youth unemployment rates where about more than half of youths in Nigeria including graduates and electrical /electronic technology are unemployed. This statistic is very huge and scary compared with some of the developing countries like India and Brazil which stood below quarter.

An emerging skill but neglected to be incorporated into the curriculum of electrical/electronic is the renewable energy including photovoltaic cells energy system, also known as solar cells. Photovoltaic Cells (PVC) are devices that convert sunlight directly into electricity using the photovoltaic effect. There are key components of solar panels and are used to harness solar energy for various applications, including electricity supply generation. PVC are typically made of a semiconductor material, such as silicon. Silicon is chosen for its ability to efficiently absorb photons (particles of light) from the sun.

Absorption of photons is done when sunlight hits the surface of a photovoltaic cell, photons are absorbed by the semiconductor material. This absorption process transfer's energy to the electrons in the material, allowing them to break free from their atomic bonds and become mobile which leads to Generation of Electron-Hole Pair where the absorbed energy causes the creation of electron-hole pairs within the semiconductor. Electrons are negatively charged particles, while holes are positively charged. Both the electrons and holes are now free to move within the semiconductor. Hence, electricity supply is said to be generated.

PVC have so many advantages over the conventional sources of electricity generation to include; its promising technology in addressing global challenge of climate degradation and meeting the pressing need for green renewable energy. In addition, is its availability and lack of Green House Gases (GHG) emission or other pollutants during operation. Also, they do not produce much sound as compared with conventional sources of electricity; this make them silent producers and require little maintenance as compared with the conventional method of

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electricity generation (Hannan, et al., 2019). But electricity supply generation through PVC can only be sufficiently and adequately harnessed by carrying out effective Photovoltaic Cell wiring (PVC-W). This knowledge is very fundamental for creating independent and sustainable electricity energy sources. PVC-W is ability to wire and connect the essential components for the safe and efficient operation of photovoltaic cell systems. It is also an ability for someone to be proficient in connecting solar panels, inverters, and batteries while adhering to electrical safety standards. Another knowledge that is equally important for generating clean and reliable electricity supply is Photovoltaic Maintenance Skills (PVC- MS) which is the ability to troubleshoot, repair, and maintain photovoltaic systems, prolonging their lifespan and reliability.

Thus, these are among the innovative, emerging and technical skills that can be possessed for self-reliance, even to be an employer of labor and make meaningful contribution to the society. Therefore, photovoltaic cell system skills are part and parcel of entrepreneurship skills that need to be possessed for self-reliance. However, the unemployment level in Nigeria has persistently keep increasing at alarming rates, this is a worrisome development which requires an urgent attention such as developing a course of training for self-reliance. But this course of training can only be developed through assessment of innovative and technical skills required to excel in such course among which is photovoltaic cell wiring and maintenance skills. That was why it was pertinent to conduct this study in order to find out the skills needed in wiring and maintenance of photovoltaic cell by electrical/electronic technology education graduates for self-reliance in northern Nigeria.

Statement of the Problem

One of the primary objectives for the establishment of technology education programmes at tertiary levels including universities, is that after successful completion of the program, the trainees and/or graduates should be able to acquire employability and practical skills that earn a good and comfortable living (self-

employed) and even an employer of labor. However, this objective seems not to be adequately achieved, because according to a report by the National Bureau of Statistics (NBS, 2022) which said the rate of unemployment among teeming youths including graduates of technology education and electrical/electronic technology education is increasing on a quarterly basis.

The graduates' unemployment (including EET graduates) is due to lack of adequate employability skills needed in the world of work (Olojuolawe et al., 2022; Madubuiké & Dimnajiégo, 2023 and Olubusoye et al., 2023). Despite photovoltaic cell system having numerous skills components that can be possessed for self-reliance, but schools are yet to incorporate these vital components into the curriculum of EET in universities in Nigeria. This assertion is being supported by Aboagye, et al., (2022) who said that essential components failure of the photovoltaic system in Nigeria is caused by poor wiring and maintenance. These problems are associated with inadequate training in photovoltaic cell wiring and maintenance. The cause of this inadequate training is associated with a complete absence of it in the curriculum of electrical/electronic technology education in universities in Nigeria.

Therefore, one of the ways to curb the menace of unemployment among the teeming unemployed graduates including EET graduates is by incorporating photovoltaic cell wiring and maintenance skills course into the curriculum of electrical/electronic technology education so that the graduates will possess relevant innovative practical skills needed to become self-employed and even the ability to employ others. Hence, it was imperative to conduct this study.

Purpose of the study

The main purpose of this study was to find out the photovoltaic cell wiring and maintenance skills needed by electrical technology graduates for self-reliance in northern Nigeria. Specifically, the study determined the following skills needs:

- 1) The photovoltaic cells wiring skills needed by electrical technology graduates for self-reliance in northern Nigeria.

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- 2) The photovoltaic cell maintenance skills needed by electrical technology graduates for self-reliance in northern Nigeria.

Hypotheses of the Study

H₀₁: There was no significant difference of the responses among the respondents on photovoltaic cell installation skills needed by electrical technology graduates for self-reliance in Northern Nigeria.

H₀₂: There was no significant difference among the respondents of the responses on photovoltaic cell load demand assessment skills needed by electrical technology graduates for self-reliance in Northern Nigeria.

METHODOLOGY

A descriptive research design was employed and questionnaire instrument was administered to 52 respondents, which comprised

lecturers, technologists and solar installers. (PVC-WMS) Needed Questionnaire instrument was used for data collection. The instrument for data collection was validated by experts, and their inputs were used for improving the instrument. The instrument was pilot tested outside the study area having the same characteristics with the study area and .93 coefficient was obtained. The instrument was administered by the researcher and two research assistants. Data collected was analyzed using mean and standard deviation.

RESULTS AND DISCUSSIONS

Research Question 1:

What are the photovoltaic cells wiring skills needed by electrical/electronic technology education graduates for self-reliance in Northern Nigeria?

Table1: Mean and Standard Deviation of Respondents on Photovoltaic Cell wiring skills needed by ETG for Self-Reliance

S/No	Items on Photovoltaic Cell Wiring Skills Needed	\bar{X}_L		\bar{X}_T		\bar{X}_S		\bar{X}_{TA}		Remark
		N =29	SD _L	N = 6	SD _T	N=17	SDs	N=52		
1	Ability know power loss due to size of wire	3.59	.825	3.17	1.16	3.29	.772	3.51	HN	
2	Ability to know voltage drop of a wire	3.38	1.17	3.17	.753	3.29	.920	3.57	HN	
3	Ability to know wire length	3.24	1.05	4.17	.753	3.18	1.01	3.52	HN	
4	Ability to know wire size	3.59	1.08	3.50	1.22	3.65	.862	3.58	HN	
5	Ability to know voltage drop	3.72	.702	3.33	.816	3.53	1.17	3.61	HN	
6	Ability to know types of wire	3.34	1.07	3.83	.753	3.47	1.12	3.43	N	
7	Ability to know conductor types	3.79	1.08	3.50	1.04	3.24	.970	3.51	HN	
8	Ability to choose correct size of wire	3.55	1.18	3.80	.837	3.76	.752	3.64	HN	

Key; Highly Needed (HN), Needed (N)

The results in table 1 provides information for answering research question 1, which reveals the mean and standard deviation of the responses of electrical technology lecturers, technologist and PVC installers on photovoltaic cell wiring. All the items had means rating between 3.50- 4.49 respectively. This indicates that their rating scale fall within 3.50 – 4.49 real

limit. Therefore, the items were highly skills needed by ETG for self-reliance. Furthermore, these items included; 1, 2,3, 4, 5, 6, 7 and 8 respectively and considering their standard deviation which fall within the same range (0-1) indicated that the respondents' responses across all the items do not vary much. Consequently, these items are highly needed by ETG for self-

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reliance.

What are the photovoltaic cell maintenance skills needed by electrical/electronic technology graduates for self-reliance Northern Nigeria?

Research Question 2:

Table 2: Mean and Standard Deviation of Respondents on Photovoltaic Cell Maintenance Skills needed by Electrical/Electronic Technology Graduates for Self-Reliance?

S/No	Items on Maintenance Skills Needed	\bar{X}_L		\bar{X}_T		\bar{X}_S		\bar{X}_{TA}	Remark
		N=29	SD _L	N = 6	SD _T	N=17	SD _S		
1.	Ability to carry out visual inspection of wiring system of solar panels.	3.55	.686	3.00	1.54	3.41	.795	3.40	N
2.	Ability to evaluate structural attachment sealing of solar panels.	3.83	.711	3.67	.816	3.47	1.00	3.69	HN
3.	Ability to clean debris of solar panels.	3.90	.673	3.50	1.04	3.53	.717	3.64	HN
4.	Ability to measure electrical characteristics of solar panels	3.46	.576	3.00	1.41	3.65	.786	3.37	HN
5.	Ability to verify system performance of solar panels	4.10	.673	3.33	1.03	3.59	.795	3.67	HN
6.	Ability to Supply the structure of solar panels.	3.93	.651	3.50	1.37	3.71	.686	3.58	HN
7.	Ability to mount solar photovoltaic panels.	4.21	.726	3.67	1.03	3.65	.702	3.84	HN
8.	Ability to mount the structure of all other system components of solar photovoltaic panels.	3.34	.769	3.50	1.22	3.69	.704	3.47	N
9.	Ability to measure the electrical characteristics of solar photovoltaic panels system from time to time.	3.52	.738	3.67	.816	3.59	.618	3.56	HN
10.	Ability to carry out basic measurement of solar panels using digital multimeter.	3.52	.688	3.50	.837	3.53	.717	3.52	HN

Key; Highly Needed (HN), Needed (N)

The result in table 2 gives information for answering research question 2, which reveals the mean and standard deviation of the responses of electrical technology lecturers, technologist and PVC installers on photovoltaic cells maintenance skills. All the items were highly needed with exception of only one item. This indicates that their rating scale fall within 3.50 – 4.49 real limit. Therefore, the items were highly needed by ETG for self-reliance. Furthermore, these items include:

2, 3,4,5,6,7,8,9 and 10 respectively and considering their standard deviation which fall within the same range (0-1) indicated that the responses of the respondents across all the items do not vary much. Consequently, these skills are needed by ETG for self-reliance.

H_{01} : There is no significant difference among the responses of electrical/ electronic lecturers, technologists and PVC installers on photovoltaic wiring skills needed by

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electrical/electronic technology graduates for self-reliance

Table 3: ANOVA Responses of Electrical/Electronic Technology Lecturers, Technologists and PVC Installers on Photovoltaic Wiring Skills Needed

	Sum of squares	df	Mean squares	F	Sig.
Between Groups	.202	2	.101	.352	.705
Within Groups	14.064	49	.287		
Total	14.266	51			

The result of the analysis of variance in table 3 suggests that the mean responses of the respondents namely; electrical/electronic technology lecturers, technologists and PVC installers do not differ significantly $F = .352, p = .705$. Therefore, the hypothesis is accepted. Accordingly, this result suggests that there is no significant difference among the three

respondents on the photovoltaic wiring skills needed by ETG for self-reliance.

H₀₂: There were no significant differences among the respondents on photovoltaic cell maintenance skills needed by electrical technology graduates for self-reliance in Northern Nigeria.

Table 4: ANOVA Responses of Electrical/Electronic Technology Lecturers, Technologists and PVC Installers on Photovoltaic Maintenance Skills Needed

	Sum of squares	df	Mean squares	F	Sig.
Between Groups	.024	2	.012	.427	.625
Within Groups	1.353	49	.25		
Total	1.387	51			

The result of the analysis of variance in table 14 indicates that the mean responses of the respondents namely; electrical/electronic technology lecturers, technologists and photovoltaic cells installers do not differ significantly $F = .427, p = .625$. Therefore, this hypothesis is also accepted consequently, this result shows that there is no significant difference of responses among the electrical/electrical lecturers, technologists and PVC installers on photovoltaic cell maintenance skills needed by ETG for self-reliance.

high rate of youth unemployment is a worrying factors and called for curriculum upgrade to capture more on skills that are needed in the labor market.

Findings from research question two reveals that the respondents rated most of the items as highly needed skills needed for the load demand assessment of photovoltaic cell, particularly by sizing correctly and accurately the solar panel, dividing the average amp-hour per day by the load of the estimated battery, determining the energy efficiency of the system just to mention few among others. This finding was supported by Aniah, and Mohammed (2021) who said that the TVET curriculum was obsolete due to lack of evolving skills and they suggested for the needs to review curriculum with more emphasis on relevant employability skills for trainee's self-reliance.

DISCUSSION OF FINDINGS

Findings on photovoltaic wiring skills needed by electrical/ electronic technology graduates for self-reliance reveal that the items were rated highly needed or needed by three respondents, to include; ability to know power loss due to size of wire, to know voltage drop of a wire, to know wire length, and ability to know voltage drop and many more among others. This finding was supported by Mata (2021) who noted that the

CONCLUSION

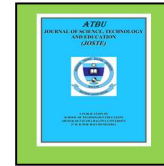
Most of the items on photovoltaic cell wiring and maintenance skills were highly needed

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by ETG for self-reliance. Therefore, they should be included into electrical/electronic technology education curriculum of universities in Nigeria.

RECOMMENDATIONS

- i. Government should consider a curriculum review and upgrade with emphasis on the acquisition of practical skills among which is the photovoltaic cell installation.
- ii. Government should also make provision of well-equipped and functional workshops with state-of-the-art facilities.
- iii. Universities should develop a comprehensive and standardized training program for photovoltaic installation to meet the unanimous demand across all respondent categories.
- iv. Universities should adapt training modules to address the significant differences in respondent ratings and enhance problem-solving abilities related to photovoltaic cell installation and load demand assessment.
- v. Universities should promote standardization in training and certification for photovoltaic cell ensuring consistency and reliability in installations and load demand assessment.

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