SOLAR PHOTOVOLTAIC SYSTEM INSTALLATION SKILLS REQUIRED BY ELECTRICAL TECHNICIANS FOR SELF-EMPLOYMENT IN ENUGU STATE

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Abstract

The study aimed at determining the solar photovoltaic system installation skill required by electrical technician for self-employment. To achieve this, two research questions and two null hypotheses tested at 0.05 level of significance guided the study. The study adopted a descriptive survey design. The population for this study was 232. This consists of 150 Electrical technicians and 82 Electrical teachers. The sample for the study is 150 respondents. This consists of 90 electrical technicians and 60 electrical teachers selected by simple random sampling. One hundred and fifty copies of the questionnaire were administered by the researchers with the help of three research assistants and retrieved immediately after completion. The instrument was subjected to face validation by three experts; two lecturers and one electrical instructor. Cronbach Alpha was used to establishing the reliability of the instrument and a reliability coefficient value of 0.87 was obtained. Data collected were analysed using mean to answer the research questions while, t-test for independent sample was used to analyse the data collected for the hypotheses at 0.05 level of significance. The result of the study identified stages and skills involved in solar photovoltaic system installation. It was concluded that electrical technicians should acquire the necessary skills required for installation of solar photovoltaic system.

Introduction

Electricity has become an integral part of modern society. It has propelled technological revolution and allowed for the ongoing information revolution. As the society progresses, human dependence on electricity continues to grow. The constant development of technology and the dependent on electricity continue to grow. The constant development of technology and the growth of developing countries add to the increasing demand for electricity (Akam, 2010). In the nearest future, the ability to keep up with the demand using current energy-producing technologies will be outstripped (Parlin, 2002). Additionally, and perhaps more urgently, current electrical production relies on fossil fuels that produce gaseous waste detrimental to global health. A number of alternatives are available to combat these problems, one such technology, is solar photovoltaic system.

A solar photovoltaic system is a power system designed to supply usable solar power by means of photovoltaic (Sambo, 2011). Photovoltaic (PV) cover the conversion of light into electricity using semi-conducting materials that exhibit the photovoltaic effect. It consists of an arrangement of several components, including solar panels to absorb and convert sunlight into electricity, a solar inverter to change the electric current from direct current (DC) to alternative current (AC), as well as mounting, cabling and other electrical accessories to set up a working system. A photovoltaic system converts the sun's radiation into usable electricity. Solar photovoltaic system according to Rob (2012), comprises the solar array and the Balance of System components (BOS) which includes power conditioning equipment and the structures for mounting, typically one or more DC to AC power converters, also known as inverters, an energy storage device, a tracking system that supports the solar array, electrical

wiring and interconnections, and mounting for other components. In solar photovoltaic system installation, standard health and safety practice and conventional electrical installation practice must be appropriately applied by solar photovoltaic system installation technician.

A technician is a worker in a field of technology who is proficient in the relevant skills and techniques, with a relatively practical understanding of the theoretical principles (International Electro-technical Commission (IEC), 2013). Experienced technicians in a specific field have a good understanding of theory and expert proficiency in method of handling tools and materials. As such, technicians are generally skilled compared to average layman and even general professionals in that field of technology (John, 2006). Technicians are found in difference field of human endeavour which includes; medicine, agriculture, electricity, electronics, aviation, pharmacy and so on. Their designation is got by attaching technician to the specific field of operation, for example technician in electrical industry are referred to as electrical technician.

Electrical technician is an individual who has completed electrical installation work module in a technical college. According to John (2006), an electrical technician installs wires, fuses and other electrical components in homes, business places and factories as well as maintaining the wiring and other installed electrical equipment. In addition to working with high voltage wiring, many electrical technicians install and maintain voice, data and video wiring. An electrician can specialize in either maintenance or construction, but many work in both areas. For one to be skilfully certified in electrical installation, he has to pass through a technical college or vocational training institute in Nigeria (National Board for Technical Education (NBTE), 2007).

Technical College in Nigeria has been a means of training people to become technicians and self-employed. The training qualifies them for jobs in both public and private organization. Both organizations required well trained and skilful technicians who can operate and maintain the available technical equipment (Ndomi, 2005). The organizations also required well trained and skilful technicians who can install and maintain Solar Photovoltaic system. For the graduates of Technical Education to be skilful in solar photovoltaic system installation work, they have to exhibit some mastery in the use of tools, equipment and materials as well as knowledge of safety requirement in the use of electricity. When a technician shows this degree of mastery both in management of material and human resources, he is referred to as skilful technician.

Skill is an ability and capacity acquired through deliberate, systematic, and sustained effort to smoothly and adaptively carryout complex activities or job functions involving ideas (cognitive skill), things (technical skills), and/or people (interpersonal skills). Skill in a broader concept is more than the ability to perform individual workplace tasks and comprises the application of all the specified technical and generic/related knowledge and skills relevant for an occupation (Faleti, 2006). Skill may require a combination of higher order knowledge and competent. It involve complex cognitive and meta-cognitive processes such as reflection, analyses, synthesis, generation, of ideas, problem solving, decision making, conflict resolution, innovation, design, negotiation, strategic planning and self-regulated learning

(Department of Education Employment and Workplace Relations (DEEWR) 2011). Skill is a cluster of related abilities, commitment, and knowledge and competent that enables a person (or an organization) to act effectively in a job or situation. In solar photovoltaic system installation work, skill indicates sufficiency of knowledge and competency that will enable a technician to install solar photovoltaic apparatus with minimal error (Ton, Brink, Vos, 2003).

Skills required for self-employment by Electrical Technician are categorised in two; skills based on the discipline of Electrical Technology (professional) and skills that are related to personal effectiveness (Ton, et.al 2003). The professional skills include knowledge of installation materials and tools, knowledge of installation circuits and systems, knowledge and design of electrical installation circuits and ability to test and actuate a finished work. Personal skills make it possible to use professional skills effectively (communication skills, ability to work in teams), as well as those that relate to attitude (creativity, curiosity, and ability to acquire new knowledge, self-assessment and ability to self-improvement) (Ton et.al, 2003). These professional and personal skills are both needed to become self-employed in solar photovoltaic system installation technician.

Tools, equipment and materials manipulation in today's world of work are an essential skill that any technician should possess. The first skill a technician required to possess is ability to know what tools, equipment and materials are needed for a particular job. Tools are instruments or devices that can be handled easily while carrying out special operations as well as instructional and learning activities (Archibong, 2004). Tools in solar photovoltaic system installation works include the following; compass, tilt angle indicator or protractor, measuring tape, screw drivers (flat blade screw driver for all mounting hardware, Philips screw driver for all mounting hardware and small jewellery size for adjusting controls), Wrenches, specific sizes for all mounting bolts, socket wrench, wire crimping, stripping and cutting tools, electrical tape, hammer, and metal hack saw, wood saw, chisel, miscellaneous for connections, split bolts, wire nuts, lugs, pliers, controllers, millimetre and current meter.

Materials in solar photovoltaic system installation works are the parts or elements used in making of any solar photovoltaic system construction project. Materials in solar photovoltaic system installation works thus include the following; electric wire, controller, battery, pole structure, lighting fixtures. Another material needed in an installation work is the working drawing. Working drawing are specialized engineering drawings that provide information required to make the part or assembly of the final design (Xinli, 2013). For a technician to produce this drawing accurately he has to possess some skills which include the following; knowledge of relevant electrical code e.g. national Electrical Code, Institute of Electrical Commission. Knowledge of workability of a drawing. Computer aided design skill. Ability to use freehand sketch to produce a working drawing (Technical Education and Science Development Authority, 2004).

Identification of tools and materials alone cannot ensure skilfulness in solar photovoltaic installation works instead there is also a need for solar photovoltaic system installation technicians to be skilful in handling the identified tools and materials. Brain (2008) observed that among the skills needed in an installation work includes ability to prepare

bill of quantity that will contain material and equipment needed to complete the solar photovoltaic system installation work, among others.

A graduate of solar photovoltaic system installation work is expected to know new trends in solar photovoltaic installation works; because technology is dynamic that is to say that every year new technology that requires new tools and materials comes up. In most technical colleges, courses are thought theoretically without the use of modern tools and materials the graduates will make use of in the world (Uwaifo, 2005). Most of the graduates lack the knowledge of safety about the new tools and materials that comes up.

Knowledge of safety is among skills needed by electrical technician for self-employment in solar photovoltaic system installation. The need for skilful handling of solar photovoltaic system installation tools and materials is very important to prevent electrical hazard in the homes, commercial places, industries as well as those who are self-employed.

Self-employment among the graduates may help the government to reduce social problems such as burglaries, armed robbery, aggression, frustration, prostitutions, drug addiction and insecurity (Oyebode, 2005) the society needs skilful solar photovoltaic installation work graduates to maintain and repair solar photovoltaic systems. Therefore there is need to identify solar photovoltaic system installation skills required by electrical technician for self-employment in Enugu State.

Statement of Problem

One of the goals of Vocational Education, of which Solar Photovoltaic System Installation work is part of, is to impart the necessary skills, knowledge work habits, attitude and other values to the recipients. Recent changes experienced in the society and in line with the rapid technological advancement, it become doubtful if the products of solar photovoltaic system installation would be able to fit into the industrialization project in Nigeria. The National Policy on Education (2004) emphasized that the present technical education programme in the country is focused on the acquisition of appropriate skills, abilities, and competences, both mental and physical, to equip the individual to live and contribute to the development of his society.

It is now surprising that many graduates of solar photovoltaic system installation works find it difficult to justify their education and practical training. The reason is not farfetched since the course content does not emphasize skilful-based training. An evidence of this is witnessed in our industries by indigenous technologists and technicians (Agha, 2013). Agha expressed much concern over the incompetence's of technicians, engineers and tradesmen who are products of Vocational Institutions in Nigeria, which hindered technological advancement. According to Agha (2013), the recent curriculum has not changed with changing situation and it suggests immediate modification.

Technical Education is a source of producing skilled personnel and the driving force behind achieving sustainable development. These skilled personnel are expected to poses appropriate skill that will make them self-reliant and self-employed. Most graduates of Technical Colleges do not have sufficient skills required to be self-reliant and therefore, unproductive. This has made unemployment to become rampant among graduate of technical institutions within which Solar

Photovoltaic System Installation work is embedded. Vocational Education and training qualifications start with the smallest component and aggregate units of competency to make a whole qualification.

This is to say that for one to have Vocational qualification in Solar Photovoltaic System Installation works, the individual must have got some skills in process of his training, but the graduates are not displaying these when employed. Thus, there is a need to identify the skills that will make a Solar Photovoltaic System Installation skilful and self-employed in Solar Photovoltaic System Installation works.

The following research questions guided the study:

1. What are the stages involved in solar photovoltaic system installation?
2. What are the skills involved in solar photovoltaic system installation?

Hypotheses

The following hypotheses were tested at 0.05 level of significance.

H_{o1}. There is no significant difference between the mean responses of solar photovoltaic system installation technicians and electrical installation teachers in technical colleges on the stages involved in solar photovoltaic system installation.

H_{o2}. There is no significant difference between the mean responses of solar photovoltaic system installation technicians and electrical installation teachers in technical colleges on the skills involved in solar photovoltaic system installation.

Methodology

This study adopted a descriptive survey research design, which involves the eliciting responses of electrical installation technicians as well as Electrical Installation and Maintenance Works (EIMW) teachers using questionnaire.

This research work was carried out in Enugu State. Enugu State has three zones of National Association of Small and Medium Scale Industries. The zones are Enugu zone, Oji zone and Nsukka zone. In addition, the study covered six education zones according to Science Technical and Vocational Schools Management Board (STVSMB) Enugu. The six education zones are Agbani zone, Awgu zone, Enugu zone, Nsukka zone, Obollo zone and Udi zone.

The population for study was 232 persons. This consists of 150 registered electrical technicians in the three zones (Enugu, Oji and Nsukka) of National Association of Small and Medium scale Enterprises in Enugu State and 82 electrical teachers in 29 technical and vocational colleges in the six educational zones in Enugu State from the record of Science Technical and Vocational Schools Management Board (STVSMB) Enugu.

The sample for the study is 150 respondents. This consists of 90 electrical technicians and 60 electrical teachers selected by simple random sampling. The study made use of questionnaire to collect information from the respondents. Each item has five response categories of; Very Highly Required, Highly Required, Moderately Required, Slightly required and Not Required. In relation to each item, the respondents are expected to choose the response category, which best appeals to them.

The questionnaire is of two sections; section A and section B. Section A sought personal information of the respondents. Section B consist of 26 items on the tools and material

required by a solar photovoltaic system installation technicians, 7 items on the stages involved in solar photovoltaic system installation, 12 items on the skills involved in the stages of photovoltaic system installation, and 6 items on the safety practices required in solar photovoltaic system installation. The questionnaire has 5 response options of Very Highly Required (5), Highly Required (4), Moderately Required (3), Slightly Required (2), and Not Required (1).

The instrument was subjected to face validation by three experts; two lecturers and one electrical instructor from Industrial Technical Education Department, University of Nigeria, Nsukka. Cronbach Alpha was used to establishing the reliability of the instrument. The instrument was administered on 20 respondents who are not part of the study population and the data collected were analysed to determine the internal consistency of the instrument. A reliability coefficient of 0.87 was obtained. The researchers administered and collected the copies of the questionnaire with the help of three research assistants. The research assistants were asked to read and explain the content of the instrument to the respondents.

The research questions were analysed using mean and the results obtained were interpreted using real limit of numbers as follows: any item that has a mean value of 4.50 to 5.00 was interpreted as Very Highly Required, 3.50 – 4.49 was regarded as Highly Required, 2.50 – 3.49 was regarded as Moderately Required, 1.50 – 2.49 was regarded as Slightly Required, and 1.00-1.49 was regarded as Not Required. The null hypotheses were tested using t-test for independent sample at 0.05 level of significance. Based on the result, any item whose probability value is less than or equal to 0.05 was regarded as significant and the null hypothesis rejected while, any item whose probability value is greater than 0.05 was regarded as not significance and the null hypothesis was not rejected. Data collected were analysed using Statistical Package for Social Sciences (SPSS).

Results

Research Question 1

What are the stages involved in a Solar Photovoltaic system installation?

Table 1. Mean, Standard Deviation and t-table Analysis of Mean Responses of Electrical Technicians and Electrical Teachers in Technical Colleges on the Stages Involved in a Solar Photovoltaic System Installation

S/N	Stages involved in a solar photovoltaic system installation	Respondents				Grand		t-cal	Sig.	Decision
		Electrical Technician		Electrical Teacher						
		$\bar{x}_1$	SD_1	$\bar{x}_2$	SD_2	$\bar{x}_g$	SD_g			
1.	Mounting of pole structure or supporter	4.78	0.41	4.42	0.96	4.63	0.70	2.741	0.00	S
2.	Installing solar panel at the upper most height of the structure	4.89	0.31	4.83	0.37	4.87	0.34	0.944	0.34	NS
3.	Installing of controller	4.78	0.41	4.75	0.43	4.77	0.42	0.388	0.69	NS
4.	Battery preparation and installation	4.69	0.46	4.15	0.82	4.47	0.68	4.619	0.00	S
5.	Installation of lighting fixtures	4.33	0.67	4.00	0.92	4.20	0.79	2.411	0.08	NS
6.	Proper earthing of the system	4.44	0.68	3.67	1.03	4.13	0.92	5.111	0.00	S
7.	Check for short circuit on the connection	4.56	0.50	4.50	0.65	4.53	0.56	0.560	0.57	NS

Note. $\bar{x}_1$= mean for Electrical Technicians, $\bar{x}_2$ = mean for electrical teachers, SD_1 = standard deviation for electrical technicians, SD_2 = standard deviation for electrical teachers, $\bar{x}_g$ = grand

mean for all respondents, SD_G = grand standard deviation for all respondents, S = significant, NS = not significant.

Data presentation in Table 1 shows that items 1, 2, 3 and 7 have their grand mean ranges from 4.53 – 4.87, which fall within the response category of very highly required. This indicates that the items are very highly required stages involved in solar photovoltaic system installation. The result also revealed that items 4, 5, and 6 have their grand mean ranging from 4.13 to 4.47 which fall within the response category of highly required. This indicates that the items are highly required stages involved in a solar photovoltaic system installation. A cluster mean of 4.51 was obtained in relation to Table 1 and this shows that the outlined stages are very highly required by the respondents. The table also shows that the standard deviation (SD) of the items are within the range of 0.38 to 1.04. This indicates that the mean value of the respondents are not far from one another.

The result in Table 1 shows that there is a significant difference in the mean responses of electrical technicians and electrical teachers on items 1, 4, and 6. Since their probability values range from 0.00 to 0.01, therefore the null hypothesis of no significant difference at 0.05 level of significance was rejected for those items.

The result also shows that there is no significant difference in the mean responses of electrical technicians and electrical teachers on items 2, 3, 5, and 7. Since their probability values range from 0.08 to 0.69, which are above 0.05 level of significance, the null hypothesis of no significant difference at 0.05 level of significance was accepted for those items.

Research Question 2

What are the skills involved in the stages of solar photovoltaic system installation?

Table 2. Mean, Standard Deviation and t-table Analysis of Mean Responses of Electrical Technicians and Electrical Teachers in Technical Colleges on the Skills Involved in the Stages of a Solar Photovoltaic System Installation

S/N	Skills involved in the stages of a solar photovoltaic system installation are, ability to:	Respondents				Grand		t-cal	Sig.	Decision
		Electrical Technician		Electrical Teacher						
		$\bar{X}_1$	SD_1	$\bar{X}_2$	SD_2	$\bar{X}_G$	SD_G			
1	Identify IEEE regulation on solar photovoltaic system installation	4.64	0.69	4.75	0.60	4.69	0.65	-0.992	0.32	NS
2	Identify solar photovoltaic system materials and equipment	4.67	0.47	4.58	0.64	4.63	0.54	0.858	0.39	NS
3	Identify various ratings of solar photovoltaic system protective equipment	4.56	0.68	4.67	0.62	4.60	0.66	-1.020	0.30	NS
4	Read various building plans	3.39	0.95	3.58	0.86	3.47	0.92	-1.289	0.20	NS
5	Apply aesthetic requirement in solar photovoltaic system installation	3.89	0.99	4.50	0.65	4.13	0.92	-4.535	0.00	S
6	Specify solar photovoltaic system equipment.	4.11	0.57	3.75	0.83	3.97	0.70	2.923	0.00	S
7	Prepare battery for installation	4.33	0.67	4.18	0.96	4.27	0.80	1.047	0.29	NS
8	Apply National Electrical Codes	4.22	1.03	4.17	0.99	4.20	1.01	0.330	0.74	NS
9	Install controller	4.89	0.31	4.83	0.37	4.87	0.34	0.944	0.34	NS
10	Identify working colour code	4.11	0.99	3.83	1.07	4.00	0.03	1.593	0.72	NS

11	Use equipment, materials and tools safely	4.67	0.47	4.67	0.47	4.67	0.47	0.000	0.19	NS
12	Wire correctly all appliance plugs	4.78	0.41	4.42	0.96	4.63	0.70	2.741	0.00	S

Note, $\bar{x}_1$ = mean for Electrical Technicians, $\bar{x}_2$ = mean for electrical teachers, SD_1 = standard deviation for electrical technicians, SD_2 = standard deviation for electrical teachers, $\bar{x}_G$ = grand mean for all respondents, SD_G = grand standard deviation for all respondents, S = significant, NS = not significant.

Data presentation in Table 2 shows that items 1, 2, 3, 9, 11, and 12 have their grand mean ranges from 4.60 – 4.87, which fall within the response category of very highly required. This indicates that the items are very highly required skills involved in the stages of solar photovoltaic system installation. The result also revealed that items 5 to 8 have their grand mean ranges from 3.97 – 4.27, which fall within the response category of highly required. This indicates that the items are highly required skills involved in the stages of solar photovoltaic system installation. The result further shows that item 4 has its mean as 3.47 which falls within the response category of moderately required. This indicates that the item is moderately required skill involved in the stages of solar photovoltaic system installation. A cluster mean of 4.34 is obtained in table 3 and this shows that the outlined skills are highly required by the respondents. The table also shows that the Standard Deviation (SD) of the items are within the range of 0.34 to 1.04 which indicates that the mean value of the respondents are not far from one another.

The result in table 2 shows that there is a significant difference in the mean responses of electrical technicians and electrical teachers on item 5, 6 and 12. Since their significant level ranges from 0.00 to 0.00, therefore the null hypothesis of no significant difference at 0.05 level of significance was rejected for those items.

The result also shows that there is no significant difference in the mean responses of electrical technicians and electrical teachers on item 1, 2, 3, 4, 7, 8, 9, 10, and 11.Since their no significant level ranges from 0.11 to 0.74, therefore the null hypothesis of no significant difference at 0.05 level of significance was accepted for those items.

Discussion of the Findings

The findings of the study revealed that 7 items constitutes the stages involved in a solar photovoltaic system installation. The items are; mounting of pole structure or supporter, installing solar panel at the upper most height of the structure, installing of controller, battery preparation and installation, installation of lighting fixtures, proper earthling of the system, check for short-circuit on the connection, are necessary stages in a solar photovoltaic system installation. The findings are in line with Evo Energy (2019), which identified erecting the scaffold, fitting the roof anchors, attaching the frame, installing the panels, wiring the panels on the roof, wiring the panels to the inverter, and so on as the steps involved in solar PV installation. Also, TheSolarPlanner.com (2015) identified review building, electric, fire and safety codes, among others as the steps involved in solar PV installation.

It was also revealed from the findings that 12 items constitutes the skills involved in the solar photovoltaic system installation. The items are; identify IEEE regulation on solar

photovoltaic system installation, identify solar photovoltaic system materials and tools, identify various ratings of solar photovoltaic system/protective equipment, read various building plans, apply aesthetic requirement in solar photovoltaic system installation work, specify solar photovoltaic system equipment, prepare battery for installation, apply national electrical codes, install controller. Skills play a significant part in contributing to an individual's effective and successful participation in modern workplace (common wealth of Australia, 2006). This result is in line with TESDA (2013), which stated that for one to be skilful in electrical installation work he has to be competent in the following; basic skills, common and core skills. The findings are also in line with Illinois Career Information System (2019) which identified skills required in solar photo voltaic system installation to include follow guidelines to arrange objects or actions in a certain order, use reasoning to discover answers to problems, analyse ideas and use logic to determine their strengths and weaknesses.

Conclusion

The study of solar photovoltaic system installation required by electrical technician for self-employment was carried out to increase the skills with which solar photovoltaic system installation technicians carry out solar photovoltaic installation. The study found the following as the skills which when possessed by a solar photovoltaic system installation technician will ensure success in doing the solar photovoltaic system installation. Skills in identifying tools and materials required by a solar photovoltaic system installation technician, skills required in identifying IEEE regulation on solar photovoltaic system installation; skills required in use of solar photovoltaic system installation tools and materials and safety practices in solar photovoltaic system installation; skills in preparation and installation of battery for installation, skills in controller installation.

Recommendations

From the study, the following are suggestions on what a solar photovoltaic system installation technician should do to become skilful in his work.

1. Attending solar photovoltaic system tools and material exhibition to know what are the new trends in the industry.
2. Government should have a guideline in form of laws guiding the work of a solar photovoltaic system installation technician to curtail the menace of non-competent practitioners.
3. Technical colleges should lay emphasis more on skill acquisition than theories.

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