

DEVELOPMENT AND VALIDATION OF A PSYCHOMOTOR SKILLS ASSESSMENT TOOL FOR ELECTRICAL INSTALLATION AND MAINTENANCE WORKS TRADE OF TECHNICAL COLLEGES IN NIGERIA

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Abstract

This study was carried out to develop and validate EIMW trade psychomotor skill assessment tool for technical colleges in Nigeria. Instrumentation research design was adopted for the study. The population comprised of 160 EIMW trade teachers from the nineteen federal science technical colleges in Nigeria. Four research questions were posed to guide the study. Instrument for data collection was tagged EIMWTPSATQ with 198 items. The instrument was subjected to face and content validity by three experts from department of electrical technology education, Modibbo Adama University Yola. The reliability of the instrument was obtained via Cronbach Alpha with a coefficient index of 0.99. Mean and standard deviation, factor analysis, Cronbach Alpha, and intraclass correlation were used to answer each research respectively. Findings of the study revealed that the content of the EIMWTPSAT measures accurately what it is purported to measure. Furthermore, the EIMWTPSAT is consistent and demonstrated an acceptable level of inter-rater agreement. The research therefore recommends for the adoption of the developed and validated EIMWTPSAT for use in all technical colleges in Nigeria because it will no doubt remove the inconsistencies associated with performance assessment in Workshops of Electrical Installation & Maintenance Works trade, and also help the students improve on their practical performance.

Keywords: Development, Validation, Electrical Installation, Maintenance Work, Psychomotor Skills, Assessment Tools, and Technical Colleges

Introduction

Technical College is a level of secondary education charged with the responsibility of producing trained personnel's in the applied sciences, technology and business particularly at craft, advanced craft and technical levels; providing the technical knowledge and vocational skills necessary for agricultural, commercial and economic development; and giving training or imparting the necessary skills to individuals for self-reliance (Umar and Ma'aji, 2010). Technical Colleges offer various programmes at different levels leading to the award of National Business Certificate (NBC)/National Technical Certificate (NTC) and Advanced National Business Certificate (ANBC)/Advanced National Technical Certificate (ANTC) at craft level and advanced craft level, respectively (Federal Republic of Nigeria, 2013).

Programmes offered by the Technical Colleges includes among others: Electronics Work (EW), Electrical Installation and Maintenance Works (EIMW).

The curriculum of Electrical Installation and Maintenance Works trade serves to equip students with functional skills upon graduation as technicians through their ability to understand and carry out tasks in domestic and industrial installations (NABTEB, 2015). The curriculum further emphasizes the need for students to be exposed to practical experiences through Workshop Practice and Maintenance. Workshop Practice and Maintenance is centered on providing the students with the practical skills (psychomotor skills) that takes place in the workshop where the students carry out tasks or practical projects. This practical requires the students to produce practical projects which are assessed to determine the extent to which psychomotor skills and knowledge have been acquired.

Assessment of practical skills (psychomotor skills) in workshops can be carried out by evaluation of the chronological process in which the tasks are carried out (process assessment), while evaluation at the finished task or end-product refers to product assessment or a combination of both assessment techniques can be used (Okeke as cited in Moses *et al.*, 2017). The purpose of psychomotor skills assessment is to ensure that the students can manipulate tools and equipment to attain the task specification that can serve as a valid and reliable predictor of skills acquisition in workshop practice and maintenance. Product assessment technique is the most dominant and certainly the most used form of assessment of psychomotor skills in workshops of technical colleges in Nigeria (Maxwell, 2019). This method covers mainly the assessment of completed tasks to determine the extent to which a psychomotor skill has been acquired by the students which involves the instructor providing the students with a designed blueprint that are assessed at the completion of the task (Okwelle & Okoye, 2012; Ombugus & Ogbuanya, 2014; Adamu *et al.*, 2015; Moses *et al.*, 2017; Asukwo, Akpan, & Yusuf, 2019; Asukwo *et al.*, 2019).

Evaluation of the chronological process involves carrying out task that requires attentive and consistent observation from the teacher from the beginning of the task to the end, which makes the process assessment technique more efficient technique of measuring psychomotor skill compared to evaluation of the finished task or end-product where only objective judgement of the quality of the finished task or end-product is required. Product assessment technique is done at the expense of judging the production process used by the students. Finished products are rated and marks awarded based on mere examination of the end results of the students' task (Okwelle and Okeke, 2012; Okwelle and Okoye, 2012). These assessment techniques do not encourage the development of the students' process skills under close observation of the teacher. Chiejile (2006) opined that the reason for the utilization of only product assessment technique by teachers could be that they are either reluctant or too busy to objectively assess the various stages of individual student's work through the use of a definite procedure of assessment. It is, therefore, pertinent to say that it would be difficult to

achieve the objectives of the curriculum of Electrical Installation and Maintenance Work (EIMW) using just the product assessment technique of psychomotor skill assessment.

An effective assessment technique is expected to evaluate the step-by-step practical activities carried out by the students in a workshop setting. It is also supposed to determine the extent to which the students can demonstrate practical competencies using a rating scale while the teacher observes the students perform the operations involved (Ombugus, 2014; Asukwo, Akpan, & Yusuf, 2019; Akpan *et al.*, 2019; Asukwo *et al.*, 2019). An effective assessment technique should also make use of a valid and reliable tool. It is on this basis that the researcher intends to develop a psychomotor assessment tools that will evaluate all steps involved in carrying out task in EIMW which may be more effective as to the existing product assessment guide.

Statement of the Problem

Product assessment technique have been in use by almost all examination bodies for psychomotor assessment of practical examinations. According to Asukwo, Akpan, & Yusuf, (2019), product assessment is defective because it involves bias in rating of the students by the teacher due to perception or drawing conclusion on a finished practical task. Scores are awarded to the students based on the perception of the teacher on the quality of the completed task or finished product. This approach to psychomotor skill assessment tends to make the students less keen and diligent in following the process involved in carrying out installations and maintenance work, and therefore makes the students end-product oriented. This lack of diligence in following the process executing the tasks play a vital role in the competence of electrical engineering trade graduates produced by the technical colleges in Nigeria as they would find it difficult to exhibit the required psychomotor skill needed in relevant areas of work. Product dependent assessment techniques might be the reason why most graduate cannot be self-employed as some students can come with somebody to do the task for them since the teacher will come at the end of the task to assess them which may lead to graduate not acquiring the required skills for self-employment. In order to therefore achieve observable psychomotor skills in students of electrical installation and maintenance work trade upon graduation, there is need for their performance in workshop tasks during practical's work to be observed and evaluated at every stage of the task by the teacher. This might help in improving their practical skills with the help of a well-developed and validated assessment tool. It was against this that the researchers sought to develop and validate a tool for assessing psychomotor skill in electrical installation and maintenance work trade for technical colleges in Nigeria.

Objectives of the Study

The purpose of this study is to develop and validate a psychomotor skill assessment tool in Electrical installation and maintenance work Trade for technical colleges in Nigeria. Specifically, the study sought to:

1. Identify the content agreed by teachers for inclusion into the tool for assessing students' psychomotor performance in Electrical Installation and Maintenance Work Trade
2. Assess the construct validity of the developed psychomotor assessment tool for Electrical Installation and Maintenance Work Trade Students.
3. Determine the internal consistency of the developed psychomotor assessment tool for Electrical Installation and Maintenance Work Trade Students.
4. Determine the inter-rater's reliability of the developed psychomotor assessment tool Electrical Installation and Maintenance Work Trade Students.

Research questions

1. What are the content agreed by teachers for inclusion into the tool for assessing students' psychomotor performance in Electrical Installation and Maintenance Work Trade?
2. What are the construct validity of the developed psychomotor assessment tool for Electrical Installation and Maintenance Work Trade Students?
3. What are the internal consistency of the developed psychomotor assessment tool for Electrical Installation and Maintenance Work Trade Students?
4. What is the inter-rater's reliability of the developed psychomotor assessment tool Electrical Installation and Maintenance Work Trade Students?

Methodology

This study adopted instrumentation research design to develop a psychomotor skill assessment tool in electrical installation and maintenance work trade for all technical colleges in Nigeria. The population of the study was the nineteen federal science and technical colleges of Nigeria with 160 EIMW trade teachers. Cluster sampling technique was used to group the 19 technical colleges based on the six geo-political zones and one technical college was purposively sampled from each of the geo- political zones taking into consideration the availability of materials tools, equipment's needed for the study and security situation across the states in Nigeria. Researcher-developed instruments were used for the study which was tagged; Electrical Engineering Trade Psychomotor Skill Assessment Tool Questionnaire (EIMWTPSATQ) which was extracted from the national business and technical examination board (NABTEB) syllabus for engineering trade examination and related literatures, designed on a 5-point Likert scale with response option of highly suitable (HS), suitable (S), undecided (UD), unsuitable (U), and highly unsuitable (HU) having numerical values of 5,4,3,2, and 1 respectively. The instruments (EIMWTPSATQ) went through face and content validation by three experts from the Department of Electrical Technology Education, Modibbo Adama University Yola, Nigeria. In order to determine the reliability and internal consistency of the instruments, 10 EIMW teachers in Government Science Technical Colleges of Adamawa State were selected for pilot testing and a reliability coefficient of 0.99 was obtained using Cronbach alpha. Hence the instruments were adjudged reliable for data collection. The instrument was analyzed using mean and standard deviation and then subjected to factor analysis using a factor

loading of 0.30 and above. The final assessment tools were trial tested on ST II students in GSTCs of Adamawa State with three raters.

Results:

Table 1: Content Identified for Inclusion into Tools for Assessing Student's Psychomotor Skills by Teacher in Electrical Installation and Maintenance Work Trade

S/N	Skill Items	n	$\bar{x}$	σ	Remark
MODULE I: DOMESTIC INSTALLATION					
Cluster 1: Working Drawing					
1.	Ability to correctly draw electrical symbols on a working drawing	45	4.47	.66	Suitable
2.	Ability to identify wiring accessories used on working diagram	45	4.58	.65	Suitable
3.	Ability to measure working diagrams with the aid of scale rule	44	4.27	.69	Suitable
4.	Ability to locate position of various accessories on a drawing	45	4.47	.58	Suitable
5.	Ability to list electrical accessories needed for a job from a working drawing	45	4.64	.48	Suitable
6.	Ability to explain distribution system from wiring drawing	45	4.60	.80	Suitable
7.	Ability to draw electrical installation diagram for a living house	45	4.67	.52	Suitable
Cluster 2: Surface Wiring					
1.	Ability to identify various types of wiring clips used in surface wiring	45	4.84	.36	Suitable
2.	Ability to identify various types of gim pins used in surface wiring	45	4.56	.54	Suitable
3.	Ability to identify various types of rawl drills used in surface wiring	45	4.56	.62	Suitable
4.	Ability to nail clips on walls	45	4.80	.40	Suitable
5.	Ability to gim pin on walls	45	4.64	.48	Suitable
6.	Ability to identify various types of cables used in surface wirings	45	4.58	.54	Suitable
7.	Ability to identify various sizes of cables used in surface wirings	45	4.58	.62	Suitable
8.	Ability to install socket outlets in ring circuit	45	4.73	.44	Suitable
9.	Ability to install socket outlets in radial circuit	45	4.76	.43	Suitable
10.	Ability to use plumb-line	45	4.49	.75	Suitable
11.	Ability to use chalk-line	45	4.44	.62	Suitable
12.	Ability to use sprit level	45	4.51	.62	Suitable
13.	Ability to carry out simple surface wiring using appropriate tools	45	4.73	.44	Suitable
14.	Ability to appropriately observe safety measures required in surface wiring	45	4.69	.51	Suitable
15.	Ability to adopt I.E.E regulation when carrying out surface wiring	45	4.53	.69	Suitable
Cluster 3: Conduit Wiring					
1.	Ability to identify components needed for conduit wiring	45	4.64	.57	Suitable

2.	Ability to identify tools needed for conduit wiring	45	4.60	.61	Suitable
3.	Ability to identify different types of conduits	45	4.44	.69	Suitable
4.	Ability to use various conduit accessories	45	4.56	.81	Suitable
5.	Ability to cut conduit pipes using hacksaw	45	4.56	.58	Suitable
6.	Ability to thread conduit pipes using taps and dies	45	4.36	.71	Suitable
7.	Ability to set and bend permissible radial lengths	45	4.38	.68	Suitable
8.	Ability to carry out a simple surface conduit installation	45	4.67	.60	Suitable
9.	Ability to carry out a simple conceal conduit installation	45	4.40	.61	Suitable
10.	Ability to draw-in cables in surface conduit installation using fish tape	45	4.44	.69	Suitable
11.	Ability to inspect conduit installation as required by the IEEE regulation	45	4.36	.60	Suitable
12.	Ability to carry out test of conduit installation as required by the IEEE regulation	45	4.24	.74	Suitable
13.	Ability to appropriately observe safety measures required in conduit wiring	45	4.62	.61	Suitable
14.	Ability to maintain tools after conduit installation	45	4.64	.48	Suitable
Cluster 4: Installation of Protective Devices					
1.	Ability to identify common types of protective devices	45	4.82	.38	Suitable
2.	Ability to identify current rating of fuses	45	4.56	.62	Suitable
3.	Ability to install earth leakage circuit breakers (ELCBs) to the supply authority	45	4.27	.83	Suitable
4.	Ability to install earth continuity conductor (ECC) using relevant accessories to the installation	45	4.33	.79	Suitable
5.	Ability to install earthing leads and earth electrode	45	4.51	.66	Suitable
6.	Ability to observe safety precaution when installing protective devices	45	4.60	.65	Suitable
Cluster 5: Inspection and Testing of Domestic Installation					
1.	Ability to carry out inspection on all joints made in a simple wiring made on a wiring board	45	4.56	.58	Suitable
2.	Ability to ensure that all loose contacts are properly tighten	45	4.76	.43	Suitable
3.	Ability to use bell sets	45	4.42	.72	Suitable
4.	Ability to use test lamp	45	4.78	.42	Suitable
5.	Ability to use megger instrument to test for continuity of earthing system	45	4.31	.70	Suitable
6.	Ability to use megger insulation tester to test between conductors	45	4.51	.58	Suitable
7.	Ability to use megger insulation tester to test between earth and conductors	45	4.33	.64	Suitable
8.	Ability to use megger insulation tester to test between conductors and frame body	45	4.47	.58	Suitable
9.	Ability to verify results of all test with the test instrument used	45	4.42	.54	Suitable
10.	Ability to appropriately observe safety measures	45	4.49	.72	Suitable
MODULE II: INDUSTRIAL INSTALLATION					
Cluster 1: Installation of MICC Cable					
1.	Ability to identify mineral insulated copper cables (MICC)	45	4.47	.72	Suitable
2.	Ability to select appropriate tools used in MICC cable installation	45	4.40	.72	Suitable

3.	Ability to select appropriate materials used in MICC cable installation	45	4.42	.86	Suitable
4.	Ability to terminate MICC cable installation using various pot	45	4.36	.80	Suitable
5.	Ability to carry out MICC cable installation observing the relevant regulations	45	4.24	.90	Suitable
6.	Ability to carry out tests on the completed MICC installation applying statutory regulations	45	4.24	.77	Suitable
7.	Observing precautionary measures	45	4.44	.72	Suitable
Cluster 2: Industrial Installation					
1.	Ability to interpret working drawings of industrial installations	45	4.42	.65	Suitable
2.	Ability to carry out simple surface wiring for industrial installations	45	4.47	.81	Suitable
3.	Ability to carry out simple conduit wiring for industrial installations	45	4.40	.75	Suitable
4.	Ability to install MICC cables	45	4.18	.83	Suitable
5.	Ability to observe necessary safety measures when carrying out industrial installations	45	4.57	.66	Suitable
Cluster 3: Installation of Ducts and Trunking					
1.	Ability to describe ducts and trunking system	45	4.58	.62	Suitable
2.	Ability to identify bus bar trunking	45	4.40	.68	Suitable
3.	Ability to accurately mark out when cutting holes	45	4.33	.70	Suitable
4.	Ability to bend accessories used for duct and trunking	45	4.38	.65	Suitable
5.	Ability to set accessories used for duct and trunking	45	4.31	.70	Suitable
6.	Ability to shape accessories used for duct and trunking	45	4.24	.77	Suitable
7.	Ability to file accessories used for duct and trunking	45	4.20	.86	Suitable
8.	Ability to fabricate accessories used for duct and trunking	45	3.91	1.0	Suitable
9.	Ability to carry out different types of joints used for ducts and trunking	45	4.22	.87	Suitable
10.	Ability to display different types of ducts and trunking	45	4.20	.89	Suitable
11.	Ability to provide earth continuity in all types of duct and trunking	45	4.18	.83	Suitable
12.	Ability to observe safety measures as provided by IEEE statutory regulations	45	4.33	.90	Suitable
Cluster 4: Installation of AC and DC Machines					
1.	Ability to identify various types of DC machines	45	4.53	.54	Suitable
2.	Ability to identify various types of AC machine	45	4.47	.75	Suitable
3.	Ability to identify various types of enclosures	45	4.20	.66	Suitable
4.	Ability to construct good foundation base for mounting electrical machines	45	4.04	.87	Suitable
5.	Ability to lift electrical machine properly to avoid strain	45	4.16	.73	Suitable
6.	Ability to handle electrical machine properly to avoid strain	45	4.24	.67	Suitable
7.	Ability to mount electrical machine properly to avoid strain	45	4.09	.73	Suitable
8.	Ability to carry out star-delta connections	45	4.07	.96	Suitable
9.	Ability to carry out delta-star connections	45	3.98	.76	Suitable
10.	Ability to select appropriate cable based on machine rating	45	4.11	.74	Suitable
11.	Ability to select starter circuits	45	4.16	.73	Suitable
12.	Ability to carry out tests for correct rotation	45	4.02	.81	Suitable
13.	Ability to carry out tests for short circuit	45	4.22	.70	Suitable

14. Ability to carry out tests for earth fault	45	4.40	.68	Suitable
15. Ability to observe safety measures as provided in IEEE regulations	45	4.36	.71	Suitable

Cluster 5: Maintenance of Electrical Equipment and Machine

1. Ability to carry out machine lubrication	45	4.38	.77	Suitable
2. Ability to identify different grades of lubricants	45	4.27	.72	Suitable
3. Ability to identify appropriate tools needed for machine maintenance	45	4.42	.58	Suitable
4. Ability to carry out various systematic maintenance procedure	45	4.38	.61	Suitable
5. Ability to observe safety measures during maintenance	45	4.51	.54	Suitable

Cluster 6: Repairs of Electrical Machines, Equipment and Installation

1. Ability to troubleshoot a faulty equipment	45	4.16	.60	Suitable
2. Ability to troubleshoot a faulty machine	45	4.04	.70	Suitable
3. Ability to interpret circuit diagrams of equipment	45	4.18	.71	Suitable
4. Ability to interpret circuit diagrams of machines	45	4.18	.71	Suitable
5. Ability to use appropriate tools to repair faulty parts of electrical machines	45	4.31	.79	Suitable
6. Ability to use appropriate equipment to repair faulty parts of electrical machines	45	4.27	.80	Suitable
7. Ability to carry out visual inspection on electrical machine	45	4.27	.91	Suitable
8. Ability to carry out performance test on electrical machine and equipment	45	4.27	.83	Suitable
9. Ability to observe safety measures during repairs	45	4.47	.72	Suitable

MODULE III: CABLE JOINTING

Cluster 1: Joints and Termination of Cable

1. Ability to appropriately select tools needed for cable jointing	45	4.76	.43	Suitable
2. Ability to appropriately select materials needed for cable jointing	45	4.58	.49	Suitable
3. Ability to identify insulating materials	45	4.71	.45	Suitable
4. Ability to identify conductors	45	4.71	.50	Suitable
5. Ability to insulate joints	45	4.76	.48	Suitable
6. Ability to shape conductors to avoid terminal contact	45	4.53	.58	Suitable
7. Ability to fix appliances into their terminals using various methods	45	4.47	.54	Suitable
8. Ability to fix accessories into their terminals using various methods	45	4.40	.61	Suitable
9. Ability to carry out fixing of cable lugs	45	4.40	.72	Suitable
10. Ability to carry out fixing of cable glands	45	4.20	.72	Suitable
11. Ability to make simple joints	45	4.67	.60	Suitable
12. Ability to observe safety measures during cable jointing	45	4.64	.60	Suitable

Cluster 2: Soldering and Brazing

1. Ability to use blow-lamp for soldering large cable size	45	4.31	.73	Suitable
2. Ability to use pot and ladle for soldering large cable size	45	4.24	.74	Suitable
3. Ability to use heat sink	45	4.24	.71	Suitable
4. Ability to carry out soldering on joints	45	4.53	.50	Suitable

5.	Ability to carry out brazing on joints	45	4.31	.70	Suitable
6.	Ability to carry out continuity test on electrical equipment	45	4.64	.52	Suitable
7.	Ability to maintain blow lamps	45	4.31	.76	Suitable
8.	Ability to observe safety measures	45	4.64	.52	Suitable

Cluster 3: Armoured Cables

1.	Ability to appropriately select armouring materials	45	4.18	.80	Suitable
2.	Ability to join armoured cables	45	4.07	.72	Suitable
3.	Ability to terminate armoured cables	45	4.16	.76	Suitable
4.	Ability to show the constructional features of armoured cables	45	4.13	.66	Suitable
5.	Ability to observe safety measures	45	4.49	.69	Suitable

Cluster 4: Underground Cable Installation

1.	Ability to identify various cables used for underground electrical installation	45	4.22	.70	Suitable
2.	Ability to identify tools used in underground cable installation	45	4.22	.63	Suitable
3.	Ability to prepare trench to appropriate depth for cable laying	45	4.22	.70	Suitable
4.	Ability to lay cables in trench	45	4.20	.62	Suitable
5.	Ability to make cable joints	45	4.33	.64	Suitable
6.	Ability to carry out tee straight final termination of cable	45	4.16	.63	Suitable
7.	Ability to solder underground cable	45	3.98	.89	Suitable
8.	Ability to use different types of tapes in underground works	45	4.11	.64	Suitable
9.	Ability to use different testing instruments in cable jointing	45	4.11	.71	Suitable
10.	Ability to apply relevant IEEE regulation to underground work	45	4.07	.68	Suitable
11.	Ability to observe safety measures	45	4.44	.78	Suitable

Cluster 5: Installation of Overhead Wires

1.	Ability to identify size of cables and wires used in overhead transmission/distribution	45	4.36	.71	Suitable
2.	Ability to erect poles at appropriate poles span and firmly in the ground	45	4.16	.82	Suitable
3.	Ability to identify various types of stray wires	45	4.20	.72	Suitable
4.	Ability to carry out the preparation of different types of stray wires	45	4.16	.82	Suitable
5.	Ability to use stray wire and secure poles firmly to the ground	45	4.20	.58	Suitable
6.	Ability to use different types of cross arms in high tension transmission	45	4.22	.63	Suitable
7.	Ability to make proper joints and termination in ensuring electrical continuity	45	4.27	.61	Suitable
8.	Ability to observe necessary safety regulations when making joints and terminations	45	4.49	.72	Suitable
9.	Ability to identify communication data cables	45	4.27	.68	Suitable
10.	Ability to use cable terminators in communication cabling	45	4.33	.67	Suitable
11.	Ability to connect a small PABX for communication	45	3.91	.79	Suitable

MODULE IV: WINDING OF ELECTRICAL MACHINES

Cluster 1: Tools and Equipment

1.	Ability to identify tools used for winding	45	4.51	.72	Suitable
2.	Ability to identify equipment used for winding	45	4.33	.70	Suitable
3.	Ability to select appropriate tools use for winding	45	4.44	.75	Suitable

4.	Ability to select appropriate cable size for winding	45	4.38	.71	Suitable
5.	Ability to use the work benches for winding jobs	45	4.40	.72	Suitable
6.	Ability to use the winding machines for winding	45	4.22	.67	Suitable
7.	Ability to observe safety measures during winding	45	4.56	.72	Suitable
Cluster 2: Winding Drawings					
1.	Ability to prepare simple wave winding drawing	45	4.20	.72	Suitable
2.	Ability to prepare simple lap winding drawing	45	4.16	.70	Suitable
3.	Ability to interpret simple wave winding drawing	45	4.16	.73	Suitable
4.	Ability to interpret simple lap winding drawing	45	4.13	.72	Suitable
5.	Ability to determine coil span per pitch in winding drawing	45	4.00	.76	Suitable
6.	Ability to determine coil span per phase in winding drawing	45	4.00	.85	Suitable
7.	Ability to determine coil span per pole in winding drawing	45	4.02	.81	Suitable
8.	Ability to fix coil ends on commutator/slip rings for fixed brush in a developed winding diagram	45	3.84	.85	Suitable
Cluster 3: Dismantling					
1.	Ability to record data from name plate	45	4.36	.74	Suitable
2.	Ability to dismantle machines for rewinding	45	4.27	.72	Suitable
3.	Ability to assemble machines after rewinding	45	4.22	.76	Suitable
4.	Ability to identify front and back shields	45	4.16	.73	Suitable
5.	Ability to identify type of winding/connection	45	4.13	.81	Suitable
6.	Ability to locate position of brushes	45	4.04	.82	Suitable
7.	Ability to use extractors for dismantling	45	4.11	.80	Suitable
8.	Ability to observe safety measures during dismantling	45	4.36	.77	Suitable
Cluster 4: Rewinding of Machines					
1.	Ability to identify types of conductors used in rewinding	45	4.42	.65	Suitable
2.	Ability to identify types of insulators used in rewinding	45	4.36	.64	Suitable
3.	Ability to construct winding formers	45	4.29	.62	Suitable
4.	Ability to prepare and fix winding coils in their slots	45	4.24	.60	Suitable
5.	Ability to insulate each slots	45	4.29	.62	Suitable
6.	Ability to connect windings	45	4.18	.77	Suitable
7.	Ability to carry out continuity test on rewind machines	45	4.27	.65	Suitable
8.	Ability to carry out short-circuit test on rewind machines	45	4.20	.62	Suitable
9.	Ability to test earthing of the rewinding machines	45	4.09	.76	Suitable
10.	Ability to apply varnish and dry in oven	45	4.07	.75	Suitable
11.	Ability to carry out test on the completed work	45	4.24	.77	Suitable
12.	Ability to skim armature commutator and slip rings	45	4.09	.79	Suitable
13.	Ability to undercut commutator	45	4.11	.74	Suitable
14.	Ability to observe safety measures during rewinding	45	4.61	.49	Suitable
Cluster 5: Final Inspection and Testing of Machine					
1.	Ability to inspect different parts of machines	45	4.33	.64	Suitable
2.	Ability to detect bad ball bearing in the machine	45	4.29	.66	Suitable
3.	Ability to fix the end of shield in their proper position to the machine	45	4.18	.74	Suitable
4.	Ability to apply grease to the appropriate parts of the machines	45	4.27	.58	Suitable
5.	Ability to use megger or bridge megger to test for continuity of the machine	45	4.24	.64	Suitable
6.	Ability to test for insulation resistance of a machine	45	4.16	.63	Suitable
7.	Ability to carry out test-run of machine ensuring correct rotation	45	4.13	.72	Suitable

8.	Ability to use avometer to test voltage and current to ensure they correspond to manufacturer specifications	45	4.18	.68	Suitable
9.	Ability to use tachometer to test for the speed of machine bearing to ensure they correspond to manufacturer specifications.	45	4.16	.76	Suitable

KEY: n = Number of Respondents, $\bar{x}$ = Mean Response of Technical College Teachers and σ = standard deviation.

Data in Table 1 indicates that the mean ($\bar{x}$) of responses of Technical College Teachers on the EIMW skill items considered suitable for inclusion into the EIMWTPSAT exceed the mean criterion of 3.50. Standard deviation values ranging from 0.36 to 1.01 reveals homogeneity in the responses of the EIMW teachers. These results indicate that the technical college teachers considered all the EIMW skill items identified as suitable for inclusion into the EIMWTPSAT.

Table 2.: Assessment of Construct Validity of the Developed Tools for Electrical Installation and Maintenance Works Trade

S/N	Skill Items	n	Factor Loading	Remark
MODULE I: DOMESTIC INSTALLATION				
Cluster 1: Working Drawing				
1.	Ability to correctly draw electrical symbols on a working drawing	45	.72	Important
2.	Ability to identify wiring accessories used on working diagram	45	.74	Important
3.	Ability to measure working diagrams with the aid of scale rule	45	.76	Important
4.	Ability to locate position of various accessories on a drawing	45	.75	Important
5.	Ability to list electrical accessories needed for a job from a working drawing	45	.61	Important
6.	Ability to explain distribution system from wiring drawing	45	.58	Important
7.	Ability to draw electrical installation diagram for a living house	45	.63	Important
Cluster 2: Surface Wiring				
1.	Ability to identify various types of wiring clips used in surface wiring	45	.58	Important
2.	Ability to identify various types of gim pins used in surface wiring	45	.83	Important
3.	Ability to identify various types of rawl drills used in surface wiring	45	.74	Important
4.	Ability to nail clips on walls	45	.48	Important
5.	Ability to gim pin on walls	45	.66	Important
6.	Ability to identify various types of cables used in surface wirings	45	.69	Important
7.	Ability to identify various sizes of cables used in surface wirings	45	.74	Important

8.	Ability to install socket outlets in ring circuit	45	.39	Important
9.	Ability to install socket outlets in radial circuit	45	.48	Important
10.	Ability to use plumb-line	45	.50	Important
11.	Ability to use chalk-line	45	.76	Important
12.	Ability to use spirit level	45	.76	Important
13.	Ability to carry out simple surface wiring using appropriate tools	45	.67	Important
14.	Ability to appropriately observe safety measures required in surface wiring	45	.70	Important
15.	Ability to adopt I.E.E regulation when carrying out surface wiring	45	.65	Important
Cluster 3: Conduit Wiring				
1.	Ability to identify components needed for conduit wiring	45	.84	Important
2.	Ability to identify tools needed for conduit wiring	45	.88	Important
3.	Ability to identify different types of conduits	45	.68	Important
4.	Ability to use various conduit accessories	45	.68	Important
5.	Ability to cut conduit pipes using hacksaw	45	.80	Important
6.	Ability to thread conduit pipes using taps and dies	45	.83	Important
7.	Ability to set and bend permissible radial lengths	45	.79	Important
8.	Ability to carry out a simple surface conduit installation	45	.75	Important
9.	Ability to carry out a simple conceal conduit installation	45	.76	Important
10.	Ability to draw-in cables in surface conduit installation using fish tape	45	.55	Important
11.	Ability to inspect conduit installation as required by the IEEE regulation	45	.77	Important
12.	Ability to carry out test of conduit installation as required by the IEEE regulation	45	.70	Important
13.	Ability to appropriately observe safety measures required in conduit wiring	45	.69	Important
14.	Ability to maintain tools after conduit installation	45	.55	Important
Cluster 4: Installation of Protective Devices				
1.	Ability to identify common types of protective devices	45	.51	Important
2.	Ability to identify current rating of fuses	45	.78	Important
3.	Ability to install earth leakage circuit breakers (ELCBs) to the supply authority	45	.87	Important
4.	Ability to install earth continuity conductor (ECC) using relevant accessories to the installation	45	.68	Important
5.	Ability to install earthing leads and earth electrode	45	.81	Important
6.	Ability to observe safety precaution when installing protective devices	45	.79	Important
Cluster 5: Inspection and Testing of Domestic Installation				
1.	Ability to carry out inspection on all joints made in a simple wiring made on a wiring board	45	.63	Important
2.	Ability to ensure that all loose contacts are properly tighten	45	.66	Important
3.	Ability to use bell sets	45	.74	Important
4.	Ability to use test lamp	45	.35	Important
5.	Ability to use megger instrument to test for continuity of earthing system	45	.74	Important

6.	Ability to use megger insulation tester to test between conductors	45	.79	Important
7.	Ability to use megger insulation tester to test between earth and conductors	45	.87	Important
8.	Ability to use megger insulation tester to test between conductors and frame body	45	.81	Important
9.	Ability to verify results of all test with the test instrument used	45	.67	Important
10.	Ability to appropriately observe safety measures	45	.72	Important
		45	.63	Important
MODULE II: INDUSTRIAL INSTALLATION				
Cluster 1: Installation of MICC Cable				
1.	Ability to identify mineral insulated copper cables (MICC)	45	.90	Important
2.	Ability to select appropriate tools used in MICC cable installation	45	.85	Important
3.	Ability to select appropriate materials used in MICC cable installation	45	.85	Important
4.	Ability to terminate MICC cable installation using various pot	45	.80	Important
5.	Ability to carry out MICC cable installation observing the relevant regulations	45	.80	Important
6.	Ability to carry out tests on the completed MICC installation applying statutory regulations	45	.68	Important
7.	Observing precautionary measures	45	.87	Important
Cluster 2: Industrial Installation				
1.	Ability to interpret working drawings of industrial installations	45	.90	Important
2.	Ability to carry out simple surface wiring for industrial installations	45	.87	Important
3.	Ability to carry out simple conduit wiring for industrial installations	45	.89	Important
4.	Ability to install MICC cables	45	.84	Important
5.	Ability to observe necessary safety measures when carrying out industrial installations	45	.79	Important
Cluster 3: Installation of Ducts and Trunking				
1.	Ability to describe ducts and trunking system	45	.59	Important
2.	Ability to identify bus bar trunking	45	.70	Important
3.	Ability to accurately mark out when cutting holes	45	.84	Important
4.	Ability to bend accessories used for duct and trunking	45	.82	Important
5.	Ability to set accessories used for duct and trunking	45	.87	Important
6.	Ability to shape accessories used for duct and trunking	45	.85	Important
7.	Ability to file accessories used for duct and trunking	45	.81	Important
8.	Ability to fabricate accessories used for duct and trunking	45	.75	Important
9.	Ability to carry out different types of joints used for ducts and trunking	45	.90	Important
10.	Ability to display different types of ducts and trunking	45	.87	Important
11.	Ability to provide earth continuity in all types of duct and trunking	45	.89	Important
12.	Ability to observe safety measures as provided by IEEE statutory regulations	45	.78	Important
Cluster 4: Installation of AC and DC Machines				
1.	Ability to identify various types of DC machines	45	.53	Important

2.	Ability to identify various types of AC machine	45	.54	Important
3.	Ability to identify various types of enclosures	45	.71	Important
4.	Ability to construct good foundation base for mounting electrical machines	45	.74	Important
5.	Ability to lift electrical machine properly to avoid strain	45	.77	Important
6.	Ability to handle electrical machine properly to avoid strain	45	.85	Important
7.	Ability to mount electrical machine properly to avoid strain	45	.73	Important
8.	Ability to carry out star-delta connections	45	.84	Important
9.	Ability to carry out delta-star connections	45	.85	Important
10.	Ability to select appropriate cable based on machine rating	45	.78	Important
11.	Ability to select starter circuits	45	.73	Important
12.	Ability to carry out tests for correct rotation	45	.52	Important
13.	Ability to carry out tests for short circuit	45	.53	Important
14.	Ability to carry out tests for earth fault	45	.62	Important
15.	Ability to observe safety measures as provided in IEEE regulations	45	.54	Important
Cluster 5: Maintenance of Electrical Equipment and Machine				
1.	Ability to carry out machine lubrication	45	.81	Important
2.	Ability to identify different grades of lubricants	45	.90	Important
3.	Ability to identify appropriate tools needed for machine maintenance	45	.88	Important
4.	Ability to carry out various systematic maintenance procedure	45	.89	Important
5.	Ability to observe safety measures during maintenance	45	.81	Important
Cluster 6: Repairs of Electrical Machines, Equipment and Installation				
1.	Ability to troubleshoot a faulty equipment	45	.58	Important
2.	Ability to troubleshoot a faulty machine	45	.88	Important
3.	Ability to interpret circuit diagrams of equipment	45	.79	Important
4.	Ability to interpret circuit diagrams of machines	45	.84	Important
5.	Ability to use appropriate tools to repair faulty parts of electrical machines	45	.83	Important
6.	Ability to use appropriate equipment to repair faulty parts of electrical machines	45	.89	Important
7.	Ability to carry out visual inspection on electrical machine	45	.89	Important
8.	Ability to carry out performance test on electrical machine and equipment	45	.88	Important
9.	Ability to observe safety measures during repairs	45	.88	Important
MODULE III: CABLE JOINTING				
Cluster 1: Joints and Termination of Cable				
1.	Ability to appropriately select tools needed for cable jointing	45	.71	Important
2.	Ability to appropriately select materials needed for cable jointing	45	.60	Important
3.	Ability to identify insulating materials	45	.66	Important
4.	Ability to identify conductors	45	.86	Important
5.	Ability to insulate joints	45	.88	Important
6.	Ability to shape conductors to avoid terminal contact	45	.75	Important

7. Ability to fix appliances into their terminals using various methods	45	.54	Important
8. Ability to fix accessories into their terminals using various methods	45	.72	Important
9. Ability to carry out fixing of cable lugs	45	.76	Important
10. Ability to carry out fixing of cable glands	45	.82	Important
11. Ability to make simple joints	45	.86	Important
12. Ability to observe safety measures during cable jointing	45	.80	Important
Cluster 2: Soldering and Brazing			
1. Ability to use blow-lamp for soldering large cable size	45	.78	Important
2. Ability to use pot and ladle for soldering large cable size	45	.65	Important
3. Ability to use heat sink	45	.81	Important
4. Ability to carry out soldering on joints	45	.77	Important
5. Ability to carry out brazing on joints	45	.81	Important
6. Ability to carry out continuity test on electrical equipment	45	.64	Important
7. Ability to maintain blow lamps	45	.85	Important
8. Ability to observe safety measures	45	.71	Important
Cluster 3: Armoured Cables			
1. Ability to appropriately select armouring materials	45	.86	Important
2. Ability to join armoured cables	45	.94	Important
3. Ability to terminate armoured cables	45	.95	Important
4. Ability to show the constructional features of armoured cables	45	.87	Important
5. Ability to observe safety measures	45	.84	Important
Cluster 4: Underground Cable Installation			
1. Ability to identify various cables used for underground electrical installation	45	.83	Important
2. Ability to identify tools used in underground cable installation	45	.77	Important
3. Ability to prepare trench to appropriate depth for cable laying	45	.63	Important
4. Ability to lay cables in trench	45	.78	Important
5. Ability to make cable joints	45	.88	Important
6. Ability to carry out tee straight final termination of cable	45	.90	Important
7. Ability to solder underground cable	45	.68	Important
8. Ability to use different types of tapes in underground works	45	.88	Important
9. Ability to use different testing instruments in cable jointing	45	.76	Important
10. Ability to apply relevant IEEE regulation to underground work	45	.76	Important
11. Ability to observe safety measures	45	.66	Important
Cluster 5: Installation of Overhead Wires			
1. Ability to identify size of cables and wires used in overhead transmission/distribution	45	.48	Important
2. Ability to erect poles at appropriate poles span and firmly in the ground	45	.65	Important
3. Ability to identify various types of stray wires	45	.63	Important
4. Ability to carry out the preparation of different types of stray wires	45	.73	Important
5. Ability to use stray wire and secure poles firmly to the ground	45	.87	Important
6. Ability to use different types of cross arms in high tension transmission	45	.84	Important

7. Ability to make proper joints and termination in ensuring electrical continuity	45	.88	Important
8. Ability to observe necessary safety regulations when making joints and terminations	45	.72	Important
9. Ability to identify communication data cables	45	.88	Important
10. Ability to use cable terminators in communication cabling	45	.88	Important
11. Ability to connect a small PABX for communication	45	.69	Important

MODULE IV: WINDING OF ELECTRICAL MACHINES

Cluster 1: Tools and Equipment

1. Ability to identify tools used for winding	45	.89	Important
2. Ability to identify equipment used for winding	45	.91	Important
3. Ability to select appropriate tools use for winding	45	.93	Important
4. Ability to select appropriate cable size for winding	45	.93	Important
5. Ability to use the work benches for winding jobs	45	.89	Important
6. Ability to use the winding machines for winding	45	.86	Important
7. Ability to observe safety measures during winding	45	.92	Important

Cluster 2: Winding Drawings

1. Ability to prepare simple wave winding drawing	45	.90	Important
2. Ability to prepare simple lap winding drawing	45	.92	Important
3. Ability to interpret simple wave winding drawing	45	.91	Important
4. Ability to interpret simple lap winding drawing	45	.87	Important
5. Ability to determine coil span per pitch in winding drawing	45	.93	Important
6. Ability to determine coil span per phase in winding drawing	45	.88	Important
7. Ability to determine coil span per pole in winding drawing	45	.94	Important
8. Ability to fix coil ends on commutator/slip rings for fixed brush in a developed winding diagram	45	.84	Important

Cluster 3: Dismantling

1. Ability to record data from name plate	45	.88	Important
2. Ability to dismantle machines for rewinding	45	.91	Important
3. Ability to assemble machines after rewinding	45	.90	Important
4. Ability to identify front and back shields	45	.91	Important
5. Ability to identify type of winding/connection	45	.88	Important
6. Ability to locate position of brushes	45	.79	Important
7. Ability to use extractors for dismantling	45	.87	Important
8. Ability to observe safety measures during dismantling	45	.84	Important

Cluster 4: Rewinding of Machines

1. Ability to identify types of conductors used in rewinding	45	.73	Important
2. Ability to identify types of insulators used in rewinding	45	.63	Important
3. Ability to construct winding formers	45	.80	Important
4. Ability to prepare and fix winding coils in their slots	45	.85	Important
5. Ability to insulate each slots	45	.90	Important
6. Ability to connect windings	45	.52	Important
7. Ability to carry out continuity test on rewind machines	45	.81	Important
8. Ability to carry out short-circuit test on rewind machines	45	.80	Important
9. Ability to test earthing of the rewinding machines	45	.80	Important
10. Ability to apply varnish and dry in oven	45	.80	Important
11. Ability to carry out test on the completed work	45	.61	Important
12. Ability to skim armature commutator and slip rings	45	.72	Important
13. Ability to undercut commutator	45	.56	Important

14. Ability to observe safety measures during rewinding	45	.28	Unimportant
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Cluster 5: Final Inspection and Testing of Machine

1. Ability to inspect different parts of machines	45	.90	Important
2. Ability to detect bad ball bearing in the machine	45	.86	Important
3. Ability to fix the end of shield in their proper position to the machine	45	.88	Important
4. Ability to apply grease to the appropriate parts of the machines	45	.81	Important
5. Ability to use megger or bridge megger to test for continuity of the machine	45	.90	Important
6. Ability to test for insulation resistance of a machine	45	.90	Important
7. Ability to carry out test-run of machine ensuring correct rotation	45	.83	Important
8. Ability to use avometer to test voltage and current to ensure they correspond to manufacturer specifications	45	.87	Important
9. Ability to use tachometer to test for the speed of machine bearing to ensure they correspond to manufacturer specifications.	45	.84	Important

KEY: n = Number of Respondents

Data in Table 2 indicates that 197 out of 198 EIMW skill items were considered important base on the factor analysis on responses of technical college teachers on the EIMW skill items considered important for inclusion into the EIMWTPSAT. These results indicate that 197 out of 198 EIMW skill items considered suitable for inclusion into the EIMWTPSAT by the technical college teachers measures the psychomotor skills it is designed to measure.

Table 3: Internal Consistency OF EIMWTPSATQ

S/N	n	α	Remark
1. Electrical Installation and Maintenance Work	49	0.747	Consistent

KEY: n = Number of Observations, α = reliability coefficient

Data in Table 3 indicates that EIMW of the EIMWTPSAT possess a reliability coefficient of 0.747 which is therefore adjudged consistent and acceptable.

Table 4: Determination of Inter-Rater Reliability of the Developed Tool

S/N	n	α	Remark
1. Electrical Installation and Maintenance Work	49	0.745	Reliable

KEY: n = Number of Observations, α = reliability coefficient

Table 4 also indicated that the raters exhibited an acceptable level of agreement among themselves in terms of how they rated the students using the EIMWTPSAT, based on the reliability coefficient benchmark of 0.7 or above. The EIMWTPSAT possesses a reliability coefficient of 0.745 and is therefore adjudged to possess an acceptable level of inter-rater agreement in rating psychomotor performance of students.

Discussion of Findings

From Table 1, the findings indicate that the mean responses of technical college teachers on the skill items considered suitable for inclusion into the electrical installation and maintenance work Trade of EIMWTPSAT is between 3.84 and 4.84 which exceeds the mean criterion of 3.50 indicating that the skill items identified as suitable for inclusion into the EIMWTPSAT. This finding is distinct from Moses *et al.* (2017), Asukwo, Akpan, and Yusuf (2019), Akpan *et al.* (2019), and Asukwo *et al.* (2019) as not all items identified by the researchers were considered suitable by the respondents for inclusion in the instruments developed in the various studies. Therefore, only skill items considered suitable were included in the draft copy of their instruments. However, this finding is analogous to Yalams (2001), Okwelle and Okoye (2012), Ombugus (2014), Ombugus and Ogbuanyia (2014), and Adamu *et al.* (2015) as all the items of the test instruments they developed were considered by the respondents as appropriate for use in assessing students' performance. The similarity and distinctness in findings is credited to the discretion among the Technical College teachers on the skill items perceived suitable for assessing practical skills.

The result on Table 2 Shows that, from factor analysis on responses of the technical college teachers on the skill items considered important for inclusion into the EIMWTPSAT, only one skill item was considered unimportant in the Electrical Installation and Maintenance Works trade. These results indicate that almost all skill items considered suitable for inclusion into the EIMWTPSAT by the technical college teachers measure the psychomotor skills they are designed to measure. This finding is consistent with Ombugus and Ogbuanyia (2014), Ombugus (2014), Asukwo, Akpan, and Yusuf (2019), Akpan *et al.* (2019), and Asukwo *et al.* (2019) where only few instrument items were considered unimportant through factor analysis. The consistence of the findings between the studies is hinged on the use of factor analysis, which searches for joint variations in responses to unobserved latent variables, to determine which skill items measure the skill they are designed to measure. Therefore, only skill items that measure the psychomotor skill they are designed to measure were included in the final draft of the EIMWTPSAT.

The findings on Table 3, shows that all parts of the EIMWTPSAT possess a reliability coefficient exceeding the benchmark of 0.70. The EIMWTPSAT also possesses a reliability coefficient of 0.747 and is therefore considered consistent and acceptable. This finding is analogous with Yalams (2001), Ombugus (2014), Ombugus and Ogbuanyia (2014), Adamu *et al.*

al. (2015), Moses *et al.* (2017), Asukwo, Akpan, and Yusuf (2019), Akpan *et al.* (2019), and Asukwo *et al.* (2019) where the instrument developed from their study possessed a high reliability coefficient and was therefore adjudged consistent and reliable. This analogy in findings arises from how well several skill items that propose to measure the same general construct on the instrument developed produce similar scores. The similarity in scores from the skill items in the EIMWTPSAT shows general agreement between them.

The result on Table 4, shows that the three raters exhibited an acceptable level of agreement in EIMW trade of the EIMWTPSAT. Furthermore, the EIMWTPSAT possesses a reliability coefficient of 0.745 and is therefore adjudged to possess an acceptable level of inter-rater agreement in rating psychomotor performance of students. This finding is similar to Ombugus and Ogbuanya (2014), Ombugus (2014), Asukwo, Akpan, and Yusuf (2019), Akpan *et al.* (2019), and Asukwo *et al.* (2019) where the developed instruments possessed an inter-rater reliability coefficient that was adjudged reliable. This finding is also consistent with Moses *et al.* (2017) where the developed instrument had a full length inter-rater reliability coefficient of 0.77 and was adjudged highly reliable. Varying inter-rater reliability coefficients can be attributed to the inter-rater reliability method and design adopted as research has shown that reliability coefficients for inter-rater agreement of three or more raters is usually less than that of two raters.

Conclusion

Data obtained in this study indicates that the Electrical installation and maintenance work Trade Psychomotor Skill Assessment Tool (EIMWTPSAT) is a valid and reliable assessment tools that can be used in rating students' practical skills performance in EIMW Trade Workshops practice in technical colleges. The skill items of the assessment tool, as identified by the researchers, were considered suitable by the technical college teachers for evaluating psychomotor performance in Electrical Installation & Maintenance Works Trade. Findings of the study also revealed that the content of the EIMWTPSAT measures accurately what it is purported to measure. Furthermore, the EIMWTPSAT is consistent and demonstrates an acceptable level of inter-rater agreement. Therefore, adoption of the developed and validated EIMWTPSAT for use in all technical colleges in Nigeria will no doubt remove the inconsistencies associated with performance assessment in Workshops of Electrical Installation & Maintenance Works Trade, and also help the students improve on their practical performance.

Recommendations

1. National Business and Technical Examinations Board (NABTEB) should adopt the Electrical installation and maintenance work Trade Psychomotor Skill Assessment Tool (EIMWTPSAT) for rating students' practical performance in the workshops at NTC levels and other examinations at post- primary level.

2. Employers should also consider and adopt EIMWTPSAT for recruiting electrical & electronics technicians.
3. EIMW trade teachers at technical colleges should downplay the use of product assessment only, but rather combine both product assessment method and the EIMWTPSAT.
4. Seminars and workshops should be organized to get EIMW Trade teachers of technical colleges acquainted with the EIMWTPSAT to enhance uniformity in the standard of rating students' practical work using the assessment tool.
5. Educational administrators of technical colleges should extract the skill items of the 3ETPSAT and make it available to their students for study and practice, thus acquainting them with the knowledge of what is expected of them.

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