



Development of Self-Instructional Guide for Installation of Solar Power System for Electrical Craftsmen in Nigeria

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ABSTRACT

The study developed a self-instructional guide for installation of solar power system for electrical craftsmen in Nigeria. The lack of good installation in solar power industries and lack of reliable and sustainable electricity in Nigeria has made solar power systems a viable option for providing power to households and businesses. However, the installation of solar power systems requires specialized knowledge and skills that are not readily available to electrical craftsmen in Nigeria. The development of a self-instructional guide provided solution to this challenge by equipping electrical craftsmen with the necessary knowledge and skills to install and maintain solar power systems. The guide was developed through a review of existing literature and consultations with Subject Matter Experts (SMEs) in the field of solar power systems. The guide was designed to be user-friendly and included detailed step-by-step instructions, diagrams, and illustrations. The effectiveness of the self-instructional guide was evaluated through a field study involving electrical craftsmen in Nigeria. The results of the study provided insights into the usefulness of the guide and its potential impact on the adoption of solar power systems in Nigeria.

ARTICLE INFO

Article History

Received: November, 2022

Received in revised form: January, 2023

Accepted: March, 2023

Published online: May, 2023

KEYWORDS

Self-instructional guide, Installation, Solar power system, Electrical craftsmen.

INTRODUCTION

Solar Power System (SPS) is a form of photoelectric process of converting solar energy directly to electrical energy. According to Dahuwa *et al*, (2017) SPS is the process which sunlight is converted in to electricity through a photocell, this could be in a stand-alone home system or industrial layout fashion. It includes a Photovoltaic (PV) module, charge controller, inverter, battery, solar tracker, combiner box, fuse, and interconnection cable installed as a unit to produce direct or alternating current (Messenger, 2017). Solar power

system derived directly or indirectly as an effect of the "sun's energy" is classified as Renewable Energy (RE) and is renewed indefinitely by nature. SPS is sustainable, it can be replenished, and has no harmful side effects for the most part of climate change, majorly caused by environmental pollution (e.g., carbon emission), it has been the main trigger for actions taken by most world governing bodies towards the employment of these renewable (alternative) energy resources. SPS is very reliable and clean source of electricity that can suit wide range of application such as residence,

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industry, agriculture and others but Mughees *et al*, (2020) noted that solar power system installed face degradation of efficiency due to shading, temperature rise and dust accumulation as a result of improper installation.

Installation is a combination of electrical equipment arranged from electrical supply to fulfil a particular purpose. Ihediwah, (2017) defined installation as the coordinated activities carried on a piece of equipment or machines in a systematic manner to make it active for use. Despite the potentials of SPS, the number of solar energy projects in Nigeria are still minimal because of several installation issues that really require much attention (Mutezo and Mulopo, 2021). Some of these issues are listed thus: wrong selection of panels (Mono or Poly) placement of panels at very wrong degrees, poor understanding of the consumption rate, under sizing of system, poor designing, wrong cabling and incompetent installers (Zhang *et al*, 2021). Ukandu, (2016) further stated that there are many factors that limit installation of solar power system. These are determination of weather condition, location, load factor, complicated wire tie-ins, battery wiring, solar cells positioning, roof placement installation, and electrical panel connections. The fragile nature of the SPS requires experts on the components since proper installation is an activity that help prolong the life of the SPS, it is an activity that require professionals with reasonable level of expertise like electrical craftsmen.

Electrical craftsmen are individuals who have undergone training in any electrical trade from the

technical college system. Ejo-Orusa and Mpi (2019) define electrical craftsmen as trained persons who have acquired sufficient skills in the practice of a trade over long period and in most cases self-employed. According to Lemon (2018), despite the training enjoyed by electrical craftsmen, they required the technical training on SPS to meet the demands of electrical industry and the needs of the individual. Hence, the technical training can be achieved through the use of self-instructional guide. A self-instructional guide is a manual designed to contain sequential procedures or instructions for accomplishing various tasks in different areas or aspects of human endeavour (Srivastava, 2019). Salem *et al*, (2019) further stated that the following should be taken into consideration when designing a self-instructional guide: objectives, content-topics, tasks, procedures, evaluation and facilities required for installation. From the foregoing therefore, Self-instructional guide in the context of this study refers to a compilation of planned contents which specifies; operational tasks, learning objectives for accomplishing identified tasks, tools/materials, and instructional criterion that serve as a guide in teaching the procedures required to carry out installation and maintenance of SPS. The benefits of Self-instructional guide are enormoust the realization of these benefits is hinged on the quality of inputs from the Subject Matter Experts. The Subject Matter Experts (SMEs) are people with special knowledge or skills in a particular area of endeavour (Uduafemhe, 2019). The SMEs are important in development of a self-instructional guide because, they determine the steps, related knowledge,

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attitudes, performance standards, tools and materials needed, and safety concerns required of people performing tasks, for inclusion into the content of the self-instructional guide.

Statement of the Research Problem

Electrical Installation and Maintenance Works (EIMW) taught in technical colleges are poised with potentials of equipping the students with prerequisite skills to propel them to contribute meaningfully to national economic development, be self-reliant and job creators towards reduction of unemployment. Unfortunately, Ihediwah (2017) stated that, most electrical craftsmen roam the street unhired because they lack saleable skills which includes installation and maintenance of solar power system. The lack of skills among electrical craftsmen on the installation and maintenance of solar power system is simply due to the absence of the contents of Solar Power System in the curriculum used for teaching them. Many solar installations today get bad after short period of installations due to quacks taking over the installations. Therefore, if a self-instructional guide for the installation and maintenance of solar power system for electrical craftsmen is developed, it could serve as a basis that will lift them into the competitive market of the industry in which they have a huge stake. The problem of this study is therefore to develop self-instructional guide for installation and maintenance of solar power system for Electrical craftsmen in Nigeria.

Research Questions

1. What are the objectives of self-instructional guide for installation of solar power system?
2. What are the contents of self-instructional guide for installation of solar power system?

Hypotheses

The following hypotheses were tested at 0.05 level of significance:

- H0₁:** There is no significant difference among the mean responses of Electrical/Electronics personnel from Government solar industries and institutions, and solar private industries on the objectives of self-instructional guide for installation of solar power system.
- H0₂:** There is no significant difference among the mean responses of Electrical/Electronics personnel from Government solar industries and institutions, and private solar industries on the contents of self-instructional guide for installation of solar

METHODOLOGY

The study adopted Research and Development (R&D) using Successive Approximation Model (SAM) and quasi experimental research design. Specifically, the Pre-test Post-test non-equivalent Treatment Group Design was employed for the study, in this design, there are two or more groups, but they are not randomly assigned. The groups are compared based on their exposure to different conditions or treatments. The study was carried out in Niger, FCT Abuja, Kaduna and Sokoto States. The population for the study is 235, the

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population consisted of all the 189 Subject Matter Experts (SMEs) from six solar companies/institutions of learning and 46 electrical craftsmen. Purposive sampling technique (PST) was used for the study, from the population of 189 possible SMEs, purposive sampling technique was therefore used to select 110 SMEs. The instrument for data collection developed by the researcher is titled: Solar Power Systems installation

and maintenance self-instructional guide development questionnaire (SPSIMSIGDQ). Solar Power Systems installation and maintenance self-instructional guide psychomotor achievement test (SPSIMSIGPAT), Solar Power Systems installation and maintenance self-instructional guide psychomotor rating scale (SPSIMSIGPRS).

The responses scale is stated below:

Strongly Agree (SA)/	Highly required,	5
Agree (A)	Required,	4
Disagree (D)	Not Required,	3
Strongly Disagree (SD)	Highly Not Required	2
Undecided (U)	Undecided	1

Source: researcher

The Solar Power Systems installation and maintenance self-instructional guide psychomotor achievement test (SPSIMSIGPAT) contains five items is a practical question on Solar Power system. The instrument will be a five-point rating scale of Strongly Agree/ Highly Required (SA/HR=5), Agree/Required(A/R=4), Disagree/Not Required(D/NR=3), Strongly Disagree/Highly Not Required (SD/HNR=1) and Undecided (UD=1).

The research instruments SPSIMSIGDQ, SPSIMSIGPAT, SPSIMSIGPRS were face and content validated by three experts. The instrument (SPSIMSIGDQ) was pilot tested using 18 SMEs in four solar companies' and. the coefficient of internal consistency of the instrument was calculated using Cronbach's Alpha and found to be: 0.82 and 0.76, for section B and C respectively and overall reliability index of 0.79. The research

instruments were administered on the respondents with help of four research assistants, one each from Niger, Sokoto, Kaduna, and FCT Abuja. Data collected from the respondents will be analysed using mean and Analysis of Variance (ANOVA) Mean will be used to analyse data to answer research questions 1-2, ANOVA will be used to test hypothesis 1-2. The choice of mean to answer research questions 1-2 is based on the fact that, it is the commonly used measure of central tendency used in educational reach. The choice of ANOVA to test hypothesis 1-2 is because, it is the most appropriate test to measure the significant difference between the mean scores of three group of respondents above 30 in number. In order to determine the agreement level of the items of the research questions, the mean ratings of respondents will be interpreted using real limits of numbers. Real limits are boundaries located

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exactly half-way between adjacent categories used to define continuous variables in research (Foster *et al.*, 2018). The real limits of numbers to be used in this study are shown in Table 1.0

RESULTS

Analysis and presentation of data are ordered according to the

research questions and hypotheses that guided the study

RQ1: What are the objectives of self-instructional guide for installation of Solar Power System?

Data for providing answer to this research question 1 are presented in Table.1

Table 3.1: Mean and Standard Deviation of respondents on the objectives of self-instructional guide for installation of solar power system

S/NO	ITEM	GIS		GSL		PSI		AVERAGE		REM
		X	SD	X	SD	X	SD	X	SD	
1	Fundamentals of Electricity	3.83	0.77	4.03	0.85	4.18	0.83	4.01	0.82	Agreed
2	Solar power designs and sizing	4.11	0.85	4.06	0.79	4.09	0.79	4.09	0.81	Agreed
3	Safety precautions	4.17	0.77	3.73	0.84	3.94	0.78	3.95	0.80	Agreed
4	Installation of PV Module	3.97	0.81	4.00	0.87	4.00	0.82	3.99	0.83	Agreed
5	Installation of solar conductor	4.06	0.89	4.03	0.85	4.15	0.89	4.08	0.88	Agreed
6	Installation of charge controller	3.89	0.78	3.85	0.83	3.85	0.82	3.86	0.81	Agreed
7	Installation of inverter	3.83	0.85	3.97	0.85	4.18	0.72	3.99	0.81	Agreed
8	Installation of solar batteries	4.06	0.83	4.21	0.82	4.00	0.78	4.09	0.81	Agreed

The results in Table 3.1 show the mean and standard deviation of the responses of Electrical/Electronic personnel from Government solar industries, Government solar institutions, and Private solar industries on the objectives of self-instructional guide for installation of solar power system. The result of analysis shows that average means of all items of the research question were in the range of 3.86 – 4.09, all of which are in the

3.50 – 4.49 real limit. Therefore, the respondents were in agreement with all the items as the objectives of self-instructional guide for installation of solar power system. Furthermore, the average standard deviations of the items were in 0.80 and 0.88 range. This is an indication that all the responses were dispersed close to the mean. In addition to this, none of the standard deviations was up to the standard normal deviate of

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1.96. This therefore strengthens the integrity of the mean.

Data for providing answer to this research question 2 are presented in Table 3.2

RQ2: What are the Contents of self-instructional guide for installation of Solar Power System?

Table 3.2: Mean and standard deviation of respondents on contents of self-instructional guide for installation of Solar Power System

S/N	Contents on Fundamentals of Electricity	GIS		GSL		PSI		AVERAGE		REM
		X	SD	X	SD	X	SD	X	SD	
1	Power (P) is the rate of energy conversion measured in Watts	4.06	0.79	4.12	0.86	3.97	0.76	4.05	0.80	Agreed
2	Voltage (V) is the potential difference in electrical charge between two points measured in Volts	3.83	0.88	4.15	0.71	3.88	0.73	3.95	0.77	Agreed
3	Current (I) is the flow of electrons in a circuit/wire between two points measured in Amperes	3.72	0.74	4.09	0.77	4.15	0.78	3.99	0.76	Agreed
4	When electrical circuits are wired in parallel, currents are added and voltage stays the same.	3.86	0.80	4.15	0.87	4.15	0.70	4.05	0.79	Agreed
5	Power (P) is the rate of energy conversion measured in Watts	4.14	0.90	3.91	0.84	4.21	0.77	4.09	0.84	Agreed
6	Voltage (V) is the potential difference in electrical charge between two points measured in Volts	4.03	0.88	4.00	0.79	4.06	0.85	4.03	0.84	Agreed
7	Current (I) is the flow of electrons in a circuit/wire between two points measured in Amperes	3.83	0.70	4.15	0.83	4.12	0.69	4.03	0.74	Agreed
8	When electrical circuits are wired in parallel, currents are	3.89	0.75	4.24	0.87	4.00	0.78	4.04	0.80	Agreed

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	added and voltage stays the same.									
9	Resistance (R) is the opposition to the flow of electrical current in the material through which it is passing measured in Ohms	3.89	0.82	3.82	0.73	4.26	0.86	3.99	0.80	Agreed
10	Energy (E) refers to the capacity for work i.e., the power used over time, measured in Watt hours	4.03	0.77	4.00	0.87	3.94	0.85	3.99	0.83	Agreed
11	In electricity generation there are two distinct types of electrical current - direct current (DC) and alternating current (AC).	3.72	0.85	4.03	0.81	3.85	0.78	3.87	0.81	Agreed
12	Alternating current is the type of current most commonly used in households to power electrical appliances (for example TVs, refrigerators, radios and computers). Grid supplied electricity is alternating current.	4.08	0.81	3.97	0.92	4.09	0.83	4.05	0.85	Agreed
13	Direct current is produced by PV modules and stored in batteries.	3.94	0.79	4.09	0.84	3.94	0.81	3.99	0.81	Agreed
14	Alternating current can be transferred over a long distance	4.17	0.77	4.12	0.78	4.12	0.88	4.14	0.81	Agreed
15	Direct current cannot be transferred over long distance	4.00	0.79	3.94	0.83	3.76	0.82	3.90	0.81	Agreed
16	Alternating current has a frequency of 50Hz or 60Hz	4.03	0.91	4.15	0.76	4.09	0.79	4.09	0.82	Agreed
17	Direct current has zero frequency	3.94	0.86	4.06	0.86	3.68	0.68	3.89	0.80	Agreed

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18	Alternating current cannot be stored	3.89	0.92	4.03	0.85	4.06	0.85	3.99	0.87	Agreed
19	Direct current can be stored in batteries	3.92	0.91	3.97	0.85	3.97	0.80	3.95	0.85	Agreed
20	Energy cannot be created nor be destroyed but can be transformed from one form to another e.g. Sunlight to Electricity	3.94	0.79	4.03	0.81	3.85	0.74	3.94	0.78	Agreed

	Contents on Solar Power Designs and Sizing	GIS		GSL		PSI		AVERAGE		REM
		X	SD	X	SD	X	SD	X	SD	
21	Power = Volts x Current, P = V x I in Watts	4.11	0.85	3.82	0.73	3.82	0.87	3.92	0.82	Agreed
22	Volts= Power /Current, V= P/I in Volts	4.06	0.79	3.76	0.83	3.97	0.90	3.93	0.84	Agreed
23	Current = Power/ Volts, I= P/V in Amperes	4.14	0.87	4.06	0.90	4.24	0.85	4.15	0.87	Agreed
24	Resistance = Volts/ Current, R= V/I in Ohms	3.75	0.84	4.00	0.83	3.91	0.90	3.89	0.86	Agreed
25	Energy = power x time E= P x t in watt-hours	4.11	0.78	4.00	0.94	3.97	0.87	4.03	0.86	Agreed
26	10 watt + 7 watts + 5 watt + 3 watts + 15 watt = 40 watts	3.81	0.79	3.94	0.79	4.12	0.81	3.96	0.80	Agreed
27	A battery of 12V, 200Ah is having a 2400 Watts of Power	3.94	0.89	4.24	0.83	4.21	0.81	4.13	0.84	Agreed
28	Total voltage of four 1.5V DC batteries connected in series is 6 V	4.11	0.75	4.21	0.74	4.00	0.89	4.11	0.79	Agreed
29	Total voltage of four 1.5V DC batteries connected in parallel is 1.5V	4.06	0.83	4.18	0.81	3.94	0.74	4.06	0.79	Agreed
30	Total voltage of three solar panel 120W, 30V connected in series is 90V	3.86	0.83	4.15	0.83	4.00	0.78	4.00	0.81	Agreed
31	Total voltage of three solar panel 120W, 30V each connected in parallel is 30 V	3.92	0.84	3.94	0.79	4.18	0.80	4.01	0.81	Agreed
32	The total amperage of three PV panels in parallel with 32 amps each is 96 A	3.94	0.89	3.79	0.78	3.94	0.85	3.89	0.84	Agreed
33	Total current of three solar panel 120W, 30A connected in series is 30A	4.06	0.79	4.09	0.80	3.88	0.81	4.01	0.80	Agreed

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34	On a clear day, the total insolation striking the earth is about 1,000 watts per square meter.	3.75	0.73	3.97	0.81	4.15	0.82	3.96	0.79	Agreed
35	A 29-inch colour TV with 120W used for 4hours will need energy of 280 Watt-Hours	4.08	0.84	3.94	0.83	3.91	0.83	3.98	0.83	Agreed
36	Two Fluorescent Lamps 15W each used for 4 hours will need energy of 120watt-Hours	4.11	0.82	4.15	0.80	3.82	0.83	4.03	0.82	Agreed
37	PV Module Size = $\frac{\text{Total Daily Watt Hours}}{\text{Average Daily Solar Insolation}}$	4.06	0.83	4.06	0.83	3.91	0.87	4.01	0.84	Agreed
38	Battery Capacity = $\frac{\text{Daily Load}}{\text{Battery Efficiency}}$	3.78	0.76	3.64	0.78	4.21	0.77	3.88	0.77	Agreed
39	The size of the inverter will be given by $246 \times 1.3 = 319.8$ Watts, the right size of inverter will be 400 Watts	3.83	0.81	3.91	0.88	3.94	0.81	3.89	0.83	Agreed
40	Connect PV panels in series and in parallel	3.92	0.81	3.94	0.86	3.76	0.78	3.87	0.82	Agreed
41	Ensure safety practices in solar power installations are obeyed	3.89	0.78	3.88	0.82	3.97	0.80	3.91	0.80	Agreed
42	Ensure tools and equipment used in solar power installation are adequate for the job to be carried out	3.97	0.84	4.00	0.87	3.85	0.86	3.94	0.86	Agreed
43	Ensure the diagnostic tools are functional	4.00	0.79	3.94	0.83	3.85	0.82	3.93	0.81	Agreed
44	Ensure proper sizes for the PV panel, charge controller, inverter and battery.	4.33	0.79	4.18	0.88	3.97	0.80	4.16	0.82	Agreed
45	Ensure the right cables sizes for solar power installation	4.03	0.84	3.94	0.90	3.88	0.88	3.95	0.87	Agreed
46	Ensure the D. C. Circuit breakers are functional	4.03	0.70	4.00	0.97	4.03	0.80	4.02	0.82	Agreed
47	The total amperage of the four panels connected in series is 3A. and total current ratings of all panel strings should not exceed 80% of the charge controller's current rating (i.e. 24A for the 30A charge controller)	4.08	0.84	4.03	0.92	3.94	0.78	4.02	0.85	Agreed
48	Make sure the material is strong enough to provide mechanical support to the solar panels and mounting hardware against possible wind load	4.11	0.85	4.12	0.89	4.09	0.79	4.11	0.84	Agreed

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49	Position the panels to minimize wiring distance between the solar panel and the charge controller	3.86	0.72	3.97	0.77	4.12	0.77	3.98	0.75	Agreed
50	Batteries contain very corrosive diluted sulfuric acid as electrolyte. Precautions should be taken to prevent contact with skin, eyes, or Clothing	3.86	0.87	4.24	0.75	4.09	0.87	4.06	0.83	Agreed
51	Check the AC voltage output/input, frequency, temperature, load consumption and DC input	4.03	0.88	4.06	0.75	4.09	0.87	4.06	0.83	Agreed
52	Use Multimeter or hygrometer to test the voltage output from the battery	4.08	0.91	4.03	0.92	3.97	0.87	4.03	0.90	Agreed
53	Connect the positive (+) cable from the battery bank to the positive terminal of the direct current (battery) side of the inverter. (DC Input). Test that the cable is secure	4.00	0.83	3.76	0.83	4.09	0.87	3.95	0.84	Agreed
54	Install the inverter close to the battery bank	3.94	0.75	3.91	0.84	4.00	0.85	3.95	0.81	Agreed
55	Pure sine wave power inverter produces cleaner power	3.97	0.84	4.21	0.82	4.09	0.71	4.09	0.79	Agreed
56	These two 12V batteries are paralleled, the amperage is same (that is 12V) but the voltage is doubled	4.25	0.69	4.06	0.83	3.85	0.78	4.05	0.77	Agreed
57	For series connection connect negative (-) to positive (+) terminal	3.89	0.82	3.88	0.78	4.06	0.89	3.94	0.83	Agreed
58	Parallel connection of two number of 12volts batteries Connect the negative terminal (=) negative (=) terminal of the next battery and also positive (+) to positive (+) terminal.	4.11	0.75	3.94	0.83	4.29	0.72	4.11	0.77	Agreed
59	The charge controller should ideally be located in an area relatively close to the battery	3.94	0.79	3.91	0.80	3.88	0.88	3.91	0.82	Agreed
60	The "100 watts" rating on the solar panel isn't extremely useful, unless you know that it's 100 watts at 12V	3.86	0.90	4.18	0.68	3.94	0.78	3.99	0.79	Agreed
61	Two or more solar panels connected in parallel to increase the current output while the	3.89	0.78	4.09	0.77	4.06	0.69	4.01	0.75	Agreed

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	output voltage remains the same.											
62	Two or more batteries connected in parallel to increase the current output while the output voltage remains the same.	4.03	0.81	4.18	0.73	3.97	0.80	4.06	0.78	Agreed		
63	Only use properly insulated tools when making battery connections	4.00	0.83	3.76	0.75	3.97	0.80	3.91	0.79	Agreed		
64	Do not over use the battery while at low voltage else it will die quick	3.81	0.79	3.88	0.86	4.00	0.85	3.90	0.83	Agreed		
65	Check the general condition of the array module wiring and mounting hardware bi-annually	4.19	0.75	4.12	0.82	3.88	0.84	4.06	0.80	Agreed		
66	Always use the correct tools during maintenance operations to avoid damaging the solar panel	3.92	0.73	4.06	0.86	4.06	0.81	4.01	0.80	Agreed		
67	Replace any broken or cracked panel to ensure full system functionality	4.03	0.81	3.85	0.80	3.88	0.77	3.92	0.79	Agreed		
68	Make sure inverter ratings exceed total system wattage by 20%	4.03	0.82	3.88	0.81	3.92	0.78	3.94	0.80	Agreed		
	Contents on Safety Precautions											
		GIS		GSL		PSI		AVERAGE	REM			
		X	SD	X	SD	X	SD	X	SD			
69	Understand the components to be install or maintained before starting the process of installation or maintenance.	4.11	0.89	4.12	0.74	4.00	0.74	4.08	0.79	Agreed		
70	Wear Safety goggles when installing a solar battery	4.11	0.85	3.97	0.88	4.21	0.84	4.10	0.86	Agreed		
71	Wear Safety hard hats, when installing a solar PV Module	4.00	0.86	4.30	0.81	3.82	0.83	4.04	0.83	Agreed		
72	Wear Safety protective gloves carrying out installation on solar power system.	4.14	0.83	3.91	0.84	3.91	0.83	3.99	0.83	Agreed		
73	Wear Safety clothing, non-slip boots, when	3.89	0.85	4.03	0.85	4.32	0.77	4.08	0.82	Agreed		

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	installing a Solar power system										
74	Wear Safety clothing, non-slip boots, when installing a solar power system	3.83	0.81	4.15	0.87	4.12	0.77	4.03	0.82	Agreed	
75	Wear Safety respiratory protection. It is important to wear the appropriate safety gear while working with solar power systems to avoid potential injury or harm.	4.00	0.83	3.82	0.77	4.12	0.88	3.98	0.83	Agreed	
76	Secure the Roof: Make sure the roof is structurally sound and secure. If it is necessary to walk on the roof, use safety precautions such as using a safety harness and non-slip shoes	4.06	0.63	4.09	0.95	3.85	0.82	4.00	0.80	Agreed	
77	Choose the Right Equipment: Choose components that are certified and designed for solar installation	3.94	0.79	3.91	0.72	4.03	0.87	3.96	0.79	Agreed	
78	Install Properly: Install components according to manufacturer's instructions, using the appropriate tools and fasteners.	4.22	0.87	3.94	0.79	3.91	0.79	4.02	0.82	Agreed	
79	Properly Ground System: Ground the system to meet local electrical codes.	4.11	0.92	3.88	0.74	3.76	0.82	3.92	0.83	Agreed	
80	Protect the Inverter: Install the inverter in an area protected from weather and direct sunlight	4.11	0.78	4.06	0.90	4.00	0.89	4.06	0.86	Agreed	
81	Monitor System Performance:	3.72	0.74	3.67	0.69	4.03	0.87	3.81	0.77	Agreed	
82	Install the charge controller far from any inflammable substance	3.78	0.76	4.03	0.81	3.88	0.84	3.90	0.80	Agreed	
83	Install the battery far from any inflammable substance	4.06	0.83	4.03	0.81	3.85	0.82	3.98	0.82	Agreed	

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84	Maintain the System: Perform routine maintenance, such as cleaning solar panels and replacing batteries, to keep the system operating safely and efficiently.	3.81	0.82	4.09	0.80	4.03	0.87	3.98	0.83	Agreed
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	Contents on Installation of PV Module	GIS		GSL		PSI		AVERAGE		REM
		X	SD	X	SD	X	SD	X	SD	
85	Select the right tool for the job	3.97	0.77	4.00	0.79	3.97	0.87	3.98	0.81	Agreed
86	Position your scaffold or ladder properly on the wall.	4.00	0.79	3.97	0.88	4.29	0.76	4.09	0.81	Agreed
87	Climb the ladder to the roof or the rack where panels will be mounted	4.06	0.86	4.21	0.89	4.06	0.85	4.11	0.87	Agreed
88	Determine the right location for the installation.	3.97	.81	4.03	.81	4.09	.87	4.03	0.83	Agreed
89	Take measurement and compare with the size of panels to be mounted	4.03	0.81	4.03	0.85	3.82	0.87	3.96	0.84	Agreed
90	Mount fasteners and brackets.	4.14	0.80	4.12	0.89	4.32	0.81	4.19	0.83	Agreed
91	Two or more people should carry the panel gently and gradually to the top of roof	3.94	0.86	4.18	0.77	3.97	0.80	4.03	0.81	Agreed
92	Attach Solar Panel - Secure the solar panel to the mounting system with the appropriate hardware	4.31	0.82	4.00	0.87	4.24	0.89	4.18	0.86	Agreed
93	Connect Wiring - Connect the wiring on the solar panels	4.03	0.77	3.91	0.80	4.00	0.89	3.98	0.82	Agreed
94	Connect the wiring from the solar panel to the central conductor.	4.06	0.86	3.88	0.89	4.06	0.81	4.00	0.85	Agreed
95	Test and Inspect - Test the system and inspect all panels to ensure that the installation has been completed correctly	3.89	0.85	3.97	0.77	3.76	0.82	3.87	0.81	Agreed

	Contents on Installation of Solar Conductor	GIS		GSL		PSI		AVERAGE		REM
		X	SD	X	SD	X	SD	X	SD	
96	Plan the solar conductor system: Determine the size of the system	3.94	0.86	4.03	0.88	4.00	0.89	3.99	0.88	Agreed

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needed, the location of the system, and any other requirements.

97	Obtain permits and approval: Secure all necessary permits, such as electrical and building permits, and approval from local authorities or utility companies.	4.11	0.85	3.97	0.88	4.00	0.78	4.03	0.84	Agreed
98	Prepare the installation site: Clear the area if necessary, and make any necessary modifications to the structure	4.11	0.82	4.30	0.81	3.82	0.72	4.08	0.78	Agreed
99	Install the mounting structure: Construct the mounting structure or frame to support the solar conductors	4.06	0.89	4.27	0.72	3.94	0.81	4.09	0.81	Agreed
100	Install the solar conductors: Connect the solar conductors to the mounting structure and adjust the angles of the conductors for maximum exposure to the sun.	4.17	0.81	3.91	0.88	4.03	0.87	4.04	0.85	Agreed
101	Connect the system to the electrical system: Connect the solar conductors to the electrical system, including any necessary wiring, breakers, and control equipment.	4.11	0.82	3.76	0.83	4.18	0.76	4.02	0.80	Agreed
102	Test the system: Perform a thorough test of the solar conductor system to ensure proper operation	3.83	0.85	4.00	0.83	3.91	0.83	3.91	0.84	Agreed
103	Monitor the system: Monitor the system regularly to ensure it is operating correctly and making the most of available solar energy.	4.00	0.89	4.21	0.82	3.82	0.83	4.01	0.85	Agreed

Contents on Installation of Charge Controller		GIS		GSL		PSI		AVERAGE		REM
		X	SD	X	SD	X	SD	X	SD	
104	Install the Solar Charge Controller: Begin by opening the solar charge controller's box and taking out the contents. Make sure that all the necessary components are included in the box. Place the solar charge controller in an area that has easy	3.89	0.92	3.97	0.85	4.15	0.82	4.00	0.86	Agreed

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	access to both the photovoltaic (PV) array and the battery bank									
105	Connect the Photovoltaic Array: Use an appropriate cable to connect the photovoltaic array to the solar charge controller's PV input terminals. Make sure that the cables used to connect the array is rated for the intended current and voltage	3.89	0.75	3.70	0.77	3.97	0.72	3.85	0.75	Agreed
106	Connect the Battery Bank: Connect the battery bank to the solar charge controller's battery output terminals using an appropriate cable. Make sure that the cables used to connect the battery bank are rated for the intended current and voltage.	3.89	0.82	4.21	0.82	4.15	0.82	4.08	0.82	Agreed
107	Connect the Load: Connect the load to the solar charge controller's load terminals using an appropriate cable. Make sure that the cables used to connect the load are rated for the intended current and voltage	4.17	0.81	4.27	0.84	4.06	0.78	4.17	0.81	Agreed
108	Test the System: Turn on the system and test for proper operation. Make sure that the load is receiving power from the battery bank and that the battery bank is being charged	4.08	0.84	4.00	0.87	3.97	0.76	4.02	0.82	Agreed
109	Try to read the battery voltage on the screen of the charge controller to be okay	3.92	0.73	3.97	0.88	4.12	0.77	4.00	0.79	Agreed
110	Make sure the indicator lights are showing properly	3.75	0.84	3.97	0.81	4.00	0.82	3.91	0.82	Agreed
111	Connect the battery to the charge controller	4.03	0.81	3.88	0.86	4.03	0.83	3.98	0.83	Agreed
<hr/>										
	Contents on Installation of Solar Inverter	GIS		GSL		PSI		AVERAGE		REM
		X	SD	X	SD	X	SD	X	SD	
112	Clean the Inverter.	4.06	0.79	3.70	0.81	3.79	0.73	3.85	0.78	Agreed
113	Check the Fuses and Circuit Breakers:	4.11	0.85	3.94	0.79	3.91	0.83	3.99	0.82	Agreed
114	Check the Connections: Make sure all the connections are securely connected and all screws are tightened.	4.00	0.83	4.06	0.83	4.03	0.72	4.03	0.79	Agreed

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115	Inspect the Wiring: Check for any signs of fraying or corrosion on the wiring and replace any damaged wires.	3.86	0.83	4.06	0.75	4.00	0.82	3.97	0.80	Agreed
116	Test the Inverter: Turn on the inverter and test it to make sure it is working properly.	4.08	0.77	4.03	0.95	3.97	0.76	4.03	0.83	Agreed
117	Check the Temperature: Make sure the inverter is not getting too hot.	3.97	0.77	3.97	0.77	3.65	0.69	3.86	0.74	Agreed
118	Check the Control Panel: Make sure all the settings are correct and functioning properly.	3.97	0.81	4.06	0.79	4.18	0.80	4.07	0.80	Agreed
119	Run a Diagnostic Test: Run a diagnostic test to make sure the inverter is working correctly.	4.03	0.81	4.00	0.83	4.09	0.90	4.04	0.85	Agreed
Contents on Installation of Solar Battery		GIS		GSL		PSI		AVERAGE		REM
		X	SD	X	SD	X	SD	X	SD	
120	Purchase the right solar batteries based on your needs. Consider the number of batteries you need and the type of battery that works best for your application.	3.92	0.84	4.15	0.71	4.06	0.74	4.04	0.76	Agreed
121	Connect all the batteries together to form a series, so that they are able to store the same amount of charge. This is done by connecting the positive terminal of one battery to the negative terminal of the next battery in the series	4.00	0.83	3.76	0.79	4.09	0.87	3.95	0.83	Agreed
122	Connect the solar panel to the solar battery. Ensure that the voltage of the solar panel is the same as the voltage of the solar battery, otherwise the battery will not be able to charge properly.	4.03	0.77	3.88	0.78	4.12	0.77	4.01	0.77	Agreed
123	Mount the solar panel and the solar battery on a secure surface. Make sure that the solar panel is facing the sun and that the solar battery is in a well-ventilated area, as heat can affect the performance of the battery.	3.97	0.81	4.09	0.80	3.82	0.83	3.96	0.81	Agreed
124	Connect the solar panel to the solar battery using the proper wiring. Make sure to connect the positive terminal of the solar panel to the	4.11	0.89	3.85	0.80	3.85	0.74	3.94	0.81	Agreed

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	positive terminal of the solar battery and the negative terminal of the solar panel to the negative terminal of the solar battery.									
125	Ensure that the solar controller is connected properly to the solar panel and solar battery. This will ensure that the solar battery is not overcharged.	4.08	0.81	3.94	0.79	4.15	0.82	4.06	0.81	Agreed
126	Connect the inverter to the solar battery. This will allow you to use the electricity stored in the solar battery for different appliances.	3.97	0.81	4.21	0.78	4.06	0.89	4.08	0.83	Agreed
127	Test the installation to make sure that everything is working properly and that the solar battery is charging correctly	3.83	0.74	4.15	0.71	3.91	0.83	3.96	0.76	Agreed

The results In Table 3.2 show the mean and standard deviation of the responses of Electrical/Electronic personnel from Government solar industries, Government solar institutions, and private solar industries on the objectives of self-instructional guide for installation of solar power system. The result of analysis shows that average means of all items of the research question in all the tables were in the range of 3.81 – 4.18 all of which are in the 3.50 – 4.49 real limit. Therefore, the respondents were in agreement with all the items as the Contents of self-instructional guide for installation of Solar Power System. Furthermore, the average standard

deviations of the items were in 0.74 and 0.88 range. This is an indication that all the responses were dispersed close to the mean. In addition to this, none of the standard deviations was up to the standard normal deviate of 1.96. This therefore strengthens the integrity of the mean.

Hypothesis 1

H0₁: There is no significant difference among the mean responses of Electrical/Electronics personnel from Government solar industries and institutions, and solar private industries on the objectives of self-instructional guide for installation of solar power system.

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Table 3.3: Summary of Analysis of Variance (ANOVA) in responses to Electrical/Electronics personnel from government solar industries, Government solar institutions of learning and solar private industries on the objectives of self-instructional guide for installation of solar power system.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.084	2	0.042	0.470	0.627
Within Groups	8.911	100	0.089		
Total	8.995	102			

The results of Analysis of Variance (ANOVA) for the research hypothesis (H0₁) show that there is no significant difference among the mean responses of Electrical/Electronics personnel from Government solar industries, Government solar institutions of learning and solar private industries on the objectives of self-instructional guide for installation of solar power system. The value of F (0.470) is less than the critical value of F (3.84) and the significance level (0.627) is greater than the level of significance (0.05). This suggests that the null hypothesis (H0₁) can be accepted. In other words, there is no significant difference among the mean

responses of Electrical/Electronics personnel from Government solar industries and institutions, and solar private industries on the objectives of self-instructional guide for installation of solar power system.

Hypothesis 2

H0₂: There is no significant difference among the mean responses of Electrical/Electronics personnel from Government solar industries and institutions, and private solar industries on the contents of self-instructional guide for installation of solar power system.

Table 3.4: Summary of Analysis of Variance (ANOVA) in responses to Electrical/Electronics personnel from government solar industries, Government solar institutions of learning and solar private industries on the contents of self-instructional guide for installation of solar power system

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.009	2	0.005	1.129	0.328
Within Groups	0.416	100	0.004		
Total	0.425	102			

The results of Analysis of Variance (ANOVA) for the research hypothesis (H0₂) show that there is no significant difference among the mean responses of Electrical/Electronics personnel from Government solar

industries, Government solar institutions of learning and solar private industries on the contents of self-instructional guide for installation of solar power system. The results indicate that there is no significant difference among the mean

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responses of the two groups on the contents of the self-instructional guide. This is evidenced by the low F-value of 1.129 and the high Sig. value of 0.328. These results support the hypothesis (H_0) that there is no significant difference among the mean responses of Electrical/Electronics personnel from Government solar industries and institutions, and private solar industries on the contents of self-instructional guide for installation of solar power system. In conclusion, the results of this t-test analysis support the hypothesis (H_0) that there is no significant difference among the mean responses of Electrical/Electronics personnel from Government solar industries and institutions, and private solar industries on the contents of self-instructional guide for installation of solar power system.

DISCUSSION OF FINDINGS

The findings on objectives of self-instructional guide for installation of Solar Power System revealed that all the 8 items were agreed on by respondents as objectives of self-instructional guide for installation of Solar Power System, their mean ranges from 3.86 -4.09. There was no significant difference among the mean responses of Electrical/Electronics personnel from Government solar industries, Government solar institutions of learning and solar private industries on the objectives of self-instructional guide for installation of solar power system

The findings on contents on for installation of Solar Power System revealed that all the 127 items were agreed on by respondents as the contents on fundamentals of electricity for

installation of solar power system with mean ranges from 3.50- 4.18. the items include Power (P) is the rate of energy conversion measured in Watts, Voltage (V) is the potential difference in electrical charge between two points measured in Volts, Current (I) is the flow of electrons in a circuit/wire between two points measured in Amperes, Power (P) is the rate of energy conversion measured in Watts, Voltage (V) is the potential difference in electrical charge between two points measured in Volts, When electrical circuits are wired in parallel, currents are added and voltage stays the same, Energy (E) refers to the capacity for work i.e., the power used over time, measured in Watt hours, Alternating current is the type of current most commonly used in households to power electrical appliances (for example TVs, refrigerators, radios and computers). Grid supplied electricity is alternating current (AC) and direct current (DC) is produced by PV modules and stored in batteries, among others.

In the same vein, analysis of hypothesis two revealed that there was no significant difference between the mean responses of Electrical/Electronics personnel from Government solar industries, Government solar institutions of learning and solar private industries on the contents of installation of solar power system.

CONCLUSION AND RECOMENDATIONS

Government policies maker in Tambari, and Kelechi (2022) expects electrical craftsmen in Nigeria to possess the skills and knowledge necessary to safely install, repair, and maintain

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electrical systems and equipment. They must be able to read and interpret electrical diagrams and schematics, and be able to troubleshoot and repair electrical systems. Craftsmen must be knowledgeable in the use of tools and safety procedures, and be able to work efficiently and accurately. Government policies makers should lay more emphasis on curriculum review as when due to introduce new trades like solar power system installation in order to address the technological advancement across all trades in the technical colleges in Nigeria. The findings of this study have a positive implication for electrical craftsmen, company supervisors, Lecturers in Electrical Engineering Technology, curriculum developers, individuals interested in independent power system, National Energy Commission, Commissions in charge of rural and urban streetlight development and maintenance should adopt the self-instructional guide.

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