



## Solar Power System Course Contents for Inclusion in the Minimum Standards for Nigeria Certificate in Education in Electrical and Electronics Technology

Doma, S. Y., E. Raymond, G. A. Usman, A. S. Owodunni.

Department of Industrial and Technology Education  
Federal University of Technology Minna

### ABSTRACT

The study developed a Solar Power System Course Contents for Inclusion in the Minimum Standards for Nigeria Certificate in Education in Electrical and Electronics Technology in North-Central Nigeria. Three research questions were raised and answered by the respondents. The study adopted a mixed method which include the survey research design and interview protocol and the study was conducted in the North-central, Nigeria with the total population 142 subjects which include 44 lecturers from colleges of education (Technical) teaching electrical and electronics technology, 95 industrial personnel and three experts. The instruments used for data collection consisted of Solar Power System Course Contents for Inclusion into Electrical and Electronics Technology Questionnaire (SPSCCIEETQ) which was validated by three experts and pilot tested using 14 respondents which consists of 5 lecturers of Electrical and Electronics Technology department at the Federal College of Education Bichi in Kano State and 9 solar power system industrial personnels from Sokoto Energy Research Centre (SERC) Sokoto State Nigeria and its reliability coefficient was determined using Cronbach's Alpha statistical technique and yielded to 0.85. Data collected was analyzed using mean and standard deviation to answer all the research questions. The finding of the study revealed that all the EET lecturers and the industrial personnel jointly agreed to all the items presented on the Psychomotor skills, the strategies for teaching and learning of solar power system course contents and on the facilities required for wiring, installation and maintenance of solar power system necessary for inclusion in the minimum standard for NCE in EET. Based on the findings from the study, the study recommended among others that, both State and Federal ministries of education should provide the needed support in areas of facilities and equipments for both the teaching and learning of practical skills of solar power system course contents, State and Federal ministries education should ensure qualified lecturing staff are employ to teach the students the appropriate psychomotor skills contents and appropriate teaching method should be use while teaching and learning of practical skills like the solar power system contents.

### ARTICLE INFO

#### Article History

Received: November, 2024

Received in revised form: December, 2024

Accepted: January, 2025

Published online: March, 2025

### KEYWORDS

Solar Power System, Course contents,  
Nigeria Certificate in Education

### INTRODUCTION

Education is the best legacies a nation can give to her citizens. This is because the development of any nation or society depends on the quality of education delivered to

its citizens (Ogumah, *et al.*, 2019). Hence education remains the vehicle for social and economic development of any nation. In Nigeria; education system is divided into primary, secondary and higher or tertiary education

Corresponding author: Doma, S. Y.

✉ [abramis@gmail.com](mailto:abramis@gmail.com)

Department of Industrial and Technology Education, Federal University of Technology, Minna, Nigeria.

© 2025. Faculty of Technology Education. ATBU Bauchi. All rights reserved



levels. Tertiary level of education or institution is referred to as the third level. Tertiary institution is that level of education which includes Universities, Polytechnics, monotechs, Nursing Schools, Aviation colleges, Colleges of Agriculture, Research Centres, Colleges of Education and among others. The Polytechnics and monotechs according to NBTE (2022) are tertiary institutions of learning that issues National Diploma (ND) and Higher National Diploma (HND) certificates while Universities Issues Bachelors, Masters and Doctoral Degree certificates and Nigeria Certificate in Education issued at the Colleges of Education.

Colleges of Education is an institution of learning where the learners are trained as professional teachers to basic technology at primary and junior secondary schools. In order to maintain a uniform standard among Colleges of Education, the Federal Government of Nigeria in 1989 established National Commission for Colleges of Education (NCCE) with the mandate given to the NCCE was to develop and implement down minimum standard for all programmes of teacher education and accrediting their certificates and other academic awards after obtaining thereof prior approval of the Minister of education (NCCE, 2020) and also to ensure that the Nigerian Certificate in Education (NCE) graduates are equipped with professional knowledge, practice, engagement and pedagogical skills. Consequently, the NCCE produces the minimum standards for NCE which is used for all the programmes and courses offered in all the Colleges of Education in Nigeria including NCE (Technical) programmes. According to the National Commission for Colleges of Education (NCCE) (2020) the philosophy of NCE (Technical) programme is to provide technical teachers with the intellectual and professional background adequate for teaching technical subjects and make them compliant to any varying situation in technological development, produce quality graduates who are equipped with relevant technical knowledge and employable skills for effective service delivery and also produce quality NCE technical teachers that are equipped with employable skills that are globally competitive. According to NCCE courses

offered in the NCE (Technical) programme includes: Automobile Technology (AUT), Building Technology (BLD), Metalwork Technology (MWT), Woodwork Technology (WWT) and Electrical and Electronics Technology (EET).

Electrical and Electronic Technology is a field of study that implements and applies the principles and behaviour of electrons to develop devices and equipment. It deals with the design, application, installation, manufacturing, operation and/or maintenance of electrical/electronic systems (Robinson, 2023). The teaching and learning of Electrical and Electronic Technology are based on the minimum standard of NCCE. Generally, the NCE (Technical) which Electrical and Electronic Technology contents are included in the minimum standard that was reviewed in 1998, 2003, 2012 and 2020 respectively in order to accommodate the emerging issues and reflect global best practices (Owo *et al.*, 2021). According to Owo *et al.*, the NCCE 2020 revised edition is unique in its structure, content and presentation with emphasis on professional standards and ethical responsibilities for NCE (Technical) teachers. Owo *et al.* added that the new NCCE revised edition consist of professional knowledge, practice and shift of pedagogical skills and approach for learning at the NCE level. The teaching and learning of Electrical and Electronic Technology are based on the minimum standard course contents. Course contents are educational plan that spells out which goals and objectives have to be achieved, which topics should be covered and which methods are to be used for learning, teaching and evaluation (Arowolo, 2019). Ogumah *et al.* (2019) posited that course contents support the achievement of graduate competencies and allows students the flexibility to broaden their knowledge and deepen their expertise. The mode of teaching electrical and electronic technology courses contents according to NCCE (2020) would be by lecturers.

Lecturers are employees of higher educational institutions to perform teaching, research and administrative functions. Lecturers have various degrees in a specialist subject area and they do not only teach and conduct research but also

Corresponding author: Doma, S. Y.

✉ [abramis@gmail.com](mailto:abramis@gmail.com)

Department of Industrial and Technology Education, Federal University of Technology, Minna, Nigeria.

© 2025. Faculty of Technology Education. ATBU Bauchi. All rights reserved

impact both theoretical and practical skills on learners. According to Olanrewaju (2023), a lecturer is a qualified professional who teaches students at the tertiary level and are responsible for delivering lectures, leading tutorials, and assessing student work. Lecturers play an important role in the training of NCE (Technical) students to enable them acquire both theoretical knowledge and practical skills so that after graduation they will be well equipped with adequate knowledge and skill to work with the industrial personnels (Oluwamayowa *et al.*, 2019). Industrial personnel are industrial staff that performs the functions of planning, organizing, staffing, directing and controlling activities in an industrial setting. Industrial personnel possess a reasonable qualification like ND, HND and B.Sc/B.Eng, M.Tech, M.Sc/M.Eng and Ph.D that will enable him to be able to train young men and women in various field or trades (Kalpana, 2020). Most of the industrial personnel are the graduates of ND, HND and B.Sc/B.Eng and some are graduates from Colleges of Education (Technical) which Electrical and Electronics Technology is inclusive.

Despite the series of these reviews of the NCCE minimum standard for colleges of education NCE (Technical), some of the course contents are yet to be included which is part of electrical and electronics technology course contents that is mostly practice and utilized by most of the people in their houses, offices and business centers. Some of this course contents that are yet to be added includes satellite installation, advanced robotics, artificial intelligence (AI) in electronics, hardware design and verification, high-frequency electronics and solar power system among others. Solar power system is an important source of renewable energy and can be captured and converted into electric and thermal energy. Solar power system can be harnessed using a range of ever-evolving technologies such as solar heating, solar thermal energy, molten salt power plants and artificial photosynthesis but the common technology used by experts is the photovoltaic solar panels that can convert the sun's rays into usable electricity (Jesuleye and Siyanbola, 2018). Uninterruptability of the solar power system made it possible to eliminate all

suspense from mains outage during the execution of an important and urgent assignment as may be required.

Presently, solar power system training has no formal content which can be followed for the training on installations and maintenance of the solar power system at NCE (technical) in Electrical and Electronics technology in colleges of education Nigeria. Today many NCE (Technical) in Electrical and Electronics technology graduates still undergoes private training from master craftsmen as apprentice to learn the installation and maintenance of solar power system and this is because of the high demand by the society as the cheapest and the most reliable means of electricity today (Owo *et al.*, 2021). Karen (2019) also observed that for one to acquire an employable skill on solar power system installation and maintenance, trainee must have a course content to be followed during the training. The solar power system needs a course contents that can be used for teaching, training of students electrical and electronics technology at the college of education (Technical) and solar power system employees. This course contents can function as operational policies guides and procedures and this will help to ensure that trainers and master craftsmen follow safe procedures during installation and maintenance of the solar power system. Hence the need for development of solar power system course contents for inclusion in the minimum standards for Nigeria Certificate in Education in Electrical and Electronic Technology in North-Central Nigeria.

### Statement of the Research Problem

The minimum standard for NCE (Technical) in Electrical and Electronic Technology in College of Education is expected to produce qualitative teachers of technology, who are capable of teaching basic technology at primary and junior secondary schools or be self-reliant, employable in government and private organizations as well as be motivated to start the so much desired revolution of technological development right from the Nigerian schools (NCCE, 2020). In order to facilitate the attainment of this objective the Minimum Standards were introduced in 1990,

Corresponding author: Doma, S. Y.

✉ [abramis@gmail.com](mailto:abramis@gmail.com)

Department of Industrial and Technology Education, Federal University of Technology, Minna, Nigeria.

© 2025. Faculty of Technology Education. ATBU Bauchi. All rights reserved

and reviewed in 1998, 2003, 2008, 2012 and 2020 respectively. However, from 2020 to date a lot of technological developments in the field of Electrical and Electronics Technology have taken place which are not captured in the NCCE minimum standard such as 5G connectivity, internet of thing (IOT), Artificial intelligence (AI) and electric Vehicles (EVs) among others which necessitated the inclusion of new contents in order to produce graduates who will be competent, current and relevant in today's work environment. Enamul (2019) observed that the design of minimum standard (work guideline) which does not cover all necessary basic areas is inadequate and is one of the bottlenecks affecting the actual training of manpower in these creditable areas like electrical and electronic which solar power system is inclusive. This therefore has created a gap in the trade theory and practice components of the Minimum Standards as well as the tools and equipment needed in the study and practice of solar power system. Owing to the current technological advancement and ever high demand of constant power supply led to the idea of using the solar power system by consumers (Zacchaeus *et al.*, 2020). Due to demand of electricity for use at home, business areas, offices has led to the use of solar power system and also due to shortage of power supply for our home use, business areas and offices, cost and environmental friendliness of grid supply many home are venturing into renewable energy such as solar power system which is cheaper and easy to maintain. Today all sort of informal training on solar power system like installation of solar panel, charge controllers, inverters, batteries repairs and their maintenances are being carried out haphazardly since they are not included in any course content that is legally approved and accepted by educational bodies like NBTE and NCCE. These problems are what prompted the researcher to develop a solar power system course contents for inclusion into the minimum standards for Nigeria Certificate in Education in Electrical and Electronic Technology in North-Central Nigeria in order to increase the knowledge, skills and employability of the graduates.

### Aim and Objectives of the Study

The aim of the study was to develop a solar power system course contents for inclusion in the minimum standards for Nigeria Certificate in Education in Electrical and Electronics Technology. The specific objectives of the study were to develop and validate:

1. Psychomotor skills contents in solar power system necessary for inclusion in the minimum standards for NCE in EET
2. Strategies for teaching and learning of solar power system
3. Facilities required for wiring, installation and maintenance of solar power system necessary for inclusion in the minimum standards for NCE in EET

### Research Questions

The following research questions were formulated to guide the study:

1. What are the psychomotor skills contents in solar power system necessary for inclusion in the minimum standards for NCE in EET?
2. What are the strategies for teaching and learning of solar power system?
3. What are the facilities required for wiring, installation and maintenance of solar power system necessary for inclusion in the minimum standards for NCE in EET?

### METHODOLOGY

An embedded mixed methods research design which include survey research design and interview protocol were used in this study and the study was carried out in Colleges of Education offering Nigerian Certificate in Education (Technical) in Electrical and Electronic Technology in North-central States including FCT Abuja. North-central states were chosen because is among zone that have a large cluster of solar installations as a result of their high solar and sun radiations of which this have attracted several solar companies and business men into sales, installations and trainings. The population for the study is 139 subjects which includes 44 lecturers of Federal and State Colleges of Education (Technical) offering electrical and electronics Technology, 95 industry personnel and three experts in solar power system located within the North-Central

Corresponding author: Doma, S. Y.

✉ [abramis@gmail.com](mailto:abramis@gmail.com)

Department of Industrial and Technology Education, Federal University of Technology, Minna, Nigeria.

© 2025. Faculty of Technology Education. ATBU Bauchi. All rights reserved

States of Nigeria. The entire 44 lecturers of EET in colleges of Education (Technical) and 95 industry personnel were used for this study. The instrument for data collection is a structured questionnaire titled: Solar Power System Course Contents for Inclusion in EET Questionnaire (SPSCIEETQ) and Solar Power System Interview Protocol (SPSIP). The questionnaire consists of Part 1 seeking for personal data from the respondent and Part 2 consists of research question 1-3 with response options of Highly Appropriate (HA), Appropriate (A), Inappropriate (IA), Highly Inappropriate (HI) and Undecided (U) which were based on the research objectives. The questionnaire was subjected to both face and content validity by three research experts and they were requested to suggest modifications on the structure of the items, organization as well as their appropriateness and then rate them according to their suitability for use in the present study. Their corrections, observations and suggestions made by these experts were taken into consideration in the production of the final copies of the instrument and the instrument was pilot tested using 14 respondents which consists of 5 lecturers of Electrical and Electronics Technology department at the Federal College of Education Bichi in Kano State and 9 solar power system industrial personnels from Sokoto Energy Research

Centre (SERC) in Usman Danfodiyo University Sokoto State Nigeria which is not part of the study area, and it yielded 0.89. Data was collected by administering the questionnaire to Electrical and Electronics Technology Lecturers the colleges of education (Technical) and the Industrial personnel in North-Central region. A total of 139 copies of the questionnaire were distributed to the respondents by the researcher and with the help of research assistants and the data collected was analyzed using mean and standard deviation. Therefore, the decision rule for all the items is that item with mean score of 3.00 and above was considered agreed, adequate or suitable, while below 3.00 was considered disagreed, inadequate or unsuitable for inclusion into the new minimum standard.

## RESULTS AND DISCUSSION

The data collected for the study were analyzed and presented in this chapter. The analysis and presentation were organized based on research questions.

### Research Question 1

What are the psychomotor skills contents in solar power system necessary for inclusion in the minimum standards for NCE (Technical) in EET North-Central Nigeria?

The data for answering research question one is contained in Table 4.1

**Table 1:** Mean and standard deviation of respondent on the psychomotor skills contents in solar power system necessary for inclusion in the minimum standards for NCE (Technical) in EET North-Central Nigeria.  
**N = 139**

S/N	Items	$\bar{x}$	SD	Remark
<b>Installation and wiring of solar power systems</b>				
1	Prepare the solar power installation site by clearing it	4.07	0.82	Agreed
2	Plan the solar power system conductors by determining the needed sizes and location of the system	4.00	0.80	Agreed
3	Installation and replacement of charge controller, panels and batteries in a solar power system	3.78	0.84	Agreed
4	Installation of surge protectors	3.83	0.79	Agreed
5	Connecting of wires from one panel to another either in series and parallel	4.06	0.83	Agreed
6	Connecting the conductor to the electrical system including wiring of circuit breakers and other control equipments	3.25	0.96	Agreed
7	Connecting of wires from one panel to the central conductors	3.32	0.91	Agreed
8	Installation of lightening arrestors	3.31	0.96	Agreed
9	Mounting of fastener and brackets for holding panels	3.24	0.92	Agreed

Corresponding author: Doma, S. Y.

[abramjs@gmail.com](mailto:abramjs@gmail.com)

Department of Industrial and Technology Education, Federal University of Technology, Minna, Nigeria.

© 2025. Faculty of Technology Education. ATBU Bauchi. All rights reserved

10	Connecting the solar power system to the electrical system	3.92	0.81	Agreed
11	Wiring and installation test of electrical connections of the solar power system and the system performance	3.67	0.82	Agreed
12	Connection of battery bank to the solar charge controller using appropriate cables	3.58	0.79	Agreed
13	Testing of the solar power system for proper operation	3.73	0.97	Agreed
<b>Maintain solar power systems</b>				
1	Cleaning of the surface of the solar panels	4.01	0.80	Agreed
2	Cleaning of the batteries terminals	3.78	0.84	Agreed
3	Checking the temperature of the batteries, inverter and charge controller	4.00	0.81	Agreed
4	Cleaning of metallic object or conductor around the system	3.78	0.85	Agreed
5	Checking of fuses	3.84	0.79	Agreed
6	Inspection of the wiring and connections	4.06	0.83	Agreed
7	Checking of solar panels mounts	4.00	0.80	Agreed
8	Replacement of damage components	3.78	0.84	Agreed
9	Checking of distilled water level	3.83	0.79	Agreed
10	Checking the wiring	4.06	0.82	Agreed
11	Testing of the batteries on load	4.00	0.80	Agreed
<b>Basic troubleshooting principles</b>				
1	Visual inspection of solar panels wiring to the charge controller	3.78	0.84	Agreed
2	Checking for damage panels, batteries and charge controller	3.83	0.79	Agreed
3	Checking for damage wires	4.06	0.82	Agreed
4	Check charge controller if damage	3.25	0.96	Agreed
5	Measure the voltage and current using multimeter	3.32	0.90	Agreed
6	Checking of inverter functions	3.23	0.91	Agreed
7	Testing of inverter output and input from battery	3.33	0.96	Agreed
8	Inspection of wiring connections look for loose connections	3.70	0.78	Agreed
9	Inspection of wire for damage	3.67	0.81	Agreed
10	Monitor system performance and compare the data	3.58	0.79	Agreed
<b>Grand Total</b>		<b>3.72</b>	<b>0.85</b>	<b>Agreed</b>

Table 1 show the mean and standard deviation response of the respondents on the Psychomotor skills contents in solar power system necessary for inclusion in the minimum standards for NCE (Technical) in EET North-Central Nigeria revealed that the response of Lecturer and the industrial personnel who jointly agreed with all the items on the psychomotor skills contents in solar power system necessary for inclusion into NCE (Technical) minimum standards with mean value ranging from 3.24 – 4.07 with grand mean of 3.72 which is over the cut-off point. This implies that the Psychomotor skills contents in solar power system components necessary for inclusion into NCE (Technical) minimum standards were appropriate for teaching and learning of solar power system. The standard deviation of the

items ranges from 0.79 - 0.97 with grand total of 0.85 which is less than which is less than 1.96 meaning the respondents were not too far from the mean and were close to one another in their responses. Furthermore, experts in solar power system were interviewed on psychomotor skills contents in solar power system necessary for inclusion in the minimum standards for NCE (Technical) in EET. The experts responded to the interview by saying: "The learners should have idea on solar power system conductors by determining the needed sizes and location of the system, installation and replacement of charge controller, panels and batteries in a solar power system, connecting of wires from one panel to another either in series and parallel, wiring and installation test of electrical connections of the solar power system and the

Corresponding author: Doma, S. Y.

[abramis@gmail.com](mailto:abramis@gmail.com)

Department of Industrial and Technology Education, Federal University of Technology, Minna, Nigeria.

© 2025. Faculty of Technology Education. ATBU Bauchi. All rights reserved

system performance, cleaning of the surface of the solar panels and batteries terminals, checking the temperature of the batteries, inverter and charge controller, replacement of damage components and Testing of the batteries on load, visual inspection of solar panels wiring to the charge controller, measure the voltage and current using multimeter and system Design and Configuration, monitor system performance and compare the data, analyze a location for solar potential, including shading, orientation, and tilt angles, conduct solar assessments using equipment such as solar pathfinders or smartphone apps and

knowledge in using design software or tools to create system diagrams and layouts, the inspection of the wiring and connections and replacement of damage components and testing of the batteries on load.”

### Research Question 2

What are the strategies for teaching and learning of solar power system for inclusion in the minimum standards for NCE (Technical) in EET North-Central Nigeria?

The data for answering research question one is contained in Table 4.4.

**Table 2:** Mean and standard deviation of respondent on the strategies for teaching and learning of solar power system necessary for inclusion in the minimum standards for NCE (Technical) in EET North-Central Nigeria. **N = 139**

S/N	Items	$\bar{x}$	SD	Remark
1	Online courses	2.19	0.95	Disagreed
2	Virtual learning environments	2.01	0.83	Disagreed
3	E-books	1.96	0.72	Disagreed
4	Digital simulations	2.04	0.64	Disagreed
5	Podcasts	3.78	0.85	Agreed
6	Social media	2.39	0.98	Disagreed
7	Project-Based Learning strategy	4.06	0.83	Agreed
8	Field trip	4.00	0.80	Agreed
9	Observation	3.48	0.57	Agreed
10	Cooperative Collaborative learning	3.83	0.79	Agreed
12	Peer teaching	4.07	0.83	Agreed
13	Discussion method	4.01	0.81	Agreed
14	Inquiry-Based Learning	3.78	0.85	Agreed
15	Demonstration method	3.83	0.79	Agreed
16	Project method	4.06	0.82	Agreed
17	Assignment Method	4.00	0.80	Agreed
18	Lecture Method	3.79	0.84	Agreed
<b>Grand Total</b>		<b>3.19</b>	<b>0.78</b>	<b>Agreed</b>

Table 2 shows the mean and standard deviation of the respondents on 18 items on the strategies for teaching and learning of solar power system. The finding revealed that the respondents jointly disagreed to five (5) items with mean scores between 1.96 – 2.39 which is below the cutoff point, this shows that these methods were not adequate for teaching solar power system but they jointly agreed with all the remaining items with mean

ranging between 3.78 – 4.07 with grand mean total of 3.19 which is over the cut-off point indicating that majority of the lecturers and industrial personnel's accepted that these strategies were appropriate for teaching and learning of solar power system course contents. The result also revealed that the standard deviation (SD) of the items ranges from 0.72 – 0.98 with grand total of 0.78 which is less than which is less than 1.96 showing that

Corresponding author: Doma, S. Y.

[abramis@gmail.com](mailto:abramis@gmail.com)

Department of Industrial and Technology Education, Federal University of Technology, Minna, Nigeria.

© 2025. Faculty of Technology Education. ATBU Bauchi. All rights reserved

the respondents were not very far from mean and from one another in their responses. Furthermore, experts in solar power system were interviewed on the strategies for teaching and learning of solar power system necessary for inclusion in the minimum standards for NCE (Technical) in EET. "The experts responded to the interview by saying: Method of teaching like the experimental method, demonstration method, project method, lecture Method, assignment Method, observation method, the inquiry-Based Learning, Field trip, project-based learning, digital simulations, E-

books and discussion method, field trip and the use simulation tools to model solar energy systems and collaborative Learning for teaching and learning of solar power system."

### Research Question 3

What are the facilities required for wiring, installation and maintenance of solar power system necessary for inclusion in the minimum standards for NCE (Technical) in EET North-Central Nigeria?

The data for answering research question one is contained in Table 4.6.

**Table 3:** Mean and standard deviation of respondent on the facilities required for wiring, installation and maintenance of solar power system necessary for inclusion in the minimum standards for NCE (Technical) in EET North-Central Nigeria.

S/N	Items	$\bar{x}$	SD	Remark
<b>Measuring and Testing tools and Materials</b>				
1	Measuring tape	3.44	0.60	Agreed
2	Angle finder	3.16	0.55	Agreed
3	Digital multimeter	3.48	0.57	Agreed
4	Digital clamp-on ammeter	3.17	0.56	Agreed
5	Pyranometer	3.49	0.63	Agreed
6	The Solar Pathfinder	3.58	0.79	Agreed
7	Spirit level meter	3.73	0.97	Agreed
<b>Machine and Hand tools</b>				
8	Socket spanners	4.01	0.80	Agreed
9	Side cutter	3.78	0.84	Agreed
10	Multi contact spanner	4.00	0.80	Agreed
12	Sets of pliers	3.78	0.84	Agreed
13	Hammers	3.83	0.79	Agreed
14	chisel	4.06	0.82	Agreed
15	Shovel	3.25	0.96	Agreed
16	Hand gloves and Eye goggles	3.45	0.59	Agreed
17	Set of spanners and set of socket spanners	3.48	0.57	Agreed
18	Cable ties	3.16	0.55	Agreed
19	Silicon gun	3.61	0.83	Agreed
20	Step ladder	3.67	0.81	Agreed
21	Silicon sealant	3.58	0.79	Agreed
22	Brush and duster	3.73	0.97	Agreed
23	Screw drivers	3.78	0.85	Agreed
24	Hacksaw	3.49	0.63	Agreed
25	Sets of spanners	3.47	0.60	Agreed
26	Hand or power drilling machine and drill bits	3.49	0.57	Agreed
27	Sets of pliers	4.00	0.80	Agreed

Corresponding author: Doma, S. Y.

[abramis@gmail.com](mailto:abramis@gmail.com)

Department of Industrial and Technology Education, Federal University of Technology, Minna, Nigeria.

© 2025. Faculty of Technology Education. ATBU Bauchi. All rights reserved

28	Copper clamp and connectors	3.78	0.84	Agreed
29	Silicon gun, duster, water and brush	3.84	0.79	Agreed
30	Voltmeter and ammeter	4.06	0.82	Agreed
31	Cable ties	3.25	0.96	Agreed
32	Copper clamp	3.32	0.90	Agreed
33	Scraper angle iron	3.16	0.55	Agreed
34	Power drilling machine	3.69	0.78	Agreed
<b>Grand Total</b>		<b>3.49</b>	<b>0.72</b>	<b>Agreed</b>

Table 3 revealed the mean and standard deviation of the respondents on 34 items posed the facilities required for wiring, installation and maintenance of solar power system necessary for inclusion in the minimum standards for NCE (Technical) in EET North-Central Nigeria. The respondents agreed to all the 34 items as the facilities required for wiring, installation and maintenance of solar power system necessary for inclusion into NCE (Technical) minimum standards with mean ranging from 3.16 to 4.06 with grand mean total of 3.49 which is over the cut-off point. This implies that the facilities required for wiring, installation and maintenance of solar power system necessary for inclusion into NCE (Technical) minimum standards were adequate. The standard deviation of the items ranges from 0.55-0.97 with grand total of 0.72 which is less than which is less than 1.96 which implies that the respondents were close to one another in their responses. Furthermore, experts in solar power system were interviewed on the facilities required for wiring, installation and maintenance of solar power system necessary for inclusion in the minimum standards for NCE (Technical) in EET. "The experts responded to the interview by saying: "Clamp-on ammeter, spirit level meter, brush and duster, screw drivers, scraper angle iron, sets of spanners, silicon gun, sets of pliers, hacksaw, cable ties, silicon gun, set of flat spanners, set of socket spanners, hand gloves and eye goggles. They added solar pathfinder, hand or power drilling machine and drill bits, voltmeter, ammeter, copper clamp and connectors, digital clamp-on ammeter, scraper angle iron, duster, water and brush, silicon sealant and pyranometer as facilities required for wiring, installation and maintenance of solar power system."

## FINDINGS OF THE STUDY

The following findings emerged from the study based on the data collected from the research questions answered.

1. The Psychomotor skills contents in solar power system necessary for inclusion in the minimum standards for NCE in EET to include: planning of the solar power system conductors by determining the needed sizes and location of the system, installation and replacement of charge controller, panels and batteries, installation of lightening arrestors, cleaning of the batteries terminals and surface of solar panels, replacement of damage components, wiring, charge controller batteries and panels among others. These finding were supported by qualitative responses of experts to include: learners should have idea on solar power system conductors by determining the needed sizes and location of the system, installation and replacement of charge controller, panels and batteries in a solar power system, wiring and installation test of electrical connections of the solar power system and the system performance among others.
2. The strategies for teaching and learning of solar power system course contents necessary for inclusion in the minimum standards for NCE in EET to include: the use of online course, virtual teaching, project method, lecture Method, assignment method and discussion method among others. These finding were supported by qualitative responses of experts to include: experimental method, demonstration method, assignment method, observation method,

Corresponding author: Doma, S. Y.

[abramis@gmail.com](mailto:abramis@gmail.com)

Department of Industrial and Technology Education, Federal University of Technology, Minna, Nigeria.

© 2025. Faculty of Technology Education. ATBU Bauchi. All rights reserved

- field trip, discussion method, field trip and collaborative learning among others
3. The facilities required for wiring, installation and maintenance of solar power system necessary for inclusion in the minimum standard for NCE in EET to include: hand gloves, set of spanners, cable ties. Silicon gun, set of spanners and pliers, machine and hand tools, multimeter, clamp ammeter, angle finder pyranometer among others. These finding were supported by qualitative responses of experts regarding the facilities required for wiring, installation and maintenance of solar power system to include: clamp-on ammeter, spirit level meter, brush and duster, screw drivers, scrapper angle iron, sets of spanners, solar pathfinder and digital clamp-on ammeter, among others.

### DISCUSSION OF THE FINDINGS

Table 1 provides answer to research question three on the psychomotor skills contents in solar power system necessary for inclusion in the minimum standards for NCE (Technical) in EET North-Central Nigeria. The respondents agreed with all the items presented on the psychomotor skills contents in solar power system necessary for inclusion in the minimum standards for NCE (Technical) in EET North-Central Nigeria. This is in line with Mgonja and Saidi (2018) who established that psychomotor or practical skills are highly needed for maintenance practices of solar power systems and lack of this skills could cause total failure in the system. In line with the responses of the EET lecturers and industrial personnel, Kumar *et al.* (2020) observed that psychomotor skills content is essential in technical subjects as it enables students to develop practical skills that are required in the workplace. In agreement with Kumar *et al.*, Lee *et al.* (2020) asserted that incorporating psychomotor skills content in technical subjects can lead to enhanced learning outcomes. In agreement with Lee *et al* finding, Chizoba (2020) statement that the goals of education are to gain appropriate theoretical knowledge and practical skills and the development of mental, physical and social abilities and competencies for the

people to live and add to the development of the society.

Table 2 provides answer to research question two on the strategies for teaching and learning of solar power system. The finding revealed that the respondents jointly agreed with item 5, 7, 8, 9, 10, 11, 12, 13, 14, 16, 17 and 18 with mean ranging between 3.78 – 4.07 with grand mean total of 3.19 which is over the cut-off point indicating that majority of the lecturers and industrial personnel accepted that these strategies were appropriate for teaching and learning of solar power system course contents but disagreed to items 1, 2, 3, 4 and item 6 ) with mean scores between 1.96 – 2.39 which is below the cutoff point, this shows that these methods were not adequate for teaching solar power system course contents. The finding revealed that the respondents jointly agreed with demonstration and project method as adequate for teaching and learning of solar power system contents. In agreement with the respondent Moses *et al.* (2017) who posited that demonstration and project method of teaching has been the most common teaching method in technical education especially while teaching practical work. Moses *et al.*, added that it is easy to understand with the emphasis that comes in an activity programme based on manipulation to fabricate and service products with the materials and tools of industry.

The respondents agreed with the Instructional methods such as problem-based learning, cooperative learning and inquiry-based learning. This is in line with the finding Facione *et al.* (2020) who observed that project-based learning techniques allow students to engage in learning about a topic over a period of time, and may help the development of deep understanding. The respondent agreed with project, discussion, demonstration and field trip as method adequate for teaching and learning solar power system contents. This is in agreement with Warthen (2017) that explained that instructional methods relevant to the teaching of technical courses are project, discussion, demonstrate excursion or field trip and homework. In agreement with the view of Mohammed *et al.* (2018) who asserted that apart from demonstration method that is

Corresponding author: Doma, S. Y.

✉ [abramis@gmail.com](mailto:abramis@gmail.com)

Department of Industrial and Technology Education, Federal University of Technology, Minna, Nigeria.

© 2025. Faculty of Technology Education. ATBU Bauchi. All rights reserved

commonly used to teach fundamental operations in technical education, there are other several methods that could also help the teacher to explain the steps involved in a lesson or an operation while teaching them. In line with the above statement of Mohammed *et al.*, above Saba *et al* (2016) described teaching techniques as a practices and refinements of presentation, which teacher employs to make instructions more effective, more interesting and easier when using a specific method for a lesson unit. Saba *et al* added that Skill acquisition generally requires specialized instruction techniques in order to achieve maximum objectives and assisting learners to learn is the ultimate goal of any instructional activity in both formal and informal education. This is also in agreement with the statement of Mohammed *et al.* (2018) who emphasized that electrical and electronics technology lecturer must have both technical skills and pedagogical/teaching methodology to effectively prepare students in TVET to be able transit from school to work without any delay.

The respondents disagree with online course as teaching and learning strategies. In agreement with the finding of Hsu *et al.* (2020) who observed that online learning environments "lack the hands-on experience and face-to-face interaction that is essential for developing practical skills. The respondents disagree with e-book as a strategy for teaching and learning of solar power system course contents. In agreement with the finding of Warthen (2017) noted that students who learned through e-books had lower scores on hands-on tasks compared to those who learned through traditional hands-on methods. The respondents disagree with Boud (2018) who noted that digital simulation techniques can be effective for developing certain types of knowledge and skills, but it have limitations when it comes to practical skills. In line with the respondent Kim *et al.* (2019) noted that students who learned surgical skills through simulation had lower levels of tactile awareness compared to those who learned through hands-on training. In agreement with above statement Hsu *et al.* (2020) observed that digital simulations may not accurately replicate the complexities of real-world situations and leading to a lack of

transferability of skills to practical settings. The respondents disagree with social media as a strategy for teaching and learning of solar power system course contents. In agreement with the finding of Kruike-meier *et al.* (2020) who observed that social media-based learning can result in superficial understanding and lack of depth in learning. In disagreement a study by Lee *et al.*, (2020) proved that students are very familiar with social media and gives students the ability to collaborate with peers.

Table 3 revealed the mean and standard deviation of the respondents on 34 items posed the facilities required for wiring, installation and maintenance of solar power system necessary for inclusion in the minimum standards for NCE (Technical) in EET North-Central Nigeria. The respondents agreed to all the 34 items as the facilities required for wiring, installation and maintenance of solar power system necessary for inclusion into NCE (Technical) minimum standards with mean ranging from 3.16 to 4.06 with grand mean total of 3.49 which is over the cut-off point. This implies that the facilities required for wiring, installation and maintenance of solar power system necessary for inclusion into NCE (Technical) minimum standards were adequate. In line with the respondent views Mohammed *et al.* (2018) observed that for effective teaching of any skill activity, methods, facilities and materials play an important role in facilitating the learner's achievement objectives. In agreement with Mohammed *et al.*, the finding of Kim and Lee (2020) showed that facilities for teaching and learning in workshop provide students with hands-on experience, which is essential for learning technical subjects. Kim and Lee added that hands-on learning experiences in workshop settings improved students' understanding of technical concepts and their ability to apply them in real-world scenarios.

## CONCLUSION

Electricity is a form of energy that affects almost every sphere of life. All our electrical and electronic equipment need a source of electrical energy to function. Hence the quest for obtaining this source of energy from different means is in high demand. Originally, the source of electrical energy was

Corresponding author: Doma, S. Y.

✉ [abramis@gmail.com](mailto:abramis@gmail.com)

Department of Industrial and Technology Education, Federal University of Technology, Minna, Nigeria.

© 2025. Faculty of Technology Education. ATBU Bauchi. All rights reserved

predominantly hydro but today other forms of energy are being harnessed so as to convert them to electrical energy. Even with billions of naira invested in improving electricity supply and privatizing the sector in a bid to reach more efficiency, progress has been slow. Solar energy is considered one of the main ways for Nigeria to reach its electrification targets. It is increasingly adopted across the country by households to power small appliances, in the shape of mini grids powering entire markets or (rural) communities and by corporate entities who seek to reduce their reliance on expensive diesel generators. The present study developed a solar power system course contents for inclusion in the minimum standards for the Nigeria Certificate in Education (NCE) programme in Electrical and Electronics Technology (EET). The findings of this research strongly advocate for the inclusion of comprehensive solar power system course contents within the minimum standards for the Nigeria Certificate in Education (NCE) programme in Electrical and Electronics Technology (EET) in North Central Nigeria. The growing importance of renewable energy sources, particularly solar power, necessitates the equipping of future educators with the knowledge and skills to effectively integrate this subject into their teaching and learning practices. The inclusion of solar power system content in the Nigeria Certificate in Education (NCE) programme in Electrical and Electronics Technology (EET) curriculum will not only enhance the quality of technical education in the region but also contribute to the nation's efforts in promoting sustainable energy solutions and mitigating climate change. The integration of solar power systems into the minimum standards is a critical step towards equipping future technicians and engineers with the knowledge and skills necessary to meet the growing demand for renewable energy solutions.

### RECOMMENDATIONS

Based on the finding of the study, the following recommendations are made:

1. State and Federal ministries education in-charge of tertiary education should ensure qualified lecturing staff are employ to teach

the students the appropriate psychomotor skills contents

2. Appropriate teaching method should be use while teaching and learning of theoretical contents and practical skills like the solar power system contents
3. Adequate training facilities and instructional materials should be made available in Colleges of Education offering NCE (Technical) for teaching and learning of the new theoretical contents and practical skills contents.

### REFERENCES

- Arowolo, A. A. (2019). *Historical factors that influence curriculum development in industrial technical education*. Retrieved September 10, 2023, from [https://www.academia.edu/354232/historical\\_factors\\_that\\_influences\\_curriculum\\_development\\_in\\_industrial\\_technical\\_education](https://www.academia.edu/354232/historical_factors_that_influences_curriculum_development_in_industrial_technical_education)
- Boud, D. (2018). Assessment in higher education: A review of the literature. *Journal of Assessment in Higher Education*, 43(5), 631–644.
- Chandel, S. S. (2020). Solar power system performance monitoring: A review of methods and techniques. *Journal of Solar Energy Engineering*, 142(2), 35–47.
- Chizoba, O. (2020). Effect of skill acquisition on youth employability in Nigeria. *International Journal of Research in Finance and Management*, 3(1), 33–37. <https://doi.org/10.5281/zenodo>
- Enamul, M. H. (2019). Three domains of learning: Cognitive, affective and psychomotor. *The Journal of EFL Education and Research (JEFLER)*, 2(2), 111–120.
- Facione, P. A., Facione, N. C., & Gittens, C. A. (2020). What the data tell us about human reasoning. In D. Fasko & F. Fair (Eds.), *Critical thinking and reasoning: Theory, development, instruction, and assessment* (pp. 272–297). Brill Sense.
- Hsu, T. C., Ching, Y. H., & Liu, M. C. (2020). *The effects of online learning on*

Corresponding author: Doma, S. Y.

✉ [abramis@gmail.com](mailto:abramis@gmail.com)

Department of Industrial and Technology Education, Federal University of Technology, Minna, Nigeria.

© 2025. Faculty of Technology Education. ATBU Bauchi. All rights reserved



- practical skills development in vocational education. *Journal of Educational Technology Development and Exchange*, 13(1), 1–18.
- Jesuleye, A. O., & Siyanbola, W. O. (2018). Solar electricity demand analysis for improved access to electricity in Nigeria. *Nigerian Journal of Solar Energy*, 19(1), 136–141.
- Kalpana, R. (2020). *Importance of personnel management in solving industrial problems*. Retrieved May 24, 2022, from <http://www.businessmanagementideas.com>
- Karen, Y. (2019). Career development: Enhancing employability. *Journal of Environmental Science and Engineering*, 3(1), 535–542.
- Kim, J., & Lee, Y. (2020). The effects of hands-on learning on students' understanding of technical concepts. *Journal of Engineering Education*, 109(2), 147–158.
- Kruikemeier, S., Leung, L., & Tan, E. S. (2020). The effects of social media on learning outcomes: A systematic review. *Computers & Education*, 3(4), 143–162.
- Kumar, V., Kumar, S., & Singh, J. (2020). Importance of psychomotor skills in technical education. *Journal of Technical Education and Training*, 12(1), 1–9.
- Lee, S., Kim, J., & Lee, Y. (2020). The effects of visual feedback on learning outcomes in podcast-based practical skills training. *Journal of Science Education and Technology*, 29(2), 147–158.
- Mgonja, C. T., & Saidi, H. (2018). Effectiveness on implementation of off-grid solar PV systems in public facilities – A case study of SSMP1 project in Tanzania. *International Journal of Mechanical Engineering Technology*, 8(7), 869–880.
- Mohammed, G. M., Olosunde, I. O., & Abdulwasii, A. A. (2018). Techniques for enhancing technical and vocational education and training (TVET) towards self-reliance in Niger State. *International Journal of Industrial Technology, Engineering, Science and Education (IJITESD)*, 1(1), 93–98.
- Moses, D., Diraso, D. K., Yaduma, P. S., & Agbu, D. (2017). Industrial installation skills acquired and job performance of graduates of electrical installation and maintenance works trade of technical colleges in North Eastern Nigeria. *Journal of Science, Technology and Education*, 6(6), 1–8.
- National Board for Technical Education (NBTE). (2022). *Guidelines and procedures for establishment of private polytechnics*. Retrieved July 31, 2024, from <https://web.nbte.gov.ng/guidelines%20for%20establishing%20new%20institution>
- National Commission for Colleges of Education (NCCE). (2020). *Nigeria certificate in education minimum standards for vocational and technical education*. <http://www.fcezarria.edu.ng/ncce/prencce.pdf>
- Ogumah, B. A. O., Haruna, U. B., Sunday, A. A., & Adeniyi, T. (2019). Effect of guided inquiry teaching method on students' academic performance in electrical installation and maintenance work in technical colleges in Gombe State. *Journal of Science, Technology and Education*, 7(4), 343–352.
- Olanrewaju, O. T. (2023). The challenges and opportunities of teaching in colleges of education in Nigeria. *Engineering Education*, 14(1), 1–10.
- Oluwamayowa, A., Olubukola, G. Y., & Adeolu, A. A. (2019). An assessment of the influence of employee motivation on performance output: A case of Nigerian Bottling Company. *IOSR Journal of Business and Management (IOSR-JBM)*, 21(11), 47–53.

Corresponding author: Doma, S. Y.

✉ [abramis@gmail.com](mailto:abramis@gmail.com)

Department of Industrial and Technology Education, Federal University of Technology, Minna, Nigeria.

© 2025. Faculty of Technology Education. ATBU Bauchi. All rights reserved



- Owo, O. T., Isaac, A., & Udoaka, C. N. (2021). Assessment of the employability skills of polytechnic electrical/electronic engineering graduates for employment in Oil/Gas industry in Niger-Delta, Nigeria. *International Journal of Engineering Applied Sciences and Technology*, 5(3), 142–150.
- Robinson, D. A. (2023). Electrical and electronics technology. In *Encyclopedia of Engineering and Technology* (pp. 1–10). Springer International Publishing.
- Saba, T. M., Tsado, J., Bukar, B., & Ohize, E. J. (2016). Level of electrical energy management practice awareness among residents in Niger State, Nigeria. *American Journal of Engineering and Technology Management*, 1(1), 1–6.
- Warthen, S. (2017). Instructional strategies of effective mathematics teachers of African American upper elementary students (Doctoral dissertation, Walden University). *Walden Dissertations and Doctoral Studies*, 4187. <https://scholarworks.waldenu.edu/dissertations/4187>
- Zacchaeus, A. A., Joel, O., & Irimiya, B. (2020). Maintenance management regime for off-grid solar PV renewable energy system in Nigeria. *European Journal of Engineering Research and Science*, 5(11), 1–14.