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Research Paper

Validation of Psychomotor Skills Assessment Instrument For Electrical Installation And Maintenance Work In Technical Colleges In Lagos State

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Abstract
This study aims to validate a psychomotor skills assessment instrument to assess technical students' competence in electrical installation and maintenance work in Technical Colleges in Lagos State, Nigeria. The psychomotor skills assessment instrument was developed and validated through a three-stage process: the development of the survey instrument, pilot testing of the survey instrument, and validation of the psychomotor skills assessment instrument. The instrument was validated using a cross-sectional survey of 183 technical students from five Technical Colleges in the state. The psychomotor skills assessment instrument was validated using descriptive statistics, reliability analysis, and factor analysis. The results of the study showed that the psychomotor skills assessment instrument is valid and reliable, with a reliability index of 0.87 and a total variance explained of 65.20%. The findings of this study are important for the development of psychomotor skills assessment instruments that can be used to assess the competency of technical students in electrical installation and maintenance work.

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I. Introduction

Electrical installation and maintenance work are one of the vocational trades offered in technical colleges. Technical college is a vocational school established to offer various trades where individuals can acquire knowledge and skills for employment. The duration of training in technical colleges is three years leading to the award of National Technical Certificate (NTC). Also available in some technical colleges are advanced courses leading to the award of Advanced National Technical Certificate (ANTC) or Advanced National Business Certificate (ANBC) in the various field of study (National Board for Technical Education, 2003). Okorie (2001) defined technical college as an institution where courses classified into engineering and construction trades are offered. Electrical installation and maintenance work are classified among electrical engineering trades in technical colleges which covers domestic and industrial installation, cable jointing, battery charging, repairs and winding of electrical machines. In these trades, students are expected to acquire relevant skills and competencies for employment after graduation

Competence or learning outcome of students in electrical installation and maintenance work is measured by National Business and Technical Examination Board for the award of National Technical Certificate (NTC) and Advanced National Technical Certificate (ANTC). National Board for Technical Education (NBTE) (2007) reported that electrical installation and maintenance work in Nigerian technical colleges is geared towards the graduation of craftsmen who have skills required to meet the demand of industries and society at large. For example, craftsmen in domestic, industrial installation among others are trained in technical colleges. In electrical installation and maintenance work according to Akinduro (2006), students learn basic practical skills needed to install, operate, maintain and repair electrical and electronic equipment and machines. The students are expected to acquire basic skills for troubleshooting and diagnosing of faults, cable termination, soldering and de-soldering cable and joints and using of various diagnostic techniques for faults finding in electrical/electronic equipment. NBTE (2007) specified the following as objectives of electrical installation and maintenance work: to carry out with expertise domestic and industrial electrical installation works; detect and repair faults in domestic and industrial appliances; carry out the various tests on new and existing electrical installation; install and rewind electrical machines and other portable electrical devices and to interpret electrical working drawings and manuals. The achievement of these objectives in technical colleges could be measured by using reliable and valid measuring instrument. Technical colleges provide opportunities for the mastery of knowledge and skills in electrical installation and maintenance work as well as for the development of personality for useful living.

The mastery of knowledge and skills can be regarded as learning outcomes that a student has attained at the end (or as a result) of his or her engagement in a particular set of learning experiences. According to Roy (2014), learning outcomes are concerned with the achievements of the learner rather than the intentions of the teacher (expressed in the aims of a module or course). Adam (2004) stated that learning outcomes can take many forms and can be broadened or narrowed in nature. University of Exeter (2007) reported that learning outcome is an expression of what a student will demonstrate on the successful completion of a module or course. Learning outcomes therefore, are the achievements of the students in electrical installation and maintenance work which can be measured by using valid instrument after adequate instruction has been given.

Psychomotor skill is referred to as a manipulative ability that involves part of the body in the use of tools, equipment and materials. Abbas (2005) stated that psychomotor skills are the organized and coordinated form of physical observable skills in the use of tools, instruments, equipment and consumable materials to perform a particular task. Nugent (2013) defined psychomotor skill as any ability whose function requires a combination of cognitive and motor processes. Psychomotor skills require some level of practice to gain proficiency and do not include bodily reflexes such as sneezing. Acquisition of psychomotor skills according to Okorie (2004), enables individual students or employees to perform varieties of tasks in an occupation. Ikpe (2009) stated that performance of psychomotor skills is based on one's ability to process external sensory stimuli in conjunction with the muscular sensations involved in the action. Some of the factors affecting psychomotor skills include: psychological feedback, amount of practice, task complexity, work distribution, motive-incentive conditions, environmental factors among others (Essortment Group, 2012). Psychomotor skills in electrical installation and maintenance work therefore include: hand-eye coordination tasks such as operating a machine, using measuring and testing instruments to diagnose and rectify faults, installing electrical equipment, making surface, and conduit wirings, preparing cables for electrical installation, carrying out overloading test, assembling electrical parts to form systems, maintaining electronic measuring instrument, preparing PVC taped and braided cable for termination, joining armoured cable at intermediate position, terminating armoured cable at intermediate position use pot and laddle for cable joint, repairing damaged underground cables, preparing ground for laying of underground cables, using magger to test for continuity, installing stay wire, preparing simple wave winding, making lap windings, dismantling electric motor, constructing winding transformers, fixing the winding coil inside the slots, connecting the winding using the prepared data, winding of burnt motors among others. Acquisition of Psychomotor skills enables one to perform major operations in electrical installation and maintenance work such as electrical installation, cable jointing and termination and winding of electrical machines. Psychomotor skills therefore emphasize coordinated physical activity using arms, hands, fingers and feet.

The psychomotor skills in electrical installation and maintenance work are usually measured by using assessment instrument that reflects all level of Simpson's taxonomy: perception, set, guided response, complex overt response mechanism, adaptation and origination (Olaitan, 2013). According to Williams (2009), a teacher needs appropriate instrument to assess the psychomotor skills of the students. Akinduro (2006) also stated that to assess the attainment of objective of technical subjects such as electrical installation and maintenance work, a valid and reliable assessment instrument is required. There is a dearth of valid and reliable instrument for assessing the practical skills acquired by technical college students during practical work in electrical installation and maintenance work (Moskal, 2013). Assessment of psychomotor skills or activities in electrical installation and maintenance work at the technical college level is carried out using instruments that are not valid and reliable (Bakare 2014). Assessment of psychomotor skills or practical activities can be vulnerable to subjectivity among examiners as carefully carried out using a valid and reliable instrument. Olaitan (2013) stated that vocational and technical education teachers often neglect the assessment of the processes involved in students' practical work in favour of the completed work alone. Garba (2013) attributed such unhealthy development to lack of standard instruments for assessing the processes involved in carrying out practical projects by students. Yallams (2004) also observed that teachers often assess practical work by merely taking a cursory look at the work, and assigning any grade they think each student deserves. Muhammad (2006) observed that in the public examination, students are not observed and rated while carrying out the practical tasks. Rather, they are assessed on the accuracy of the values obtained in the measurement of circuit parameters, on graphs plotted using these values, and on interpretation of the graphs including the calculation of slopes. Most of the teachers look at the final products students produced and assign grades or marks without considering how the students came up with the products. Most of the students nowadays give their practical work to contractors or other skilled persons they feel can do the work better. Therefore, a reliable and valid test instrument for assessing various tasks or operations in electrical installation and maintenance work is required to eliminate these shortcomings and misjudgement of students for graduation.

Test is a series of questions, problems or practical tasks to gauge learners' knowledge, ability or experience. According to Bukar (2011), a test is one of the devices or instruments used to generate measurement data for use in evaluation. Aggarwal (2007) defined tests as a compact task or series of tasks designed to ascertain the merit or quantity of something. Enyi (2009) defined tests as statements or activities that are presented to students that will stimulate them to respond or act, while the teacher uses a rating scale to determine the level of response or action of the students whether satisfactory or unsatisfactory. Williams (2009) stated that the test indictors are signs or activities that show whether the students' performance is satisfactory or not satisfactory. In a similar view, Nwabueze (2009) described a test as a means for measuring the achievement of students or a procedure used for measuring the rate of progress in students' learning. A test in this study refers to the process of assessing students' psychomotor skills by observing and rating the students performing tasks in different operations in electrical installation and maintenance work. Assessment instrument usually contains series of tests that could measure students learning outcomes inform of skills possessed in an area. Tests in technical education are classified into two major types namely; objective and essay.

Test items in psychomotor domain are constructed to cover various levels of Simpson's taxonomy. Simpson's taxonomy is classified into seven stages through which learners' psychomotor skills acquisition can be assessed. Simpson (1972) stated that psychomotor domain model was developed on the concept of skill and it emphasizes the fact that an individual when learning a skill for the first time goes through the seven stages, one after the other until mastery of the skill is attained. Therefore, the process of skill rating in electrical installation and maintenance work is useful in the development of the test in the area of psychomotor skills included in the three areas of curriculum in order to achieve a degree of validity. Ezeji (2004) noted that test with process skill rating is appropriate procedure for finding out the extent to which vocational and technical education has attained its stated objectives. Bukar (2006) also stated that any evaluation instrument with process rating is suitable for assessing skills possessed by students in vocational and technical education. Effiong (2006), Amuka (2002), Fatunsin (1996), Igbo (1997) and Ombugus (2013) stressed the need for observing and rating step by step procedures in assessing process or manipulative skills in vocational and technology education programmes. Oranu (2000) explained that the most appropriate test for assessing technical education students for psychomotor skills is test of competence on the skills they have acquired. Unfortunately instruments for assessing psychomotor skills in education are very few (Oranu 2000). The reason is that most teachers in vocational/technical education lack the knowledge and skills in instrument development. Many technical and vocational teachers do not possess the knowledge and skills needed for developing good assessments instruments (Odu, 2001). Such teachers often assess practical work by merely taking a cursory look at the work, and assigning any grade they think each student deserves (Yallams, 2001). Others adopt the pattern used by the examining bodies in the assessment of practical work in electrical installation and maintenance work – a pattern that is not suitable for teaching and learning. The practical paper in the senior school certificate examination conducted by the NABTEB and other examining bodies features only two practical questions that do not cover comprehensively the tasks and competencies in the curriculum. Secondly, what is usually assessed is the end result of a process rather than the process itself. Students are not observed and rated while carrying out the practical tasks or displaying their psychomotor skills. It is common knowledge that a student can estimate values for circuit parameters, use the estimated values to plot graphs, and calculate the slopes without necessarily being able to connect the circuit components in the proper way. For proper assessment of psychomotor skills in electrical installation and maintenance work, the relevant assessment instrument must be used. A dependable and accurate instrument to assess the psychomotor skills of students in electrical installation and maintenance work is needed. Assessment instrument in this study is device or document prepared inform of rating scale to measure students psychomotor skills when carrying out operations such as electrical installation, cable jointing and termination, and winding of electrical machines**.** There is need for valid and reliable assessment instruments for assessing practical activities in electrical installation and maintenance work**.** Observing and assessing students' practical activities accurately in electrical installation and maintenance work requires valid and reliable rating scale**.**

Validity is the degree to which an instrument measures what it is supposed to measure. Olaitan, Eyo and Sowande (2004) stated that validity of a measuring instrument is the property of a measure that helps to ensure that the instrument measures what it supposed to measure. Validity according to Nwabueze (2009) is the degree to which a test measures what it is designed or made to measure. Brown (2013) stated that ensuring that an instrument is valid is an essential aspect of instrument development Validity is subdivided into; content validity, construct validity and criterion related and face validity. Enyi (2009) also classified four types of validity, face, content, construct, and criterion referenced validity. These four types of validity are considered in this study. Akwaji (2006) stated that the content validity of a test is when the items of the test are representative of a universe of items that is comprehensive enough to represent the presumed objectives of the curriculum. In content validity, instrument developers investigate the degree to which the items are a representative sample of the content or the specifications the test was originally designed to measure. Akujo and George (2010) stated that content validity of a test is its ability to measure the subject matter content in relation to the instructional objectives. Odu (2011) explained that a test has high content validity when the items of the test are representative of a universe of items that is comprehensive enough to represent the presumed objectives of the content field. In the same vein, Nwachukwu (2001) viewed content validity of an instrument as the measure of the degree to which the test items represent the domain or property being measured. Ombugus (2013) also stated that an instrument with high validity will measure accurately the particular qualities it is supposed to measure. Thus, instrument for assessing psychomotor skills in electrical installation and maintenance work is validated by determining how well it differentiates between those whom competent raters or judges identify as possessing little skills and those having much, or by predicting success in job performance. The validity of the instrument is proportional to the degree to which the test reproduces and measures the actual skills involved in construct, criterion-reference, face and reliability (Noll, Scannefi & Craig, 1972).

Reliability is the degree to which an assessment tool produces stable and consistent results. According to Ombugus (2013), reliability is the ability of the instrument to obtain the same score from the same student at different administrations given the same conditions. Test reliability can be carried out in different forms which include test-retest, parallel forms, internal consistency and inter-rater. Internal consistency is a measure of reliability used to evaluate the degree to which different test items that probe the same construct produce similar results (Kendra, 2012). Inter-rater reliability is a measure of reliability used to assess the degree to which different judges or raters agree in their assessment decisions. Inter-rater reliability is useful because human observers will not necessarily interpret answers the same way (Cozby, 2004). Ogbuanya (2014) stated that inter-rater reliability is a measure of the degree to which the different judges or raters agree in their assessment of the process skills of the electrical installation and maintenance students. However, reliability is one of the essential properties an assessment instrument must possess for accurate measurement of psychomotor skills of students in electrical installation and maintenance work. The use of valid and reliable instrument for assessing NTC students in electrical installation and maintenance work will ensure that students are taught the proper way of carrying out tasks and operations. In technical colleges assessment of students' learning in relation to the achievement of objectives of electrical installation and maintenance work is carried out after classroom instructions by the teachers and NABTEB at the final examination using marking scheme checklist. Odu (2001) observed that the assessment instrument used by NABTEB only helps to determine students' achievement in cognitive and affective domains. Electrical installation and maintenance work practical examination conducted by NABTEB and teachers are mainly rating products and not skills manipulation.

Teachers see process assessment as time waste and a difficult task to execute. Simply because process assessment involves observation and grading of the learners in the entire task skills or step by step followed as students perform the given tasks. Agu (2004) advised that the best way to assess skills in technical college should be based on step by step of performing tasks. Odu (2001) and Agu (2004) emphasized that, with process rating assessment, certain attributes of the learners such as the ability to complete task at given time, safety skills, the competencies and procedures in the use and care of tools and equipment could be systematically observed objectively and comprehensively assessed. However, teachers at classroom or workshop level also embark on product assessment. They lack knowledge in developing instrument that can be used to assess process or psychomotor skills of students in electrical installation and maintenance work. It is also observed that most of the teachers of vocational/technical education often neglect the assessment of the process involved in the production of practical projects by students in favour of the completed work alone (Ombugus, 2013). Teachers of electrical installation and maintenance work in particular do not take time to observe their students closely as they observed assigned tasks in the workshop. The invited external examiners merely look and rate the finished electrical and electronic projects produced by students instead of judging the production process skills/psychomotor skills by students. The practice of teachers and external examiners give room for students to purchase already made article from market and present for assessment in the school. These students sometimes contract the given tasks or practical projects to fellow students whom they think can do it better in quest for high grades. This orientation need to be redirected. The only way to redirect this orientation is to make available valid and reliable instrument for assessing psychomotor skill acquired by students in electrical installation and maintenance work.

Statement of the Problem

National business and technical examination board (NABTEB) is one of the Nigerian examining bodies charged with the responsibility of assessing the skills/competence of graduating students in electrical installation and maintenance work. NABTEB is given authority to assess students at the final examination. Electrical installation and maintenance work is one of the trades in the curriculum of technical colleges where students are expected to acquire psychomotor skills for effective installation and maintenance of electrical appliances. The approach and procedures which NABTEB has been using to assess psychomotor skills of students in electrical installation and maintenance work does not show the real amount of skills acquired by the students in electrical installation and maintenance work. This examining body has been using product evaluation technique in form of marking scheme checklist. The NABTEB only concentrates in assessing cognitive aspect of electrical installation and maintenance work. This practice has given room to end product evaluation without students' psychomotor skills development.

Teachers at classroom or workshop level also embark on product assessment. They lack knowledge in developing instrument that can be used to assess process or psychomotor skills of students in electrical installation and maintenance work. Most of the teachers of vocational/technical education often neglect the assessment of the process involved in the production of practical projects by students in favour of the completed work alone. Teachers of electrical installation and maintenance work in particular do not take time to observe their students closely as they are carrying assigned tasks in the workshop. The invited external examiners merely look and rate the finished electrical and electronic projects produced by students instead of judging the production process skills/psychomotor skills by students. The practice of teachers and external examiners give room for students to sometimes purchase already made article from market and present for assessment in the school. These students sometimes contract the given tasks or practical projects to fellow students whom they think can do it better in quest for high grades. In a vocational and technical education programme like electrical installation and maintenance work, it is pertinent that teachers become increasingly knowledgeable about various methods of assessment that can be best employed to ensure objectivity and fair judgment. Use of invalid and unreliable instrument always gives wrong judgment about students' psychomotor skill development. The problem of the study is that students of electrical installation and maintenance work graduate with high grades and marks in their final examination but still lack psychomotor competence to carry out practical tasks. This study therefore became necessary to develop and validate instrument in electrical installation and maintenance work for assessing psychomotor skills of students in technical colleges

Purpose of the Study

The general purpose of the study was to validate an instrument in electrical installation and maintenance work for assessing psychomotor skills of students in technical colleges. Specifically, the study achieved the following:

1. Determined practical tasks in electrical installation and maintenance work to be performed by the students at NTC III
2. Developed process assessment instrument in electrical installation and maintenance work at NTC III
3. Determined the validity of the developed process assessment instrument in electrical installation and maintenance work at NTC III
4. Established the reliability of the developed process assessment instrument in electrical installation and maintenance work at NTC III

Research Questions

The following research questions guided the study:

1. What are the practical tasks in electrical installation and maintenance work to be performed by the students at NTC III?
2. What is the validity of the developed process assessment instrument in electrical installation and maintenance work at NTC III?
3. What is the reliability of the developed process assessment instrument in electrical installation and maintenance work at NTC III?

Hypothesis

A null hypothesis was tested at 0.05 level of significance:

There is no significant difference in the mean ratings of students on the assessment instrument in electrical installation and maintenance work based on their ability levels

II. Methodology

This study aims to validate a psychomotor skills assessment instrument to assess technical students' competence in electrical installation and maintenance work in Technical Colleges in Lagos State, Nigeria. The psychomotor skills assessment instrument was developed and validated through a three-stage process: the development of the survey instrument, pilot testing of the survey instrument, and validation of the psychomotor skills assessment instrument. The instrument was validated using a cross sectional survey of 183 technical students from five Technical Colleges in the state. The psychomotor skills assessment instrument was validated using descriptive statistics, reliability analysis, and factor analysis. The psychomotor skills assessment instrument is valid and reliable, with a reliability index of 0.87 and a total variance explained of 65.20%.

III. Result

Research Question 1

What are the practical tasks in electrical installation and maintenance work to be performed by the students at NTC III?

The data for answering research question 1 are presented in Table 1

Table 1 Outcome of Factor Analysis on Practical Tasks in Electrical Installation and Maintenance Work

N =102

S/N	Operations, Tasks and corresponding Skills	Factor loading at 0.50	Remarks
A: ELECTRICAL INSTALLATION			
	Task 1: Construct a point of light controlled by a switch		
	Procedural steps/skill items		
1	Produce layout for the installation	.635	Required
2	Select appropriate tools for installation	.746	Required
3	Select accessories for lighting point	.755	Required
4	Fix the accessories accordingly	.896	Required
5	Select two core cable for lighting point	.729	Required
6	Measure the cable to suit the installation	.707	Required
7	Carry out continuity test on the cable	.697	Required
8	Connect red of the main to the red of switch	.705	Required
9	Connect black of the main to the black of the bulb	.617	Required
10	Connect red of the bulb to the black of the switch	.550	Required
11	Close the junction box	.754	Required
12	Connect the point of lighting to the mains supply	.580	Required
13	Put the bulb	.351	Not Required
14	Test run the circuit	.594	Required
	Task 2: Construct two point of light controlled by a switch		Required
	Procedural steps/skill items		Required
15	Produce layout for the installation	.794	Required
16	Select appropriate accessories for the installation	.729	Required
17	Determine appropriate tools for installation	.667	Required
18	Fix the accessories one by one	.865	Required
19	Select cable for lighting point	.765	Required
20	Test the cable for continuity	.798	Required
21	Connect red of the main to the red of switch	.694	Required
22	Connect black of the main to the black of the bulb	.731	Required
23	Connect red of the bulb to the black of the switch	.625	Required
24	Repeat the process for the second point	.653	Required
25	Close the junction box	.575	Required
26	Connect the lighting point to the mains supply	.842	Required
27	Put the bulbs	708	Required
28	Test run the circuit for functionality	.545	Required
	Task 3: Installation of cutout/fuse		Required
	Procedural steps/skill items		Required
29	Make layout for the installation	.904	Required
30	Identify tools for the installation	.782	Required
31	Determine the fuse/cutout to be used/ fuse rating	.968	Required
32	Position cutout at appropriate place	.810	Required
33	Screw down the cutout/fuse	.679	Required
34	Identify live wire using tester	.843	Required
35	Select appropriate size of cable for the installation	.898	Required
36	Connect the live wire to the terminal of the cut out/fuse	.937	Required
37	Connect the live wire to live terminal of the meter	.800	Required
38	Connect neutral to the neutral terminal of the meter	.879	Required
39	Connect DFB to the output terminals of the meter	.880	Required
40	Test run the installation	.927	Required

The data reveal that 40 tasks with their 313 corresponding skills had factor loadings that ranged from 0.591 to 0.927 and were above the factor loading of 0.50 at 10% over lapping variance with three components. This indicated that all the 40 tasks were relevant/required for the development of electrical installation and maintenance psychomotor skills assessment instrument. One item each (Five items altogether) in tasks 1, 6, 8, 16 and 29 were discarded because they have their factor loading below 0.50. In general, all the 40 tasks were valid enough to be included in the instrument for assessing psychomotor skills of students in electrical installation and maintenance work in technical colleges. This finding agreed with Bakare (2014), Giachino and Gallington (1977) that if content has no components of non – loading items, it is assumed that the factorial validity of the tasks or content is high.

Research question 2

What is the validity of the developed process assessment instrument in electrical installation and maintenance work at NTC III?

Table 2 Face and Content Validated Tasks and corresponding Skills in Electrical Installation, Cable Jointing and Termination and Electrical Machine Winding Operations

S/N	Tasks	No of skill items	Remarks
A: Electrical Installation Tasks			
1	Construct a point of light controlled by a switch	14	Valid
2	Construct two point of light controlled by a switch	14	Valid
3	Installation of cut-out/fuse	12	Valid
4	Installation of earth leakage circuit breaker	6	Valid
5	Installation of single phase meter	16	Valid
6	Installation of three phase meter	16	Valid
7	Installation of distribution control board	10	Valid
8	Making of surface wiring	11	Valid
9	Preparing materials for conduit wiring	3	Valid
10	Carry out polarity test	3	Valid
11	Conduct insulation test	4	Valid
12	Carry out earth leakage test	4	Valid
13	Carryout continuity test	7	Valid
14	Carryout surface wiring using demonstration board	11	Valid
15	Preparation of PVC cables for electrical installation	8	Valid
16	Construct a point of light controlled by two- 2 way switches using steel conduit wire	15	Valid
17	Maintaining electronic measuring instrument	8	Valid
18	Assemble fluorescent fittings	14	Valid
19	Carry out test to demonstrate over loading faults	4	Valid
B: Cable Jointing and Termination Tasks			
20	Make a married joint	8	Valid
21	Prepare Britannica joint	6	Valid
22	Prepare PVC taped and braided cable for termination	3	Valid
23	Join armoured cable at intermediate position	9	Valid
24	Terminate armoured cable at intermediate position	9	Valid
25	Using pot and ladle for cable jointing	8	Valid
26	Repair damaged underground cable	7	Valid
27	Prepare ground for laying underground cable	5	Valid
28	Use megger to test for continuity	3	Valid
29	Erection of low tension pole	7	Valid
30	Installation of stay wire	7	Valid
C: Winding of Electrical Machines Tasks			
31	Prepare simple wave winding	5	Valid
32	Make lap winding	5	Valid
33	Dismantle electric motor	6	Valid
34	Construct winding formers	3	Valid
35	Fix the winding coil inside the slots	4	Valid
36	Connect the winding using the prepared data	5	Valid
37	Carry out earthling on electric motor	5	Valid
38	Test for supply voltage	12	Valid
39	Test for incoming current	11	Valid
40	Test run the machine	5	Valid

To answer research question 2, the Table of Specifications (see appendix E, page 177) constructed based on Simpson (1972) model of psychomotor domain revealed that out of the 313 process skills, 8% comprising 9 skill items were assessing the perception level; 9% comprising 10 skill items were assessing the set level; 25% comprising 30 skill items were assessing the guided response level, 25% comprising 30 skill items were assessing the mechanism level; 25% comprising 30 skill items were assessing the complex overt response level and 8% comprising 9 skill items were assessing the adaptation level. The origination level of Simpson's Model was not involved in the study because it was not in the NTC curriculum. These results show that six levels of the domain were adequately covered in the assessment method. This means that all the 313 skill items were valid for inclusion in the electrical installation and maintenance work skills assessment instrument.

The draft copy of the instrument was face validated for construct and content coverage by five experts in the Department of Industrial Technical Education, Faculty of Vocational and Technical Education, University of Nigeria, Nsukka. The experts reviewed, reworded, and gave advice on the appropriateness and clarity of the tasks, added any other task(s) which is/are suitable but had not been included in the electrical installation and maintenance psychomotor assessment instrument and removed any other task(s) which is/are considered not suitable and ambiguous or redundant statement(s) in order to improve the structure of electrical installation and maintenance psychomotor assessment instrument. On the whole as shown in Table 2, there were still 40 tasks with 313 corresponding skill items to be included in the electrical installation and maintenance psychomotor assessment instrument

Research question 3 What is the reliability of the developed process assessment instrument in electrical installation and maintenance work at NTC III?

Table 3 Reliability Estimates (Cronbach alpha) for Items in Electrical Installation and Maintenance Psychomotor Assessment Instrument

S/N	Tasks	Reliability Coefficient	No of items	Remarks
1	Construct a point of light controlled by a switch	0.78	14	Reliable
2	Construct two point of light controlled by a switch	0.81	14	Reliable
3	Installation of cut-out/fuse	0.72	12	Reliable
4	Installation of earth leakage circuit breaker	0.69	6	Reliable
5	Installation of single phase meter	0.77	16	Reliable
6	Installation of three phase meter	0.76	16	Reliable
7	Installation of distribution control board	0.68	10	Reliable
8	Making of surface wiring	0.78	11	Reliable
9	Preparing materials for conduit wiring	0.66	3	Reliable
10	Carry out polarity test	0.61	3	Reliable
11	Conduct insulation test	0.65	4	Reliable
12	Carry out earth leakage test	0.71	4	Reliable
13	Carryout continuity test	0.76	7	Reliable
14	Carryout surface wiring using demonstration board	0.79	11	Reliable
15	Preparation of PVC cables for electrical installation	0.74	8	Reliable
16	Construct a point of light controlled by two- 2 way switches using steel conduit wire	0.82	15	Reliable
17	Maintaining electronic measuring instrument	0.79	8	Reliable
18	Assemble fluorescent fittings	0.84	14	Reliable
19	Carry out test to demonstrate over loading faults	0.62	4	Reliable
20	Make a married joint	0.76	8	Reliable
21	Prepare Britannica joint	0.66	6	Reliable
22	Prepare PVC taped and braided cable for termination	0.60	3	Reliable
23	Join armoured cable at intermediate position	0.77	9	Reliable
24	Terminate armoured cable at intermediate position	0.78	9	Reliable
25	Using pot and ladle for cable jointing	0.75	8	Reliable
26	Repair damaged underground cable	0.76	7	Reliable
27	Prepare ground for laying underground cable	0.65	5	Reliable
28	Use megger to test for continuity	0.60	3	Reliable
29	Erection of low tension pole	0.73	7	Reliable
30	Installation of stay wire	0.71	7	Reliable
31	Prepare simple wave winding	0.62	5	Reliable
32	Make lap winding	0.64	5	Reliable
33	Dismantle electric motor	0.66	6	Reliable
34	Construct winding formers	0.60	3	Reliable
35	Fix the winding coil inside the slots	0.71	4	Reliable
36	Connect the winding using the prepared data	0.77	5	Reliable
37	Carry out earthling on electric motor	0.75	5	Reliable
38	Test for supply voltage	0.83	12	Reliable
39	Test for incoming current	0.84	11	Reliable
40	Test run the machine	0.81	5	Reliable

Analysis in Table 3 reveals that each of the 40 electrical installation and maintenance work tasks had high Cronbach alpha reliability coefficients ranged from 0.60-0.84. Also, the reliability coefficient of the entire item was computed to be 0.834 which indicated that the assessment instrument was a refined test in consonance with the recommendation of (Landis & Koch, 1977) which stated that acceptable reliability of test or agreement of the raters on test given to students in education is generally in the range of 0.41 to 1.00.

Therefore given the high reliability coefficients or substantial agreement for various tasks in the instrument, the answer to research question about the reliability of the tests would be in the affirmative. Thus, the items in the instrument for assessing the psychomotor skills of students in electrical installation and maintenance work were reliable and could be considered for assessing students' psychomotor skills in electrical installation and maintenance work in technical colleges.

Hypothesis

There is no significant difference in the mean ratings of students on the assessment instrument in electrical installation and maintenance work based on their ability levels Data for testing hypothesis one are presented in Table 4

Table 4 Summary of ANOVA Utilized for Testing Null Hypothesis One

Sources of Variance	Sum of Squares	Df	Mean Square	f-cal	P-Value	Level of Sig.	Rmks
Between Groups	2.558	2	1.279	1.26	0.302	0.05	**NS**
Within Groups	22.183	22	1.008				
Total	23.845	24					

Data presented revealed a P-value of 0.302 which is greater than 0.05 at degree of freedom 2 and 22. This indicated that there was no significant difference in the mean ratings of students on the assessment instrument in electrical installation and maintenance work based on their ability levels. Therefore, the null hypothesis of no significant difference between the three groups of students based on their ability levels (high, average and low ability levels), when using the electrical installation and maintenance work psychomotor skills assessment instrument was accepted. The results further indicated that psychomotor skill items in electrical installation and maintenance work were not too difficult for high, average and low ability groups of students.

Findings of the study

The following findings emerged from the study based on the research questions answered and hypotheses tested

A. Findings on the assessment instrument items in performing tasks by students of electrical installation and maintenance work in Electrical Installation, Cable Jointing and Termination and Electrical Machine Winding Operations at NTC level

The findings relating to factorial validity of the electrical installation and maintenance psychomotor assessment instrument Assessment Instrument revealed that 14 skill items in the three operations (Electrical Installation, Cable Jointing and Termination and Electrical Machine Winding) could not load and were discarded.

It was found out from the study that 19 tasks with 181 corresponding skill items were suitable for inclusion into instrument for assessing psychomotor skills of students in electrical installation operation

Task - Construct a point of light controlled by a switch

1. Produce layout for the installation
2. Select appropriate tools for installation
3. Select accessories for lighting point
4. Fix the accessories accordingly
5. Select two core cable for lighting point
6. Measure the cable to suit the installation
7. Carry out continuity test on the cable
8. Connect red of the main to the red of switch
9. Connect black of the main to the black of the bulb
10. Connect red of the bulb to the black of the switch
11. Close the junction box
12. Connect the point of lighting to the mains supply
13. Test run the circuit

Task - Construct two points of light controlled by a switch

1. Produce layout for the installation
2. Select appropriate accessories for the installation
3. Determine appropriate tools for installation
4. Fix the accessories one by one
5. Select cable for lighting point
6. Test the cable for continuity
7. Connect red of the main to the red of switch
8. Connect black of the main to the black of the bulb

9 Connect red of the bulb to the black of the switch
10 Repeat the process for the second point
11 Close the junction box
12 Connect the lighting point to the mains supply
13 Put the bulbs
14 Test run the circuit for functionality

Task - Installation of cut-out/fuse

1 Make layout for the installation
2 Identify tools for the installation
3 Determine the fuse/cut-out to be used/ fuse rating
4 Position cut-out at appropriate place
5 Screw down the cut-out/fuse
6 Identify live wire using tester
7 Select appropriate size of cable for the installation
8 Connect the live wire to the terminal of the cut out/fuse
9 Connect the live wire to live terminal of the meter
10 Connect neutral to the neutral terminal of the meter
11 Connect DFB to the output terminals of the meter
12 Test run the installation

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