DEVELOPMENT AND VALIDATION OF AN INSTRUMENT FOR ASSESSING BASIC ELECTRONICS PROCESS SKILLS IN SENIOR SECONDARY SCHOOLS IN LAGOS STATE, NIGERIA

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AUGUST, 2016

TITLE PAGE

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A THESIS SUBMITTED TO THE DEPARTMENT OF INDUSTRIAL TECHNICAL EDUCATION,
FACULTY OF VOCATIONAL AND TECHNICAL EDUCATION UNIVERSITY OF NIGERIA, NSUKKA IN FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF DOCTOR OF PHILOSOPHY (Ph.D) DEGREE IN INDUSTRIAL TECHNICAL EDUCATION

AUGUST, 2016

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DEDICATION

This thesis is dedicated to God almighty the beginning and the end of every activity performed by human beings. It is also dedicated to my Dear wife Mrs Unwana Raphael Umanah and children - Ekemini, Emmanuella, Lawrencia, Michael, and Raphael Jnr.

ACKNOWLEDGEMENTS

The completion of this doctoral thesis has been possible through the support and encouragement the researcher received from many people. The researcher wishes to express his gratitude to his supervisor, Dr. T. C. Ogbuanya, for her sincere guidance, encouragement and understanding throughout the various stages of this project and for sharing her wealth of experience in research and imparting knowledge and wisdom into him. May Almighty God continue to bless her and grant her more favour in all her endeavours.

In addition, the researcher wishes to acknowledge the useful observations, modifications and corrections made by members of the panel that examined this work at the Department proposal stage ï Prof. C. A. Igbo, Prof. K. O. Usman, Prof, E. O. Ede and Dr. F. M. Onu. Equally acknowledged are the contributions of the panelists to who scrutinized the work at the faculty seminar stage including Prof. C. A. Obi, Dr. V. C. Nwachukwu, Prof. E. O. Ede and Dr. L. D. Nwabuko.

The contributions of the experts who took part in validating the instrument developed for this study are also acknowledged. The experts are Dr. B.C. Madu of the University of Nigeria Nsukka, Dr. N.A. Udofia of the university of Uyo, Dr. M. I. Odo of the University of Lagos and Dr. A.U. Igwe of the Federal College of Education (Techhnical) Akoka, Lagos and A. A. Ghandi, Head, Electrical Department, Government Technical College, Farfaru, Sokoto.

The researcherôs gratitude equally goes to the Principal and research assistants at Federal Science and Technical College, Yaba for facilitating the study and to the following computer operators: Usman Danfodio Bala, Ekemini R. Umanah, Clement Chukwu and Anietie Udonkuku who typed, retyped and carried out the necessary corrections.

Finally, the researcher is particularly indebted to his beloved wife ï Unwana ï for reading through the finished work to identity avoidable mistakes.

Usman, Raphel Anyiekan

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Abstract

The study was carried out to develop and validate an instrument for assessing basic electronics process skills in senior secondary schools. Six research questions guided the study while three null hypotheses were formulated and tested at 0.05 level of significance. The study adopted instrumentation design and was carried out in Lagos State, Nigeria. The population for the study was 188 subjects made up of 158 basic electronic students and the 30 teachers who taught basic electronics in the 25 senior secondary schools that offered basic electronics as a subject up to senior secondary three level during the 2014/2015 school year. The sample size for the study was 30 which comprised five teachers of basic electronics and 25 senior secondary III students that offered basics electronics in Federal Science and Technical College, (FSCT) Yaba, Lagos State. Purposive sampling technique was used to select FSCT Yaba Lagos State. Basic electronics process skills assessment instrument was used as instrument for data collection for the study. The instrument was face validated by five experts while content validation was carried out using a table of specifications based on Simpsonôs model of psychomotor domain in the area of measuring and testing, construction of electronic analysis after which six skill items in five tasks were discarded. Based on the result of the validation processes basic electronics process skills assessment instrument made up of 32 tasks and 239 process skills was developed. The developed instrument was employed in assessing 25 SS III students of basic electronics students in Federal Science and Technical College, Yaba. Five teachers of basic electronic were employed as raters for observing and rating the students as they carried out the given tasks. The internal consistency of the basic electronics process skill assessment instrument was then determined using Cronbach alpha reliability method and a reliability coefficient of 0.72 operation and 0.69 for fault tracing operation, with 0.77 as the overall reliability coefficient for the instrument. Analysis of variance (ANOVA) was employed to test the null hypotheses at 0.05 level of significance. It was found out that there was no significant difference in the mean scores of the ability groups (high, average and low ability). The interrater reliability coefficient of the developed instrument was 0.75 and there was a high degree of agreement among all the five raters used in the study. It was recommended that the relevant external examination bodies should include process skills assessment in their examination scheme for certification of the students in basic electronics. The study also recommended that government should organize seminars and workshops for teachers of basic electronics on how to make use of the developed basic electronics process skills assessment instrument. It was further recommended that equipment, materials and funding that would facilitate the use of the basic electronics process skills assessment instrument in senior secondary schools should be provided by stakeholders including the government and parentsô teachersô associations.

CHAPTER ONE

INTRODUCTION

Background of the Study

Basic electronics is one of the technology or vocational subjects taught in senior secondary schools. Adesina (2002) described electronics as a field of study that is both science and technology oriented. It is concerned with the way in which the movement of electrons through space is controlled and manipulated. In electronics, students study the behavior of electrons and the practical uses to which such study can be applied (Knight, 1994). College Board (2008) explained that students of electronics learn the basic skills needed to operate, maintain, install and repair electrical and electronic equipment.

Specifically, the objectives of electronics in senior secondary schools in Nigeria are: to develop a further understanding of the basic concepts and principles of electronics, to build and test simple electronics devices, to develop skills in fault-tracing and repairs, to apply simple electronic devices in the construction of electronic systems, and to prepare adequately for further work in electronics (Nigerian Educational Research and Development Council, 2008).

The basic electronics curriculum for senior secondary schools in Nigeria has twelve themes as follows: electrical quantities, electronic components and circuits, basic electrical theory, thermionic devices, semiconductor devices, power supply, measuring instruments and tools, transducers and sensors, digital basics, communication system, control system, and entrepreneurship in electronics (NERDC, 2008). Students are expected to acquire both the knowledge and skills in the themes specified by Nigerian Educational Research and Development Council. Audu (2008) described students as some persons undergoing a course of study in any learning environment. In this study students are learners that are at the third year of senior secondary school offering basic electronics. In order to measure their level of achievement or goal attainment, studentsô performance on all aspect of the basic electronics curriculum needs to be assessed.

Assessment is the process of making judgment or forming an opinion after careful consideration. In the classroom setting, assessment is the process of gathering, analyzing, interpreting and using information about studentsô progress and achievements to improve teaching and learning (New Zealand Ministry of Education, 2011). According to Aggarwal (2007), assessment is a process of making judgments that are to be used for further planning. It is used in improving the product, the process and even the goals themselves. In the words of Baehr (2011) ñassessment provides feedback on knowledge, skills, attitudes, and work products for the purpose of elevating future performance and learning outcomesò. Assessment therefore is the process of making judgments about the performance of senior secondary students in carrying out the practical tasks in basic electronics, with a view to improve or determine performance. Students are assessed based on learning experiences they are exposed to as contained in the curriculum.

Curriculum is a group of learning experiences which students are exposed to through the teacher in order to change their behaviors. According to Offorma (2002), curriculum is all the planned experiences provided by the school to assist the learners in attaining the designated learning outcomes. Biggsand Sommefeldt (2002) defined curriculum as a social construct designed to transmit the characteristics of the society. The authors further stated that a society maintains and develops its identity over time through a continuous defining and redefining of its particular culture within the context of an ever-changing world. Ella (2007) also described curriculum as a structured series of intended learning experiences through which educational institutions endeavour to realize the hopes of the society. Curriculum is all the learning experiences the learner is exposed to under the guidance of the school. In other words, curriculum is an organized and logically arranged body of knowledge, skills and attitudes that enable the teacher to assist the students master its content during instruction in senior secondary schools.

The senior secondary school is the third phase of the 6-3-3-4 system of education. It can also be described as the second phase of the 9-3-4 education system where the first nine years represents basic education (primary and junior secondary) and the last phase represents tertiary education (Nigerian Educational Research and Development Council, 2004). Every student is expected to offer five core subjects, namely english language, mathematics, computer science, civic education and a trade/ entrepreneurship subject. In addition, every student is expected to offer three or four subjects to be chosen from science and mathematics group, humanities group, social science group, business studies group, technology or vocational group, and trade subjects group. Basic electronics is one of the subjects in the technology or vocational group.

The students in the senior secondary schools are of various ability levels. Ability level of a learner is a personal characteristic that influences the learnerôs performance. Bellingham (2008) defined ability as the power to perform a physical or mental task or function. Ability provides the competence to carry out activities efficiently. Such performance can be either before or after training (Scott & Marshall, 2005). Ability level is the degree of success with which a given mental or physical task or action can be performed. Ability level can pertain to an individual or to the average range of abilities found in a group of persons. In education, the term is often used in connection with studentsô performance, on a comparative basis in a subject or study area (Bellingham, 2008). In a classroom situation, students can be differentiated into high, average and low ability levels. A good assessment instrument should place the learner in the correct ability level. The current assessment scenario with regard to basic electronics in the senior secondary schools in Lagos State is characterized by the inability of most teachers to develop good assessment instruments, the unavailability of already developed process assessment instruments for use, and extensive use of product assessment in both internal and external examinations. Product assessment has severe limitations. Students can get outside assistance in developing the products to be presented for assessment, knowledge and competence on safety hazards and correct use of tools/equipment by the students cannot be assessed. In addition, the time spent on constructing or repairing the product, or the number of mistakes made in the process, are not considered (Okoro 2002). These limitations on product assessment are enough to hinder skill development. With the use of process assessment certain attributes of the students ï such as the ability to complete a task within a given time frame, safety practices, the skills/competences and procedures used in the care of tools and equipment can be observed and assessed (Odu, 2011). For proper assessment of practical work in basic electronics, the relevant assessment instrument must be used. Such an instrument should be able to assess the performance of the students in all the operations and tasks involved.

An operation is a job consisting of one or more tasks while a task is the smallest identifiable and essential piece of a job that serves as a unit of work, and as a means of differentiating between the various components of an operation or project. (businessdictionary.com, 2015) Merger in Olaitan and Ali (1997) defined task as logically related set of actions required for completion of a job objective. Microsoft Encarta dictionary (2009) described task as a piece of work that somebody is given to do, usually short in duration or with deadline. Task therefore is a piece of work that must be performed by students of basic electronic within a stipulated period of time. In essence, therefore a group of related tasks constitute an operation. In this study, the practical content of the basic electronics curriculum is divided into measuring and testing operation, constructing electrical circuit operation, and fault tracing operation. These three operations are further sub-divided into thirty-two tasks. Measuring and testing operations covers such task as using ammeter to measure current, measuring power with three-phase wattmeter, using oscilloscope to measure electrical quantities. Under constructing electrical circuit operation, are such tasks as constructing a step down transformer, constructing a half-wire rectifier and constructing a simple common emitter amplifier. Under fault tracing and repair operations are identifying bad components/faults in the circuit, and fixing in good components in the circuit as tasks. These tasks are carried out through the exhibition of process skills.

Process Skills, in science education, are the tactics and strategies that students use to investigate the world around them and to construct science concepts. Science process skills include: observing, measuring, questioning, hypothesizing, predicting, planning and investigating, interpreting and communicating (Ostlund, 1998). However, in technical and vocational education, process skills are the practical skills used in the process of carrying out a task (Ombugus, 2013). Process skills, according to the National Volunteer Skill Center (2011) are organized and coordinated forms of physically observable activities exhibited in carrying out tasks in vocational and technical education. Elijah, (2006) defined process skills as the procedures adopted for performing tasks with high level of accuracy. In the context of this study, process skills are the steps of performing or carrying out a given task in basic electronics. For instance, to carry out the task of measuring current using an ammeter, the process skills used include: selecting the ammeter to use, adjusting the pointer of the analogue meter to zero, setting the selector knob to the applicable current range, connecting the ammeter in series with the current, and connecting the positive lead (RED) of the ammeter to the positive terminal of the voltage supply. Others include: connecting the negative lead (BLACK) of the ammeter to the negative terminal of the voltage supply, switching on the power supply, making sure the meter is placed on a horizontal surface, viewing the pointer from directing above such that the pointer concise with the calibrating point, and taking and recording the ammeter reading. Assessing the process skills studentsô exhibit in carrying out practice tasks is very necessary in determining what they have learnt and whether the objectives have been achieved.

Educational objectives are commonly classified into three major domains ï the cognitive, the affective and the psychomotor domains. The cognitive domain is concerned with learning related to knowledge ï from simple recognition and memory to complex problem solving and evaluation (Clark, 2000). The affective domain covers learning related to attitudes, feelings and emotions (Okoro, 2002), while the psychomotor domain is concerned with learning related to actions and motor skills ï from simple actions to complex choreography (Thomas, 2004). The psychomotor domain addresses skill development relating to manual tasks and physical movement. However, it also covers modern day business and social skills such as communication and operation of information technology equipment. In developing the process skills assessment instrument, Simpsonôs taxonomy of the psychomotor domain was utilized. (Simpson, 1972). Elizabeth Simpson developed her taxonomy of the psychomotor domain on the concept of skill and argued that for mastery to be attained, a first time learner goes through seven stages viz: perception, set, guided response, complex overt response, mechanism, adaptation, and origination (Ombugus, 2013).

Psychomotor skills are usually assessed by product and process assessment. Product assessment is concerned with the assessment of only the final product. The process or procedure adopted in the construction and servicing of the product is not of concern to the product assessor. Scores are awarded on the basis of how the final product is, not on how it was prepared (Effiong, 2006). Process assessment, on the other hand, involves observing the learners and rating them on the process or procedure adopted when carrying out the practical activity. The edge that process assessment has over product assessment in the teaching/learning process is that process assessment is more likely to ensure that the learner can perform the task by him/herself (Okoro, 2002). Assessment instruments are expected to be valid.

Validity is the degree to which an instrument measures what it is supposed to measure. Ensuring that an instrument is valid is an essential aspect of instrument development (Brown, 1996), Validity is subdivided into; content validity, construct validity and criterion related validity (Wolming, 1998). 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 (Brown, 2000). Odu (2001) 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 context of this study, content validity is the extent to which the items in the process skills assessment instrument measures the instructional objectives of basic electronics in the areas of measuring and testing operation, constructing electronic circuit operation, and fault tracing and repair operation. Another type of validity is criterion related validity.

Criterion related validity involves the correlation of an instrument with some well respected outside measures of the same objectives and specifications (Brown, 2000; Nitko, 1996). Criterion related validity according to Stedman (2006) is the degree of effectiveness with which performance on a test or procedure predicts performance in a real life situation. Contextually, criterion ï related validity refers to the extent to which items in the process skills assessment instrument represent the level of which performance of students in the field or work place can be judged as acceptable and sustainable. Face validity ascertains that the instrument appears to be assessing the intended construct under study. It determines how closely the instrument appears to measure what it is supposed to measure. Anastasi and Urbina (1997) described face validity as what an instrument or test appears superficially to measure. Face validity is not an empirical way of determining validity of an instrument, but it is important in the instrument/test-giving situation. If students taking the test think it measures what it is supposed to measure, their motivation and cooperation levels may increase, and low scorers may feel less dissatisfied. Face validity in the context of this study is the extent to which the items in the process skills assessment instrument appear to measure the intended construct in the basic electronics curriculum for senior secondary schools.

A construct refers to any complex psychological concept not directly measurable such as motivation, anger, personality, intelligence, love and fear. According to Gall, Gall and Borg (2007) a construct is a concept that is inferred from commonalities and observed phenomena and that can be used to explain those phenomena. In theory development, a construct is a concept that refers to a structure or process that is hypothesized to underlie a particular phenomenon. The construct validity of a test is the extent to which the test may be said to measure a theoretical construct or trait. Examples of such construct include scholastic aptitude, mechanical comprehension, verbal fluency, speed of walking, and anxiety (Anastasi & Urbana, 1997). Evidence for construct validity is established through a series of activities in which the researcher defines a construct and simultaneously develops the instrument to measure it. This process is often used when no criterion or universe of content is accepted as entirely adequate to define the quality to be measured (Sacket, 2003). Construct validity involves assembling of evidence about what a test means. This is done by showing the relationship between a test and other tests or measures. Each time a relationship is demonstrated, an additional bit of reasoning can be attached to the test. Then, over a series of studies, the meaning of the test gradually takes shape. Two important set of considerations for establishing evidence of construct validity logically are convergent evidence and discriminant evidence (Kaplan & Saccuzzo, 2009). When a measure correlates well with other tests believed to measure the same construct, convergent evidence for construct validity is obtained. Similarly when test measures something unique it has discriminant evidence of construct validity. To demonstrate discriminant evidence a test should have low correlations with measures of unrelated construct or evidence for what the test does not measure. In addition to being valid, a good assessment instrument must also be reliable.

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 reliability, parallel forms reliability, internal consistency reliability and inter-rater reliability. Internal consistency reliability 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. Raters may disagree as to how well certain responses or material demonstrate knowledge of the construct or skill being assessed (Cozby, 2001). In the context of this study, inter ï 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 basic electronics students. Reliability is one of the essential characteristics of a good test.

A test is one of the devices or instruments used to generate measurement data for use in evaluation. Badmus & Omoifo (1998) defined tests as any kind of device or procedure for measuring ability, achievement, interest, attitude or any other traits. Also, Aggarwal (2008) defined tests as a compact task or series of tasks designed to ascertain the merit or quantity of something. In the context of this study, a test is a series of items designed to assess the process skills of senior secondary basic electronics students using a rating scale.

A rating scale is one of the devices used in observation. It is used to determine the degree to which the learner exhibits a behavior or the quality of that behavior. Each trait is rated in a continuum and the observer decides where each learner fits on the scale. Sambo (2008) defined rating scale as an instrument which can be used by observers in recording their judgment about an event, activity or behavior they have observed. Aggarwal (1997) explained that rating scale is a method by which the expression of opinion concerning a trait is systematized. Rating may be done by teachers, parents, a board of interviewers, judges, or even by the individual concerned. The use of rating scales is indispensible in the development and validation of process skills assessment instrument for basic electronics, hence this study.

Statement of the Problem

Current assessment practices with regard to basic electronics in Lagos State senior secondary schools leave much to be desired. There is a dearth of valid and reliable instruments for assessing the skills acquired by senior secondary students during practical work in basic electronics. Assessment of practical work can be vulnerable to subjectivity if not carefully carried out using valid and reliable instruments. Lack of valid and reliable instruments is one of the major problems facing assessment in basic electronics.

Secondly, many technical and vocational teachers do not possess the knowledge, skills and the motivation needed for developing good assessment instruments. These teachers often assess practical work by taking a superficial look at the work, and assigning any grade they think each student deserves. Others adopt the product assessment technique despite its obvious limitations simply because that is what the external examination bodies use in the assessment of practical work in basic electronics.

While some teachers adopt the pattern used by the examination bodies in the assessment of practical work in electronics, others have no definite procedure for assessment. Such teachers often assess practical work by merely taking a cursory look at the work and assigning any grade they think each student deserves. No serious effort is made to assess the quality or character of individual practical work by developing a definite procedure of assessment. Basic electronics teachers who have adopted the pattern of assessment used by the external examination bodies teach the students through this pattern to enable them do well in the terminal examination.

These assessment approaches used for basic electronics in schools in Lagos State do not serve the best interest of teaching and learning for several reasons. First, the students are not led to acquire the necessary skills. Consequently, the main objectives of the practical work are achieved. Secondly, where the teachers have no definite procedure of assessment and assess projects by taking a cursory look at them, the students become dissatisfied with marks awarded to them and often complain because the assigned grades may not reflect the quality of workmanship of their projects. Thirdly, the inability to acquire adequate practical skills makes the students tend to lose interest in the field of study ï neither going for further studies in the same field of study nor putting their practical skills into use on the job. As a result of the absence of valid and reliable instruments, and the inability of many basic electronics teachers to develop appropriate assessment instruments, there is a clear and compelling need for an instrument to be developed and validated for use in assessing process skills in basic electronics as embedded in the senior secondary school curriculum.

Purpose of the Study

The general purpose of this study was to develop and validate a process skills assessment instrument in basic electronics for assessing practical skills of basic electronics students in senior secondary schools. Specifically, the study

1. Determined the practical tasks suitable for inclusion in the basic electronics practical process skills assessment instrument.
2. Determined the practical process skill items suitable for inclusion in the basic electronics practical process skills assessment instrument.
3. Determined the validity of the basic electronics process skills assessment instrument for senior secondary III students.
4. Established the reliability of the basic electronics process skills assessment instrument for senior secondary III students.
5. Determined the ability levels of the senior secondary III students of basic electronics

Significance of the Study

The developed and validated process skills instrument would be useful to the society, the examining bodies, teachers and students of basic electronics in senior secondary schools, and to educational researchers. The society will benefit from the findings of the study. The use of the process skills assessment instrument in assessing practical skills of basic electronics students in senior secondary schools will guarantee the production of well skilled graduates to fill some of the technical job positions available in the society. The use of valid and reliable assessment instrument would sensitize teachers to employ proper method of assessment. This will enable students to acquire the necessary skills outlined in the curriculum and consequently utilize the acquired skills in producing and providing the needed services in the society. By putting the acquired skills into practice, the graduates would be enabled to earn a living. This will help to reduce unemployment and curb social vices and crimes, including robbery and kidnapping, in the society.

Students offering basic electronics in senior secondary school will benefit from the findings of the study. The use of the process skills assessment instrument will allow the students to follow the sequence of learning tasks which will be based on the process of performing such tasks. The implementation of the process skill instrument will raise confidence of the students about the process of awards of marks and the final grades given to them. This will enhance the studentsô performance in the work place. Students of basic electronics at senior secondary level will benefit from the use of the process skill instrument as it will provide information to the students on the difficult areas of the curriculum. Students will use this information to seek help or practice on their own in order to achieve success.

The relevant examination bodies ï The West African Examination Council (WAEC) and the National Examinations Council (NECO) - could use the information from the developed process skills assessment instrument to organize teachersô seminars on the use of process skills test items for assessing students in basic electronics in senior secondary schools. The information and techniques in the developed process skills assessment instrument could be adopted by them for assessing basic electronics students in secondary schools during examinations. Use of the process skills assessment instrument will assist them during item writing and moderation meetings in the psychomotor areas of basic electronics. The developed process skill assessment instrument will also provide information to the examining bodies for basic electronics students to be skilled as expected.

Teachers teaching basic electronic at senior secondary level could choose activities for students by selecting from the list already outlined in the process skills assessment instrument. Occupational areas listed in the study could serve as a guide to the teachers in counseling studentsô occupational choice in basic electronics. With the developed process skills test, the teachers would ensure that instructional planning respond to the objectives of the senior secondary curriculum in basic electronics. The developed process skills assessment instrument could guide basic electronics teachers in test item construction for assessment of studentsô mastery of skills in the psychomotor areas of the course. Without reliable instruments, continuous assessment scores submitted by senior secondary schools to the external examination bodies as a component of the terminal examination cannot be said to be valid and reliable. Use of the process skills assessment instrument would benefit the teachers of basic electronics as it would entrench validity and reliability. The teachers could use the instrument as a guide in developing appropriate instructional strategies for teaching the practical tasks areas in the curriculum. The information from the instrument could serve as a guide to teachers of basic electronics in writing of teaching materials such as textbooks to include the teaching of skills.

The study serves as a source of information and literature for educational researchers who wish to conduct similar studies in other vocational and technical areas of specialization. That way, process skill assessments for subjects such as applied electricity, auto-mechanics, building construction, metal work and wood work can be developed where none exists. The study will guide them on what to do in order to achieve the objectives of their studies. They can also extract relevant literatures from this study build up to their own.

Theoretically the findings of the study are of benefit to test developers. The test developer can use the knowledge to know whether a developed instrument satisfies the qualities of a good test. Such qualities include validity, reliability and ease of scoring. It will also be useful to apply parameters to evaluate an existing instrument of its effectiveness.

Research Questions

The following research questions guided the researcher in carrying out the study:

1. What practical tasks are suitable for inclusion in the basic electronics practical process skills assessment instrument for senior secondary III students?
2. What process skill items are suitable for inclusion in the basic electronics practical process skills assessment instrument for senior secondary III students?
3. What is the validity of the basic electronics practical process skills assessment instrument for senior secondary III students?
4. What is the reliability of the basic electronics practical process skills assessment instrument for senior secondary III students?
5. What are the ability levels of the senior secondary III students of basic electronics?

Hypothesis

The following hypotheses were tested at 0.05 level of significance:

1. There is no significant difference in the mean ratings of students offering basic electronics in senior secondary III on measuring and testing operation, based on their ability levels, when using the process skills assessment instrument.

2. There is no significant difference in the mean ratings of students offering basic electronics in senior secondary III on constructing electrical circuit operation, based on their ability levels, when using the process skills assessment instrument.
3. There is no significant difference in the mean ratings of students on fault tracing and repair operation, based on their ability levels, when using the process skills assessment instrument.

Scope of the Study

The study was carried out in Lagos State located in south ï western Nigeria. The choice of the area was informed by the relatively large number of schools offering basic electronics up to senior secondary III class. The study covered the development and validation of a process skills assessment instrument for basic electronics at the senior secondary level using Simpsonôs taxonomy of the psychomotor domain. Practical tasks in six out of the twelve themes in the basic electronics curriculum were identified. The six themes were: electrical quantities, electronic components and circuits, basic electrical theory, semiconductor devices, power supply and measuring instruments and tools. Six themes were not used for the study because of having inadequate psychomotor content. They are: thermionic devices, communication system, transducers and sensors, digital basics, control system, and entrepreneurship in electronics. The study also determined the process skills to be exhibited by senior secondary III students in carrying out each of the identified tasks, determined the validity and established the reliability of the developed instrument.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

The review of related literature was arranged under the following sub-headings.

Conceptual Framework

Basic electronics

Process assessment

Test instrument development

Validity

Reliability

Theoretical Framework

Item Response Theory

Classical Test Theory

Classification theories of the psychomotor domain

Related Empirical Studies

Summary of Review of Related Literature

Basic Electronics

Basic electronics is one of the vocational or technology subjects taught in senior secondary schools in Nigeria. Other vocational subjects taught in senior secondary schools, apart from basic electronics, include: applied electricity, auto-mechanics, building construction, clothing and textiles, commerce, financial accounting, foods and nutrition, home management, metal work, short-hand, technical drawing, typewriting, visual art and wood-work. Adesina (2002) described electronics as a field of study that is both science and technology related. It is concerned with the way in which the movement of electrons through space is controlled and manipulated. In basic electronics, students study the behavior of electrons and the practical uses to which such study can be applied (Knight 1994). Students of electronics learn the basic skills needed to operate, maintain, install and repair electrical and electronic equipment. Aapplications of electronics feature prominently in radios, televisions, computers, transmitters, receivers and aeronautics equipment, among others (College Board, 2008). Specifically, the objective of basic electronics in senior secondary schools in Nigeria are fivefold: to develop a further understanding of the basic concepts and principles of electronics, to build and test simple electronics devices, to develop skills in fault-tracing and repairs, to apply simple electronic devices in the construction of electronic systems, and to prepare adequately for further work in electronics (Nigerian Educational Research and Development Council, 2008). The basic electronics curriculum for senior secondary schools in Nigeria was developed around twelve themes which include electrical quantities, electronic components and circuits, basic electrical theory, thermionic devices, semi-conductor devices, power supply, measuring instruments and tools, transducers and sensors, digital basics, communication system, control systems and entrepreneurship in electronics (NERDC, 2008).

The practical content of the basic electronics curriculum for senior secondary schools can be grouped under three operations, viz: measuring and testing, constructing electrical circuits, and fault tracing and repairs. Measuring and testing operation has the following tasks: measuring current using ammeter, measuring voltage with voltmeter, measuring resistance with ohmmeter, measuring power using single-phase wattmeter, measuring power using three-phase wattmeter, using multimeter to measure DCV, using multimeter to measure AC voltage, and using multimeter to measure DC current. Others are using multimeter to measure resistance, using multimeter to measure voltage of a battery, using multimeter for continuity test, applying oscilloscope to measure electrical quantities, determining waveform shapes of electronic components using oscilloscope, maintaining electronic measuring instruments, and performing simple experiments with ohmôs law.

Constructing electrical circuit operation covers the following tasks identified in this study: Constructing a step down transformer, constructing simple circuits using semi-conductor devices, constructing electric bell, constructing half and full wave rectifiers, constructing simple analogue ohmmeter, carrying out forward biasing of diodes, and carrying out wiring of electrical circuits.

Fault tracing and repair operation covers the following tasks: dismantling of electrical/electronic circuit or unit, identifying bad components/faults in the circuit, testing for bad components, fixing in good electronic components, coupling the maintained unit or circuit and testing the unit or circuit for functionality.

Each of these tasks has procedural steps for accomplishing the task. While the students performed the tasks using necessary tools and equipment, the raters (teachers) assessed their performance using the developed and validated Basic Electronics Process Skills Assessment Instrument (BEPSAI).

The senior secondary school is the third phase of the former 6-3-3-4 system of education. It can also be described as the second phase of the new 9-3-4 education system in Nigeria, where the first nine years represents basic education (primary and junior secondary) and the last phase of four years represents tertiary education (NERDC, 2004). The curriculum of the senior secondary school features five core subjects namely: English language, mathematics, computer science, civic education, and one trade or entrepreneurship subject. In addition to these five core subjects, every student is expected to offer in the terminal examination three or four other subjects to be chosen from the following five groups: science and mathematics, humanities, social sciences, business studies, technology, and trade/entrepreneurship subjects.

Basic electronics in the senior secondary school is related to this study because it helped the researcher to identify the assessable skills for the study. In addition, it gave direction to basic electronics teachers who used the process skills assessment instrument to assess studentsô performance in practical basic electronics in senior secondary schools.

Process Assessment

One of the main approaches used in assessing the performance skills possessed by students is process assessment. Process assessment involves observing the learners and rating them on the process or procedure adopted while carrying out the practical activity (Okoro, 2002). The process of building an audio amplifier, for example, involves designing the circuit, choosing appropriate components with correct ratings, preparing the printed circuit board, fixing of components at correct positions on the printed circuit board, as well as soldering of components. This process requires that studentsô progress in terms of ówhyô and óhowô at each stage of the project be observed and scored. To enable process assessment to be carried out the process skills assessment instruction must be developed and validated.

Process Skills Assessment Instrument

Process skills assessment instrument is an instrument used to assess steps of doing things. It is a systematic procedure to ascertain the level to which students have achieved the set of capabilities specified in a curriculum (Crowder, 2010). The National Teachers Institute (NTI), described process skills assessment instrument as a device for determining the extent students can demonstrate observable skills taught, and to perform them under conditions similar to working condition of the trade (NTI 2011). In the context of this study, the process skills assessment instrument is a device for rating the extent to which students can demonstrate the practical competencies of basic electronics while the student is performing the process skills involved.

Developing the process skills assessment instrument involves the following activities: identification of what to test in terms of areas or topics; specification of the skill elements in the topics (using an appropriate taxonomy model of the psychomotor domain), arrangement of these elements in a logical sequence representing order of performances, clarification of ideas or elements that may be confusing, deciding on the elements to be involved in the action, and deciding on the skill items in the group to test students understanding (Olaitan and Ali, 1997). Process skills assessment instrument developed through the steps above could help to elicit the mastery of skills of students in basic electronic.

Need for developing process skill assessment instrument

Most of the instruments in use for assessing students' abilities focus on the cognitive domain and to a lesser extent the affective domain. The teachers and the external examiners merely look and rate the finished electronic projects produced by students instead of judging the production process skill adopted by such students. The assessment methods used by the teachers in the workshops and by the external examination bodies have produced senior secondary graduates of electronics that are unemployable in the field. The fact that a student can present a quality product does not constitute a positive proof that he can actually cut the parts with acceptable degree of skills. The product rating method used by the teachers and examination bodies in measuring performance of the students is defective. This, in effect makes it impossible in the achievement of the objectives of electronics in senior secondary school. The present assessment practice does not ensure that the students of electronics are taught the proper way of carrying out tasks in electronics.

If the assessment portfolio used by the teachers and examining bodies had included process skills assessment and the students were successful as claimed through their results, they should be able to demonstrate acquired manipulative skills in the various aspects of basic electronics. The incompetence of the graduates could be attributed to the wrong conclusions about students' practical performance obtained from invalid and unreliable assessment instruments.

Little has been done to develop instruments that measure outcomes in the psychomotor domain especially in the area of electronics. Effiong (2006) threw some light as to the possible reason for this when he wrote that since manipulative skills tests are designed to measure and analyze student's skills in the performance of selected operations or procedures under controlled conditions, they are time consuming to prepare and administer. He further said that such test also tend to limit the number of students who can be tested at the same time. In addition some of the teachers were not trained in developing appropriate assessment instrument (Okoye,1991) However, there is documentary evidence that psychomotor tests have existed although informally. Before the introduction of western education into Africa, a type of education called traditional education was practiced. This indigenous form of education was mostly practical, non-verbal and informal and bordered more on the apprenticeship system (Fafunwa, 1974). The system involved a master craftsman carrying out his job while he allows his apprentice to watch and learn. The method of assessing the extent of learning was simply by giving the apprentice a piece of job to do while the master observed and corrected the apprentice where necessary. Although psychomotor tests may be old, there is lack of emphasis on non-cognitive learning outcomes in the modern western education in the developing world especially in Nigeria. Olaitan (1978) pointed out that the lack of emphasis on the non-cognitive learning outcomes has resulted in the neglect of manipulative skills, attitudes and values in our educational system. Yoloye (1988) wrote on the need for non-cognitive evaluation. He stressed that one problem with the one-shot summative evaluation approach in our school system is that assessment is directed mostly at the cognitive aspects of learning activities. Knowledge, understanding and other thinking skills acquired in the various subjects of the school curriculum are evaluated and marks are awarded relative to the pupilôs performance in the various subjects. Usually neglected in this procedure is the assessment of skills normally associated with both the character and the industry of the pupils is usually neglected (Yoloye, 1988).

Writing in the same vein, Mkpa (1992), said that psychomotor skills are those skills or special abilities required by the learner in human activities which can be acquired through learning and constant practice. It is therefore not all desired learning outcomes that can effectively be measured by cognitive or affective methods. Nwana (1982) pointed out that human behaviours belong to the head (cognitive), heart (affective) and body (psychomotor). Assessing the ability of students to perform manipulative skills is certainly an evaluation activity that lends itself well to the use of rating scales. They enable the evaluator to assess studentsô abilities and performances, leaving other more appropriate evaluation techniques to assess studentsô knowledge (Spitze and Osborne, 1983). The authors added that the performance test is very useful in assessing the students ability to perform a particular skill or execute a procedure where a paper - pencil test would be less adequate in determining mastery. Okoro (2002) further gave reasons for assessment in the psychomotor domain, when he wrote that, it contributes to a more comprehensive assessment of students and it measures the results of instruction in the context of direct and "real life" applications; and it enables students to analyze their own strengths and weaknesses.

The gap existing between the common place evaluation of cognitive learning outcomes and that of non-cognitive types seems to continually widen. This is probably why the new National policy on Education (FGN, 2004) recommended the continuous assessment method in our school system. It is aimed at arresting the imbalance existing between assessment in cognitive and non-cognitive learning outcomes through comprehensive assessment. Evaluation needs to stimulate real life situations so that measurement procedures will yield a predictive result. Leigbody and Kidd (1968), stated that the involvement of performance test requires the learner to perform the skilled operations which have been taught and to perform them under conditions which are equivalent to or which approximate the working conditions of the trade. Oranu (1988), stressed that one condition that facilitates is the availability of ready instrument for assessing the manipulative skills. Process assessment, the author explained, requires attentive and consistent teacher observation of students' performance. This process should be objectively judged by using performance rating scale. Performance rating scales should be developed in conjunction with performance objectives, student activities or process skills.

This study is concerned with assessing the process skills of the students in measuring and testing, construction of electrical/electronic circuit, and fault tracing and repair operations in senior secondary basic electronics. The assessment would be done using the process skills assessment instrument developed through Simpsonȇs taxonomy of the psychomotor domain. Wolansky (1985) gave directions for effective administration of manipulative skills assessment instrument as follows: prepare work area and provide students with all necessary equipment, tools and materials required to complete the test; inform students prior to the test about all points that will enter into their rating; create working conditions that are as nearly identical as possible for each student being tested, whether several students are being tested at one time or each is tested individually. Others were: do not offer any assistance other than to clarify directions during the test. For effective assessment, the process skill assessment instrument should be valid. instruct the students to follow directions carefully; make certain that students understand clearly what they are expected to do and how much time is available to complete the entire test; the test should contain a rating scale option requiring a minimum of writing so that one can concentrate upon the observation of studentsô performance. Be familiar with scale items prior to the administration of the test.

The above segment of the literature review is very relevant to this study because of the direct relationship it has with the mode of developing and administering the assessment instrument. By using the process skills assessment instrument, students are assessed under condition for psychomotor performance in basic electronics operations compared with a pre-determined standard. The process skills rating assessment helps the assessor to discriminate between students in a group and provide invaluable data for use in further placement of the students.

Test instrument development

It is important and useful to think of the process of test development as cyclical and interactive. This involves feeding back the knowledge and experience gained at different stages of the process into a continuous re-assessment of a given test and each administration of it. This process include perceived need for a new test, planning phase, design phase, development phase, operational phase and monitoring phase. Not all of these stages are always necessary. Whether or not they are all included is a rational decision based on the particular requirements of the test development context. Once the need for a new test has been established, the model involves a planning phase during which data on the exact requirements of candidates is collected. In the classroom context, this process may be based on direct personal knowledge of the students and experience of the teacher. In wider contexts, information may be gathered by means of questionnaires, formal consultation and so on (Bachman, 1990). Whatever the context, the aim will be to establish a clear picture of who the potential candidates are likely to be and who the users of the test results will be. The planning phase is followed by a design phase, during which an attempt is made to produce the initial specifications of a test which will be suitable for the candidates. The specifications describe and discuss the appearance of the test and all aspects of its content, together with the considerations and constraints which affect this (Van and Trim, 1990). Initial decisions can be made on such matters as the length of each part of the test, which particular item types are chosen, and what range of topics are available for use. At this stage, sample materials should also be written and reactions to these should be sought from interested parties. Even at the level of classroom tests it is always worth showing sample materials to a colleague since another personǿs reactions can be invaluable in informing the development process.

During the development phase the sample materials need to be trialed and/or pretested. This means that students who are at the appropriate level to take the test and who are similar to projected candidates (in terms of age, background, etc.) are given test materials under simulated examination conditions (Alderson, Clapham and Wall, 1995). This phase may involve analyzing and interpreting the data provided by candidate scores; useful information can also be gathered by means of questionnaires and feedback reports from candidates and their teachers, as well as video/audio recordings and observations. Decisions can then be made on whether the materials are at the right level of difficulty and whether they are suitable in other ways for use in live tests. Information from trialing also allows fairly comprehensive mark schemes and rating scales to be devised. Even small-scale trialing of classroom or school tests, using just a handful of candidates, can provide valuable information on issues such as the timing allowance needed for individual tasks, the clarity of task instructions, appropriate layout for the response, etc. At this stage it is still possible to make radical changes to the specifications, to the item types used, or to any other aspects of the test which cause concern. Once the initial phases of planning, design and development have been completed, the test specifications reach their final form, test materials are written, and test papers are constructed. A regular process of administering and marking the test is then set up. This is the operational phase (or ôliveô phase) during which the test is made available to candidates. The process described here is most applicable to end-of-year school tests, end-of-course tests in other settings, and to those administered on a wider scale.

Once a test is fully operational, the test development process enters the monitoring phase during which results of live test administration needs to be carefully monitored (Alderson and North, 1991). This includes obtaining regular feedback from candidates and teachers at schools where the test is used as well as carrying out analyses of candidates' performance on the test; such data is used to evaluate the testôs performance and to assess any need for revision. Research may be done in various aspects of candidate and examiner performance in order to see what improvements need to be made to the test or the administrative processes which surround it. Revision of the test is likely to be necessary at some point in the future and any major revision of a test means going back to the planning phase at the beginning of the cycle.

One should be able to develop assessments instrument that are of the highest quality, accurately measure the necessary knowledge and skills, and are fair to all students. Test developers understand that creating a fair, valid and reliable test is a complex process that involves multiple checks and balances. That is why dozens of professionals including test specialists, test reviewers, editors, teachers and specialists in the subject or skill being tested are involved in developing every test question, or test item. Similarly all questions (or items) are put through multiple, rigorous reviews and meet the highest standards for quality and fairness in the testing industry. To help further understand the process, here is an overview of the key steps to take when developing a new process test (Educational Testing Service, 2012).

Step 1: Defining Objectives- Educators, licensing boards or professional associations identify a need to measure certain skills or knowledge. Once a decision is made to develop a test to accommodate this need, test developers ask some fundamental questions such as who will take the test and for what purpose?, What skills and/or areas of knowledge should be tested? How should test takers be able to use their knowledge? What kinds of questions should be included? How many of each kind? How long should the test be? How difficult should the test be?

Step 2: Item Development Committee-The answers for the questions in Step 1 are usually completed with the help of item development committees, which typically consist of educators and/or other professionals with the guidance of the sponsoring agency or association. Responsibilities of these item development committees according to ETS (2012) may include defining test objectives and specifications, helping ensure test questions are unbiased and determining test format (e.g., multiple-choice, essay, constructed-response, etc.). Other responsibilities include considering supplementary test materials; reviewing test questions, or test items, and writing test items.

Step 3: Writing and Reviewing Questions-Each test question written undergoes numerous reviews and revisions to ensure it is as clear as possible, that it has only one correct answer among the options provided on the test and that it conforms to the style rules used throughout the test. Scoring guides for open-ended responses, such as short written answers, essays and oral responses, go through similar reviews.

Step 4: The Pretest-After the questions/items have been written and reviewed, they are pretested with a sample group similar to the population to be tested. The results enable test developers to determine the difficulty of each question, whether the question is ambiguous or misleading, whether the question should be revised or eliminated, or whether incorrect alternative answers should be revised or replaced.

Step 5: Detecting and Removing Unfair Questions-To meet the stringent guidelines, trained reviewers must carefully inspect each individual test question, the test as a whole and any descriptive or preparatory materials to ensure that language, symbols, words, phrases and content generally regarded as sexist, racist or otherwise inappropriate or offensive to any subgroup of the test-taking population are eliminated. Statisticians can be hired to identify questions on which two groups of test takers who have demonstrated similar knowledge or skills perform differently on the test through a process called Differential Item Functioning (DIF). If one group performs consistently better than another on a particular question, that question receives additional scrutiny and may be deemed biased or unsatisfactory. If people in different groups actually differ in their average levels of relevant knowledge or skills, a fair test question will reflect those differences.

Step 6: Assembling the Test-After the test is assembled, it is reviewed by other specialists, committee members and sometimes, other outside experts. Each reviewer answers all questions independently and submits a list of correct answers to the test developers. The lists are compared with the answer keys to verify that the intended answer is, indeed, the correct answer. Any discrepancies are resolved before the test is published.

Step 7: Making Sure - Even After the Test is administered ð that the Test Questions are Functioning Properly- Even after the test has been administered, statisticians and test developers review to make sure that test questions are working as intended. Before final scoring takes place, each question undergoes preliminary statistical analysis and results are reviewed question by question. If a problem is detected, such as the identification of a misleading answer to a question, corrective action, such as not scoring the question, is taken before final scoring and score reporting takes place. Tests are also reviewed for reliability. Performance on one version of the test should reasonably predict performance on any other version of the test. If reliability is high, results will be similar no matter which version a test taker completes.

Test Blueprint-When the specifications for a new (or revised) test are planned, the underlying aim is always to produce a test which is valid (i.e. the test should offer an appropriate way of measuring what it claims to measure); is reliable (i.e. the results produced should be as free as possible from errors of measurement); has impact (i.e. the effect on individuals and on classroom practice should be positive); is practical (i.e. the demands it makes on the resources of the test developer and the test administrator should be compatible with the resources available). During planning these factors always need to be kept in mind, and an acceptable balance among them must be achieved.

The first stage of planning should involve a situational analysis (ALTE, 1998). This means looking at the need for a test within the context of the various influences on it which will affect the form it finally takes; the aim of the analysis is to identify the principal considerations and constraints relevant to the project. These relate to all aspects of what the test must do in order to fulfill its purpose, together with the limitations placed on the test by the circumstances in which it is to be used.

Test blueprint, item development and item format are other components necessary for development of standardized test. According to Allan and James (2010), test blueprint or test specifications identifies the objectives and skills which are to be tested and the relative weight on the test given to each. After deciding upon important objectives and the specifics of what will be tested develop a plan to guide the number and difficulty of test item construction. This statement necessarily precedes any development of the test. These specifications provide a "blueprint" for test construction. The authors added that in absence of such a blueprint, test development can potentially proceed with little clear direction. The development of such a set of specifications is the first crucial step in the test development process. One must be mindful that the test specifications cannot and should not remain static. Pedagogy is not static and the specifications for each test need to be continually reviewed and modified to reflect the current state of knowledge.

The test blue print provides answers to questions such as:

How many items are to be constructed for a specific competency, and what cognitive, affective or psychomotor level are the questions going to address? The number of questions per competency should be determined by the amount of time spent on that competency during training.

Item Development-The term item is used as shorthand for questions on the test. Item development can proceed only when a clearly agreed upon set of objectives is available. As much as possible, an item should measure only a single objective. Each objective, however, should be measured by one or several items, depending on the test specifications.

Item Format-The format of the item necessarily proceeds from the test blueprint. According to John (2004), blueprint indicates the kind of skills and the balance of test content to be measured. The selection of item types and test format should be based on the kinds of skills to be measured and not on some personal likes or dislikes for a particular item format. The use of multiple-choice questions, for example, may make sense for large group testing on knowledge of the mechanics of English. This type of item is not generally appropriate, though it is a direct measure of writing skill. If the intent is to determine whether an examinee can write a clear coherent essay, then an essay or free-response format is clearly more appropriate than a multiple-choice format. The choice of item format to use must be made on the basis of the behavior to be tested.

One issue which sometimes constrains the selection of test item format is the need for fast, relatively inexpensive scoring. In general, scoring fixed-response items, such as multiple-choice items, can be done faster and less expensively than scoring free-response items such as fill-in-the-blanks, short answer or essay items. This is particularly true when there are a large number of candidates whose scripts need to be scored quickly. Many classroom objectives can be measured adequately with items that are amenable to machine scoring. There are also a number of objectives, however, which are more appropriately measured under other types of formats. Teachers are encouraged to use or select the type or types of item formats which are best suited for measuring the desired attribute.

Vetting and editing- Once all the item writers who were commissioned have submitted their materials, some preliminary decisions need to be made on which materials should go forward for detailed editing, and which should be rejected immediately or reworked. This stage is sometimes known as vetting. It is often undertaken by the test developer, perhaps with the help of another experienced item writer, and is the point at which texts that are clearly unsuitable for any of the reasons given above can be rejected. If texts without items have been commissioned, then item writers can be asked at this stage to go ahead and produce items on texts accepted at the vetting stage. Item writers who are asked to submit texts without items should be encouraged to have at least a rough or preliminary outline of the items they intend to write, so that as soon as the text is accepted the items can be supplied as quickly as possible (Van and Trim, 1990). Materials that are ready for detailed editing can be considered at a meeting attended by a group of item writers and chaired by the test developer or an experienced item writer. The test developer will decide how to group people for the editing sessions and which materials each group will consider.

Ideally, materials for editing should be sent out in advance to those who are to attend the editing meeting; this gives everyone an opportunity to work through them beforehand. For text-based items it is worth reading through the items before reading the text; this approach helps to highlight any item which can be answered without reference to the text (e.g. solely on the basis of common sense or background knowledge). Following this, it is useful to work through the items as if taking the test; this will help to identify, for example, any items in which there is more than one possible correct answer, where the answer is unclear or badly phrased, where there is a detractor so implausible that no candidate who understand it is likely to choose it, or items which are difficult or unclear even to a very proficient user of the language. Reading and listening texts should be checked for their length, suitability of topic, style and level of language. Materials sent out for preparation before the meeting should always be regarded as confidential.

At the editing meeting itself, any problems observed in the materials can be raised and discussed in detail within the group. It is unusual for materials to be accepted exactly as they were submitted and accepted materials are likely to be changed during an editing meeting. Bachman (1990) explained that special attention should also be given during the editing meeting to the suitability of rubrics and keys. There is often a lot of discussion about materials and item writers need to be able to accept as well as offer constructive criticism, which can be difficult to do. If an item writer finds it necessary to justify and explain a piece of material to experienced colleagues, then it is likely that the material is flawed in some way. It is useful for the test developer or another person with some degree of authority over the group to be able to make final decisions and decide when there has been enough discussion. In each editing group one person should take responsibility for keeping a detailed and accurate record of all decisions made about materials, showing clearly any changes made at editing. New item writers can be trained in editing by working in a group with more experienced writers. Having more than four or five people in an editing group tends to make the process slow, while fewer than three may not bring in enough variety of points of view (Alderson and North, 1991).

At the end of the meeting, it is vital that there should be no doubt about what changes were agreed on. For this reason, a clear record of changes made to accepted materials must be kept. Some materials may appear to have potential, but only if they are amended to an extent which could not be done in the course of the meeting. These may be given back to their original writers for further work or may be given to a more experienced writer for revision and further editing. After the meeting, spare and used copies of the edited materials should be destroyed for security reasons. The amended copies of accepted materials are kept by the test developer during editing of their own materials. This helps item writers to avoid repeating similar mistakes when submitting materials in future.

Pretesting and trialing – Pretesting and trialing both involve trying out test materials on a representative sample of the test-taking group to gather various types of information about their performance and measurement characteristics. Pretesting is a general term for this sort of activity, but is also used more specifically to refer to occasions when test materials are administered to large groups of test-takers in order to carry out a range of statistical studies on the scores produced. Trialing is often used to refer to a form of pretesting involving much smaller groups of test-takers who can provide useful feedback on different performance aspects of the test materials. The item types which are normally pretested are the more objective item types such as multiple-choice and gap-filling. After the stages of writing and editing, pretesting provides a further, more objective, check on whether a test item works well enough for it to be included in a live test. It is the individual items which are being tested, not the test as a whole, so a pretest paper need not necessarily resemble the actual test for which the material was written, either in length or in composition (Van and Trim, 1990).

Pretest papers are administered in the form of mock tests under simulated examination conditions to students whose teachers consider them to be at the appropriate language level to take the test. Students benefit from the practice and feedback on their performance which they receive as a result of taking the pretest. In order to carry out the necessary statistical studies and to have confidence in the results, sample sizes of 100-150 or more pretest students are recommended. Trialing is a suitable alternative to pretesting where the latter is not a practical option.

Items, whose scoring is subjective, cannot normally be pretested in the same way as items for which there are a single or limited number of correct answers. In spite of this, some check can be made of how tasks operate before they are used in a live examination. They can be trialed, again by being administered to students who are at about the correct level for the test, and the answers produced can be marked in line with the normal marking criteria by examiners who are used to marking the live papers. This sort of trialing can show the test developer whether the task was understood by the students, whether it was suitable for their experience and age-group, whether they were provided with enough information to fulfill the task adequately, and whether it gave them the opportunity to show the range of discourse structure, syntactic structure and vocabulary expected of candidates taking an examination at this level.

Both large-scale pretesting and small-scale trialing can be used to gather valuable information on practical aspects of test administration as well as on test-takers reactions to the test materials (ALTE, 1998). Statistical analysis of test scores provides the test developer with much useful information about the performance of test items, and can help to prevent the inclusion of poor or faulty items in live tests. It is important to remember, however, that it is always possible for a poor item to produce acceptable statistics; for this reason, the results of this type of analysis should be regarded as only one of the factors determining which materials are used in test papers.

Methods and Techniques for Assessment in the Psychomotor Domain

There are several methods and techniques for assessing skills in vocational and technical education. This is because skills in vocational and technical education contain cognitive, psychomotor (practical) and affective components. In the light of this, no single method or technique is effective enough in assessing skills hence the need for multiple techniques and methods. However, the choice of methods and techniques depends on the purpose of assessment and the type of domain to be assessed. The emphasis of this study is in the process assessment of basic electronics practical skills and the domain is the psychomotor.

Direct observation is one of the techniques for assessing practical skills in the psychomotor domain. The observation technique, according to Ezewu, (1984) is a process of using the sensory capacities to become aware of specific faults relating to a situation or object within an environment. Harbor-Peters (1992) observed that the main factors involved in observation are attention, sensation, perception and conception. Sensation is necessary because an observer becomes aware of any fact when sensitized appropriately and attention is necessary because a state of alertness is vital to an observer in order to isolate the needed information or facts. Observation is regarded as direct, if it involves direct recording of the behaviors or skills being observed and indirect, if it requires the observer to be part of the scene or a participant.

Harbor Peters (1992) also maintained that if observation is not systematic, the results may tend to become invalid and unreliable. The author further noted that factors such as the problem of organizing information to be collected, faking in behavior of the person being observed affects the validity and reliability of observation. Other factors affecting observation as identified by Kerlinger (1973) are personal bias of the observer and too much time required. However, Nworgu (1990) argued that the problem of organizing data to be collected through observation could be eliminated by using checklists, rating scales or anecdotal records. Nworgu (2006) believed that educating the observer about the variables being observed could reduce the problem of observer bias and in consequence, faking could be eliminated unobtrusively. These points were considered in designing this study especially in terms of rating scale for the instrument of the study.

A rating scale consists of a set of characteristics or qualities to be observed and some type of scale for indicating the degree to which each characteristic is present (Gronlund, 1985). It is a reporting procedure with structured criteria along side with a scale for identifying the degree to which the criteria exist. Therefore, with reference to assessment of skills in vocational and technical education, a rating scale contains process skills as criteria against which a scale is provided for assessing the degree of presence or absence of the skills .A rating scale for assessing process skills in vocational and technical education can be developed in any of the following formats: numerical, graphical and descriptive graphic. A numerical rating scale for assessing process skills in vocational/technical education has a number to indicate the degree to which a characteristic is present while graphical rating scale contains graphs (horizontal line) to indicate the position of the attributes or characteristics being assessed. The descriptive-graphic rating scale for assessing process skills involves the use of descriptive statements to identify the point on a graphic scale.

A checklist for assessing process skills in vocational and technical education consists of a set of characteristics or qualities being assessed on a nominal scale. A checklist does not indicate the degree of presence or absence of a skill or criteria being assessed but it does indicate the presence or absence only. Therefore, the use of observational checklist in assessing practical skills involves finding out the presence or absence of an attribute or characteristics only. It excludes the extent to which such skills or characteristic are present or absent (Tuckman 1976). In a similar vein, anecdotal record can be described as a factual description of skills that an observer sees in individual's life (Gronlund 1985). An anecdotal record therefore, does not have any written criteria but it may contain a report of all the actions or behaviors or skills exhibited which are of significance but cannot be assessed using other methods of assessment. The anecdotal technique is most useful for assessing evidence of learning that is not assessable using rating scale and checklist.

From the foregoing review of literature, it is clear that the observational rating scale is more objective and comprehensive than the observational checklist and the anecdotal record in assessing process skills in vocational and technical education. This is because it contains the specific skills and a scale for scoring such skills. This was supported by Okoro (1999) when he stated that the rating scale is useful and effective in assessing procedures and products in activities involving manipulating workshop equipment and tools. However, investigations carried out by the researcher revealed that even though some assessment of practical skills was carried out in basic electronics at the senior secondary level, but there was no evidence of the use of process skill technique for assessing students. Instead, assessment was based on mere impressionistic evaluation of students' products at the expense of the procedures followed in producing the products.

Project: The term project has several meanings. For instance, Gallington (1977) defined project as the term applied to any task that involves the construction of a product. Davies (1979) described it as a decision chain model consisting of three phases namely;

initiation, execution, and terminal result. Onwuka (1981) described project as a method of instruction that enables students to acquire wholehearted purposes. Emerging from these descriptions is the fact that the project is a problem solving exercise that involves both process and product. The process component of the project involves initiating planning, and execution, while the product is the result of the process. Therefore, the project when used as a method of assessment requires students to solve a problem and the assessor to observe the student and award marks. Thus, the project is a problem-oriented assignment given to students that require the use of knowledge and skills for solving it over a period of time.

The use of tasks as a method of assessing process skills of students in vocational and technical education has several problems. Harbaur-Peters (1992) identified the difficulty associated with grading the result and the problem of assessing the three domains of learning. Bello (1981) highlighted that too much time is required for the execution of the tasks. This makes it difficult for assessing many students. However, Harbor- Peters (1992) suggested that the problem of grading could be reduced by using a rating scale or checklist. Literature search and investigation carried out by the researcher in some of the senior secondary schools revealed that process assessment and rating was not used for assessing students in basic electronics. Perhaps this may be because the basic electronics curriculum at the senior secondary level contains several task performances which by implication would require several project tasks that will require months to accomplish the assessment. This conclusion agreed with the observation by Green (1975) when he said that the use of the project will require several class periods to complete assessment of students' performance in vocational and technical education.

Performance Test: Performance test according to Poton (2010) is an assessment that requires an examinee or student to actually perform a task or activity, rather than simply answering questions referring to specific parts. The purpose is to ensure greater fidelity to what is being tested. Performance test is a tool that requires the demonstration of physical skills. Performance tests are commonly used in workplace and professional applications, such as professional certification and licensure. Olaitan and Ali (1997) described performance tests as tests that require student to demonstrate physical skills and operations taught to them and to perform them under conditions that are similar to the working conditions for the trade. Thus, a performance test requires a job-like situation in which a student is given a task to accomplish; the tasks could be to construct an article, shape an object, or assemble parts. In performance test, a student is expected to carry out some tasks and while the student is carrying out the tasks, he or she is being observed and awarded marks. Therefore, performance test involves a task to be carried out in a testing environment, within a given time and an observational schedule is used for the award of marks during the operation. Consequently, it involves process and product assessment (Green, 1975 and Wiersma and Jurs, 1985). Therefore, assessing process skills using performance test involves more than one method and technique i.e. project tasks to be carried out and observational technique and a rating scale to guide the observation. This statement agrees with the assertion made by Ezewu (1985) that the assessment of skills in technical education requires a combination of techniques and methods such as project tasks and observation rating scale.

The verbs used to describe performance in the objectives are "to practice" and "to demonstrate". The assessment of these objectives would require students to demonstrate ability to use tools and equipment in electronic in the workshop. These therefore, would demand that students be given tasks to perform in a workshop set up and while the students are carrying out the tasks they would be observed and rated. This signifies process skill assessment in a workshop setting. Therefore, the most appropriate and suitable method for assessing the objectives of practical electronics is the process skills assessment.

Procedures for developing Process Skills Assessment Instruments

There are several published procedures and guidelines for developing process skills assessment instruments in vocational and technical education. Some of the procedures and guidelines considered in the study are presented below. UNESCO (2002) recommended four steps that constituted the procedures for designing a test instrument for assessing performance. The steps are specifying the purpose of the test; developing; the table of specifications; selecting test items; designing and developing relevant test items. Wiersma and Jurs (1985) supported a four step procedure for developing workshop-based test that include: defining task to be performed by stating what the students are expected to do, defining constraints or conditions necessary for executing the task such as tools and equipment, deciding on appropriate time and developing evaluation criteria, process, product or both. According to Nwana, (1982) the procedures for developing performance test includes the following steps: stating the objectives of the test, breaking down the objectives into specifics, deciding on the type of test to be used, deciding on the total number of items constructing a table of specifications, validating the table of specifications, constructing questions in accordance with the table of specifications, generating answers to the questions, writing instruction to accompany the test, validating the questions instructions and answers and administering the test to a small group of about 50 with the view to determining psychometric properties. Mkpa (1992) suggested the following procedures for developing instruments for assessing psychomotor skills: identifying and stating the objectives to be assessed in behavioral terms, identifying attributes, skills associated with the objectives, developing test blue print, item writing, trial testing, item selection and establishing validity and reliability of the test. Gronlund and Linn (1990) suggested the following procedures for developing process skill test: specify the performance outcome to measure, select appropriate degree of realism involving the creation of simulated condition that will require actual performance, prepare instructions' that clearly specify the test situation, prepare observation format to use in evaluating performance. Tuckman (1975) suggested the following steps for developing performance test specifying desired outcome which involves specifying the objective of the assessment, specifying the test situation which requires stating what the students should be given in order to perform the objectives and instructions, preparing performance checklist and developing the criteria for evaluation. The steps specified by Tuchman are relevant for this study but are not comprehensive enough. For instance, Tuckman suggested for specifying the test situation but failed to suggest the essential considerations in doing that. Green (1975) offered a four step procedure that includes: generating general objectives of test, breaking the general objectives into specifics, constructing evaluation plan from the specific objectives, planning for the specific instrument such as identification of test, work sample, checklist and rating scale. Thorndike and Hagen (1969) put forward a procedure for consideration in developing performance test which include: the adequacy of the test items in eliciting the student's behavior which the test is trying to measure, the degree of precision needed in the results of the test to achieve the purpose for which the test is given, the freedom from irrelevant sources of variation which is conceived from the test, the appropriateness to age and developmental levels of the tests. These procedures are relevant but not comprehensive because they do not include suggestions on performance objectives emphasized in psychomotor domain of learning. From the foregoing review of the literature relating to developing performance test, it is clear that no single suggestion is complete and comprehensive enough for use in developing process skill test. However, the suggestions are grouped into three, namely: suggestions relating to general planning, suggestions relating to specific planning and suggestions relating to evaluation of the assessment instrument. The suggestions relating to general planning require relating the curriculum with a view to identifying appropriate assessment instrument. The suggestions relating to specific planning focus on constructing the assessment instrument. The suggestions relating to evaluation aspects require establishing the psychometric properties of the assessment instrument. Based on these classifications therefore, the suggestions by Thorndike and Hagen (1969), Tuckman (1975),Mkpa (1992) and UNESCO (2002) are relevant in developing the process skill instrument for assessing students in basic electronics. For effective assessment, the process skill assessment instruction should be valid.

Validity

Validity of an instrument is the degree to which the instrument measures what it is designed or made to measure. An instrument with high validity will measure accurately the particular qualities it is supposed to measure (Nwabueze (2009). In the view of Ali, Olaitan, Eyo and Swande (2000), validity of a measuring instrument is the property that ensures that the instrument measures what it supposed to measure. In other words, the validity of process skill assessment instrument is the extent to which the students intended practical competencies outlined in the curriculum are covered by the assessment instrument. Validity is often classified into four types face (logical), content (Domain), construct and criterion-referenced (concurrent and predictive) validity.

Face validity is the degree to which the items in the test instrument appear to measure what it ought to be measuring. Anyaokoha (2009) stated that a test is said to have face validity if it looks like it is going to measure what it is made to measure. The face validity of test for assessing skills in vocational and technical education refers to whether the tests look valid to the test taker or test administrator.(Ukonze,2010) Mehren and Lehman (1984) noted that face validity is a desirable feature of a test because it is useful to determine the general characteristics of the test. Anastasi (1976) observed that face validity is concerned with whether a test looks valid to the examinee that takes it, the administrative personnel that decides on its usage and other untrained observers. Face validity is the extent to which the items in the process skill assessment instrument appear to measure the process skills in the course content of basic electronics in senior secondary schools.

Content validity of a test is its ability to measure the subject matter content in relation to the instructional objectives. Akwaji (2006) stated 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 curriculum. Earlier, Nwachukwu (2001) viewed content validity of a test as the measure of the degree to which the test items represent the domain or property being measured. Content validity is therefore the extent to which the items in the process skill assessment instrument measure the instructional objectives of basic electronics in the various operations.

There are several methods of determining the content validity. One method involves asking experts in the field of measurement and evaluation to thoroughly inspect and judge test for proper wording, consistency and reviewing the instrument based on the suggestions of the experts (Mehrens and Lehman, 1984). Butler (1976) recommended that after a test has been constructed and initially content validated by experts during construction, it should be given to subject matter specialists for further review, further corrections, and further assessment of appropriateness of the items. Furthermore, Giachino and Gallington (1976) argued that the larger the number of subject specialists used for assessing the appropriateness of test items, the better the content validity of that test.

However, the method of content validation by employing experts has been criticized for subjectivity because of lack of quantitativeness. Tuckman (1995) argued that the subjectivity or lack of quantitativeness can be eliminated by using rating scale. The rating scale would provide the means for experts to express their views on those items of test to be retained and those to be removed. Mehrens and Lehman (1984) recommended that two tests should be constructed over the same content areas and be given to same subject matter specialists for analysis. The results should be correlated to produce quantitative value. Another quantitative method of determining content validity of a test was suggested by Okoro (1993) when he observed that by building a table of specification into the process of test construction, it was possible to provide quantitative value of content validity. Earlier, Green (1976) defined a table of specifications as a table that provides general outline of intended emphasis of assessment and the assessment approaches. UNESCO (2002) described the table of specifications as a two-way chart in which content of a course/topics are correlated to the outcome/competencies, which describe the skills to be achieved from the course of the study.

UNESCO (2002) identified four steps for developing a table of specifications to include: referring to the syllabus to isolate the objectives or skills to be assessed, developing a two-way chart using the objectives or skills and domain relevant to the objectives or skills, developing the test format to match the specification in the chart, and designing a marking scheme

A well-constructed table of specification has a very high degree of distribution of test items along the various levels of the skills or competencies being assessed (Anastasi 1988; and Martens 1998).Cohen et al (2011) explained that the content validation of a test can be achieved by subjecting such a test to factor analysis. The factorial analysis would discard the test items with factor loading less than 0.40 as cut-off point at 10% over lapping variance. To ensure that the process skills assessment instrument is properly content validated, all the suggestions except the one that require constructing two tests will be considered for use in the study.

Criterion-reference validity is the demonstration of the accuracy of a measuring procedure by comparing it with another procedure which has been demonstrated to be valid. The criterion related validity of a test for assessing skills is of two types namely; concurrent and predictive. Denga (1987) observed that concurrent validity has to do with the extent to which performance in one test or activity could be used to predict performance in another test or activity taking place at the same time. This type of validity is necessary when a test for assessing skills is constructed with a view to replacing less efficient one in use. The concurrent validity of the test can be determined by administering two tests ï one serving as a criterion and the other serving as a predictor variable. The results should be correlated to determine the difference in terms of correlation coefficient. The major problem associated with this method is the need for obtaining valid and reliable test that will serve as criterion. However, Tuckman (1976) suggested that the problem of lack of valid and reliable test to serve as criterion should be eliminated by developing a rating scale for independent ratings of individual's characteristics or attribute.

Determining the concurrent validity of an instrument requires standard setting. A standard is used to classify students as either having mastered a set of objectives or not having mastered those objectives (Okoro,1994). The author clarified that a standard therefore represents a point on a scale of performance. Scoring above that point indicates competence while scoring below that point indicates a deficiency. Web (2011) emphasized that concurrent-referenced validity is significant in vocational and technical education since this type of education aims at preparing persons for employment in occupations requiring specialized skills. The level of skill possessed by an individual can be determined without reference to other individuals. Concurrent validation of an instrument according to Weiss and Davidson (1981) involves cut scores, where the examinee possesses the trait if his score exceeds the cut score and lacks the trait if his score fall below the cut score.

The predictive validity of test is the ability of the test to relate to or forecast a future outcome. The predictive validity of a test has to do with the degree to which the outcome of performance in the particular test can be used to predict performance in a future test (Punch, 2009). Therefore, the predictive validity of a test for assessing skills in vocational and technical education is the ability of the test that could be used to predict the performance of students at work place. Miller (2012) suggested that the predictive validity of a test is determined by correlating the result of the test with the result of another test administered sometime in the future. The problem associated with this method is that much time may be required to obtain the result of the predictor test.

The construct validity of a test for assessing skills in vocational and technical education refers to the psychological variables being assessed by the test. Gronlund (1985) noted that a construct is a psychological quality that exists in order to explain some aspects of behavior or theoretical construct defining the behavior. Earlier, Dalen (1979) observed that a logical construct is a property hypothesized to explain some aspects of human behaviour such as mechanical ability, intelligence or introversion. Kerlinger (1973) also observed that the construct validity of a test explains the factors or constructs that account for variance in test performance. Therefore, construct in the context of basic electronics are those abilities which enhance skills. Such abilities in basic electronics are strength, endurance dexterity, coordination and balance among others. Denga (1987) suggested that construct validation can be carried out by hypothesizing the construct and measuring to determine whether the hypothesis holds. Earlier, Tuckman (1975) and Brown (1983) suggested a method that involves conducting a pre-test and post-test to determine the effect of intervening variables. If the post-test scores exceed substantially the pre- test scores, it should be concluded that the intervening variables are good enough in explaining the construct. Again, Tuckman (1975) suggested that by correlating the outcome of a test with another standardized test measuring the same construct, the construct validity coefficient of the test could be obtained.

The internal validity of a test is an aspect of content validity of test. Okoro (1993) defined internal validity as validity concerning the analysis of students' responses to individual test items with a view to determining the extent to which each test item is measuring what the whole test was designed to measure. This is an analytical method of determining the content validity of test items. In the foregoing section, various types of validity were reviewed. The opinion expressed by the authors cited above guided the researcher to know whether the developed process skills assessment instrument measures what it is designed to measure. In addition to being valid an assessment instrument should also be reliable.

Reliability

Reliability is the consistency of scores or answers from one administration of an instrument to another. Reliability of a measuring instrument is the ability of the instrument to measure consistently the phenomenon it is designed to measure (Ofuebe and Izueke, 2011). Reliability therefore means the consistency with which an instrument measures whatever it is intended to measure. Reliability is a significant psychometric property of all measuring instruments and tests. A reliable instrument is highly dependable and consistent in outcome. Kutiszyne (1987) observed that if a test is reliable, it means it is consistently yielding the same result or nearly the same result over repeated administration during which the trait is not changed. Denga (1987) observed that the reliability of a test is defined in terms of repeatability of test result under the same condition while Gronlund (1985) observed that unless a test is shown to be consistent over different occasions or over different samples of the same performance domain, there is little confidence in the result. Therefore reliability as it relates to tests for assessing skills in vocational and technical education means the ability of the tests to yield consistently the same result.

Three types of reliability associated with tests for assessing skills in vocational and technical education are commonly identified. These are: measure of internal consistency, measure of stability and measure of equivalence. Albanese (1990) described the measure of internal consistency as consistency within a test. While Joshua (2005) observed that items of a test should be correlated with each other with a view to determining the extent to which test items measure single basic characteristic. From these two literatures, it can be said that the internal consistency of a test for assessing skills in vocational and technical education is the consistency of test items in assessing single behavior. Okoro (2002) identified four methods of determining the internal consistency of tests for assessing skills in vocational and technical education. These are: split half, Kuder Richardson formulae, Cronbach alpha, and Scorerjudge.

The split half method requires that a test should be divided into two and sub scores obtained for each of the two halves obtained. The correlation coefficient of the obtained scores explains the internal consistency of that test (Enyi, 2009). This method is appropriate for use in determining the internal consistency of objective tests. This method is appropriate and suitable for determining the internal consistency of the workshop-based process skills assessment instrument for basic electronics because the items are not dichotomously scored. This method was used in determining the internal consistency of the three subtests making up the workshop-based process skills test.

Another method of determining the internal consistency of a test is the interater reliability which requires administering a test once and using two or more judges to score the performance of students in the test (UNESCO, 2000). The two or more scores should then be analyzed to determine the correlation coefficient which is the reliability coefficient. A perfectly reliable test will give the same result. This method of determining the rater reliability is suitable for observational instruments. Therefore this method would be used in determining the inter rater reliability coefficient of the process skills assessment instrument.

The measure of stability of a test provides information on how stable the result of a test is over a given period. Amadioha (2006) observed that the measure of stability defines agreement between two sets of test scores over a period. Ebel (2006) noted that a test administered and repeated on the same group after sometime should produce the same result if it is stable. Even though data in the ability of the workshop-based process test was required but, for the fact that some time was required between the first and second administration, this quality of test was not determined at the moment.

Measures of equivalence provides information on the extent to which the test assesses the construct of behavior other standardized tests were designed to assess in the same field. Uzoagulu (2011) observed that the measure of equivalence is concerned with inferences about knowledge of skill in a specific domain. Chigbu (2011) suggested that the coefficient of equivalence of a test should be obtained by administering one form of a test and, after a period has lapsed, the other form of the test is administered. The two results should be correlated to obtain the coefficient of equivalence.

Various methods are used to determine the reliability of measuring instruments. These methods can be divided into two: external consistency and internal consistency methods or procedures. External consistency procedures utilize cumulative test results against themselves as a means of verifying the reliability of the measuring instrument. To determine the external consistency of a measuring instrument, two methods are used; test-retest and parallel forms of the same test.

To determine the reliability of the instrument using test-retest procedure, an attitudinal measuring instrument is administered to a sample of individuals at a given point in time. After some time has elapsed, the instrument is again administered to the same group of individuals. The results are correlated using either the Pearson Product Correlation Coefficient or the Spearman Correlation Coefficient. The resulting correlation coefficient is then the measure of the degree of reliability of the measuring instrument. A high correlation coefficient is considered support for the reliability of the measure assuring that nothing has intervened between the two test administrations which could affect the scores. The test-retest reliability method is useful in stable social situations where it is unlikely that the environment will change significantly from one test administration to another. According to Olaitan (1999) test-retest permits the instrument to be compared directly with itself. Test-retest directly reveals the continuity of the measure from one time period to the next. The method offers the greatest degree of control over extraneous factors that would otherwise operate to contaminate the measure.

In test-retest reliability method, individuals often are able to recall how they responded to the measuring instrument in the original time period. The test-retest method is not fool-proof. Attempts to verify the reliability of a measuring instrument should be regarded with caution, particularly to the extent that the instrument is applied to a variety of target groups. It is extremely difficult for the researcher to recognize the impact of extraneous variables on any sample of individuals participating in a test-retest reliability check. When a researcher re-enters a social situation for the purpose of administering a measuring instrument a second time, he must expect that his first visit was, in a sense, an intervening variable that must be considered.

In using parallel forms, enough examples are written and validated at the test construction stage to allow two parallel tests to develop. These tests must be similar in content, format and difficulty. The same sample of individuals takes each test and the scores are correlated and the correlation coefficient is taken as a measure of the reliability of each of them. The main advantage is that respondents are unable to affect the test results through recall in a test-retest situation. The conventional waiting period between the two test administrations is not necessary to gauge test reliability. When using parallel forms of the same test to determine the reliability of subject responses, two tests must be constructed instead of one. The labour of constructing two tests and of ensuring their parallelism is considerable. Extraneous variables such as fatigue and boredom can always intervene between tests.

In internal consistency procedures, it is assumed that items that measure the same phenomenon should logically cling together in some consistent pattern (Gay, 1987). Persons with particular traits will respond predictably in the same way to items affected by those traits. The internal consistency of a measuring instrument can be determined through the split-half technique and an item discrimination analysis.

In split-half technique, a test is divided into two using preferably the odd-even number technique. The scores are then correlated to determine the internal consistency of the scores. There are no conventional standards currently in use on how to interpret the coefficients derived. But a correlation of 0.90 or higher is taken as being indicative of high internal consistency. The Kuder-Richardson 20 test is designed to be used for split-half internal consistency reliability assessments. The split-half technique of establishing the internal consistency of an instrument pits one half of the instrument against the other half of it. The split-half method is a straight-forward means of verifying the internal consistency of a measure. The split-half reliability verification does not pinpoint specific problem items.

In item analysis, a researcher may administer an attitudinal instrument to 100 people. The instrument contains 10 items, each having a 5-point Likert scale. If each item is weighted 1, 2, 3, 4 and 5 intensity pattern (or 5, 4, 3, 2 and 1 in the case of negatively skewed items), it would be possible for a person to obtain a maximum high score of 10 x 5 = 50. This would be the number of items times the largest weight for a single item. Because 5 is the largest weight in each case and there are 10 items, a person could obtain a large score of 50. The smallest score any one could receive assuming the respondent answered all the statements, would be 10 x 1 = 10, or the number of statements (10) times 1, the smallest weight for a single item. The range of response of attitudinal intensity would be from 10 (low intensity) to 50 (high intensity).

Logically, a person with a large score would tend to respond to each item in such a way that the weight assigned his particular response would be a 3, 4 or 5. An individual with a small total score would probably give responses weighted with a 1 or 2. Sometimes, people who consistently give responses weighted with a 3, 4 or 5 respond to a particular item with a 1 or 2. The same is true of persons who respond consistently to items weighted with 1 or 2. Sometimes a response to an item in the set will be weighted with 3, 4 or 5. These deviations in response pattern are labelled inconsistencies. The inconsistent items should be removed to improve the internal consistency of the instrument. Discrimination analysis assists the researcher to eliminate more objectively and directly those items inconsistent with the rest. This method of internal reliability can increase significantly the internal consistency of any measuring instrument. Because the choice and elimination of items is almost wholly arbitrary, this somewhat lessens the value of item discrimination analysis. It is always possible that the items eliminated from the original list in an item analysis procedure may, in fact, be the best items for measuring the trait under investigation. If the difference between mean scores are employed (frequently called the t-test), it is likely that several assumptions underlying the appropriate application of this statistical technique will not be met with the data the researcher has.

Rating systems and scales

Generally, a number of rating systems and rating scales exist: However not all of them are employed at the same time in assessing students. At different specific times, each- type can be utilized. Three commonly known types of rating systems and rating scales are discussed in this section as they apply to performance assessment in vocational and technical education.

Instructor or Supervisory Rating

Apparently, this is the oldest and most commonly used type of rating system in the assessment of either process or product as a performance measure, (Erickson and Wentling, 1976). This type of performance assessment can be conducted formally and informally by teachers or supervisors as the students carry out given tasks in the workshop or class. It involves direct observation of students by the teacher as the students work on specific assignments. The instructor or supervisor walks round and observes what the students are doing and how they are doing it. These informal observations are all part of the individualization of instruction within occupational education. To carry out a more formalized performance assessment, the observation is followed with a more objective rating of the students through the use of rating forms, on which the rating is recorded.

These authors recommended that the teachers should organize and set up specific performance tests through which students could be observed or in which the products can be rated. Similarly, the authors stated that, this method of assessment is equally useful in private or public organizations, such as industries, where most employment settings use some type of assessment to aid them in determining an employee's retention on the job or for the purposes of their salaries/wages increase or adjustment. They finally called upon authorities of educational institutions to devise specific rating forms to be completed by employers of graduates of their institutions to aid them in the assessment of students' performance and the ultimate revision and improvement of their instructional programs.

Peer Rating

The peer rating system could take any form using any kind of tool. But one unique thing about it is that, students are asked to assess their peers and the final assessment is checked and recorded by the teacher. The practical aspect of peer ratings could take the form of arranging each member of the class to evaluate each of the other members of the class in terms of their processes or products, the second approach is to involve a special committee of students or a segment of the class as an evaluation committee that will be responsible for rating projects or the processes of all students in the class and the third way is to divide the students and assign them the responsibility for assessing three or four other members of the' class, thus involving, multiple ratings of each student in the class by different student or peer raters.

According to Ericson and Wentling, (1976), it is important for the peer evaluation committee to incorporate appropriate rating scales and instruments for the recording of ratings. It is equally important to have a means of combining ratings or averaging ratings especially when multiple ratings are taken of each student's product or processes. Students should be involved in the identification of important components of product and processes, as well as in the development of the rating forms to be used. Involving the students in that manner serves as a useful aid in .the instructional or learning process in addition to facilitating the assessment processes itself (Ericson and Wentling, 1976).

Four advantages of peer ratings were highlighted as follows by these authors:
First, involving students in the evaluation of performance, they are introduced to the complexity of assessment. Secondly it encourages the students to evaluate their actions and efforts. Thirdly, peer rating encourages the students to become more actively involved in the teaching-learning processes. Finally, the processes of students evaluating other students' performances provide for a recapitulation of the task and therefore reinforce retention of the acquired skills.

Self-Rating

Self-rating simply refers to the situation in which students assess the processes and products of their own work by themselves. Erickson and Wentling, (1976) stated that, although self-rating has been more informally practiced, the need for making it more formal exists. Self-rating could be made formal by providing students with a rating form, possibly the same rating form that is used by the teacher to carry out their assessment. Making students aware of the rating process and giving them the opportunity to assess their own work, probably provides the best diagnostic information to the students about their performance (Ericson and Wentling, 1976). Also such information can aid the students in improving their competencies prior to an evaluation by their teachers (NVSC, 2003). Three rating systems were discussed in this section viz instructor or supervisory rating, peer rating, and self-rating. The knowledge gained from that review helped the researcher in selecting the supervisory rating system for use in constructing the process skills assessment instrument.

Types of Rating Scales or Instruments

A number of rating instruments or scales for assessment have been developed and are in common use in vocational and technical education. These scales include: ranking, product scales, checklists, numerical scales, graphic rating scales, and identification tests scales. Some authors (Ericson &Wentling, 1988; Mehrens& Lehmann 1978, Okoro, 1999 and Enyi (2006)) have described these rating scales in detail, the summary of which is presented below:

- **Ranking**

Ranking involves comparing process or products within a group of students and then ordering each from the best in the group to the worst or poorest. This, according to

Okoro (2002) is strictly utilized in a norm-referenced evaluation in which a student's performance in a subject or particular tasks is reported with regards to others in the norm group. The ranking system simply shows how an individual compares to others included in the ranking. But it has the shortcoming that it does not really indicate the adequacy or depth/level of performance of the completed product. In spite of this weakness, the ranking of products or processes can be a reliable assessment in vocational and technical education provided the teacher has the ability of being a good judge.

- **Product Scales**

Product scales incorporate a means of taking measures similar to rankings and allowing for criterion references rather than relying solely upon inter group comparisons of products. Basically, a product scale is a collection of samples of products that vary in degree of accuracy or quality. The samples are usually arranged on a board or display panel from the outstanding or very good ones to the less acceptable or poor samples depending on the focus of product. Numbers are then generally assigned to each one of the samples along the line of quality.

Evaluating a student's product with a product scale involves the comparison of the student's product to the scale and then identifying or awarding the number that corresponds to the sample on the scale which most closely represents the student's product. An example of a product scale may be that of a picture sketches or a sample of the products of various filing surfaces made by mechanical engineering craft students in which different points are assigned to various filed surfaces depending on the degree of skillfulness and type of file used. For instance, ten marks/points could be assigned to surface filed with the appropriate amperage or heat setting, and proportionately fewer points could go to surfaces that are judged as being either too "rough" or too "smooth.

Product scales are easily developed by first, choosing those products that can be ranked one better than another, and then placed along a scale. The scale may be updated as additional products are developed that do not compare with any one of the products already included in the scale. Hence, additions are always made between two existing points on the scale.

The product scale has advantage over ranking method in that when used in vocational and technical education, students are compared to a developed standard and any number of the students within a class can have outstanding products. Simply put, an entire class may perform in an outstanding manner compared to other classes. Yet, if class ranking are used, someone in the class has to receive the lowest rank. An extreme but possible occurrence is that the lowest ranking in one class could exceed the highest ranking in another class when actual products are considered. Therefore, the product scale can help minimize this problem and allow for a criterion reference of performance.

Harbour-Peters (1999) stated that the above type of students' activity checklist is exceptionally useful when there is more than one way or sequence for completing a task! In addition to focusing on correct maneuvers or actions, the checklist can also include incorrect actions to indicate an individual's lack of proper response in certain instances.

In most cases, this type of information is useful to the vocational/technical teacher for diagnostic purposes and in aiding both teacher and student in correcting deficient behavior.

- **Checklists**

Checklists are simply lists of behaviors or activities that are checked by a vocational or technical teacher as a particular observation session. Checklists are valuable instruments for determining what a student can do or cannot do and can be extended to record the number of times a particular activity or technique has been used (Oranu,1998).

- **Numerical/Qualitative Rating Scales**

Numerical rating scales measure characteristics by assigning numbers to specific rating categories. For example, mechanical engineering craft students may be rated on their adequacy in filing a "metal piece" flat and square. The scale might range from one to ten, one being poor and ten being excellent. This type of scale in Ezendu (1992) simply asks that a check mark be placed in the appropriate box. Other types of rating scales ask that check marks be placed along a continuum ranging from zero or one to a higher number ranging anywhere from three to ten.

- **Graphic Rating Scale or Descriptive Scale**

The graphic-rating scale also sometimes called Likert Scale is simply a-five item stem followed by a straight line with rating categories positioned along the line. The scale can assume many different forms with or without descriptive categories or members for the scale units (Enyi, 2006). However the graphic scale does not have numbers.

According to Enyi (2006) one of the problems with numerical rating scale without graphic description is that, the scale of one to five or one to ten used for instance is basically the scale possessed by the individual assessor. In other words, a score of "5" to one vocational teacher may be a score of "3"to another. The graphic scale therefore, serves to standardize ratings by providing a number of different assessors a more consistent description of the behaviors that represent each category along the scale.

Also, graphic items can be grouped with a number of stems using the same categories for rating. This can be a great advantage in terms of saving space and preventing the vocational teacher from changing his response mode for each item. On many rating scales, the line or continuum of a characteristic is divided into unit distances usually of equal length. Sometimes, numbers are even assigned to points along the continuum. This facilitates scoring, summary, and averaging the item responses.

The rating scales described in this section constitute the majority of those that are appropriate for performance appraisal. One of their characteristics is that, rating scales used in the measurement of process and products of performance provide a good basis for systematically judging and recording judgments. The knowledge gained from the review of literature for this section helped the researcher in selecting the type of rating scale, used in constructing the process skill assessment instrument in this study. The nature of the tasks to be observed and the skills involved called for a descriptive rating scale along the pattern of the one described above as summarized from Ericson and Wentling (1988).

Ability Level

Ability is the mental or physical power that enables a person to achieve or accomplish something. Ability provides the competence to carry out activities efficiently. Such performance can be either before or after training (ScotlandMarshall, 2005). Ability level is the degree of success with which a given mental or physical task or action can be performed. Ability level can pertain to an individual or to the average range of ability found in a group of persons. In education, the term is often used in connection with studentsô performance, on a comparative basis in a subject study area (Bellingham, 2008). Adeyomo (2010) identified three ability levels in relation to teaching-learning situation, viz: high, average and low. According to the author, the first 33% of students with high scores in a test are in high ability group, while the least 33% in the test are low ability group. The middle 34% of students belong to average ability group. The above section will help the researcher in grouping senior secondary basic electronics students into various ability levels after the administration of the developed process skills assessment instrument so as to ascertain the effectiveness of the developed assessment instrument.

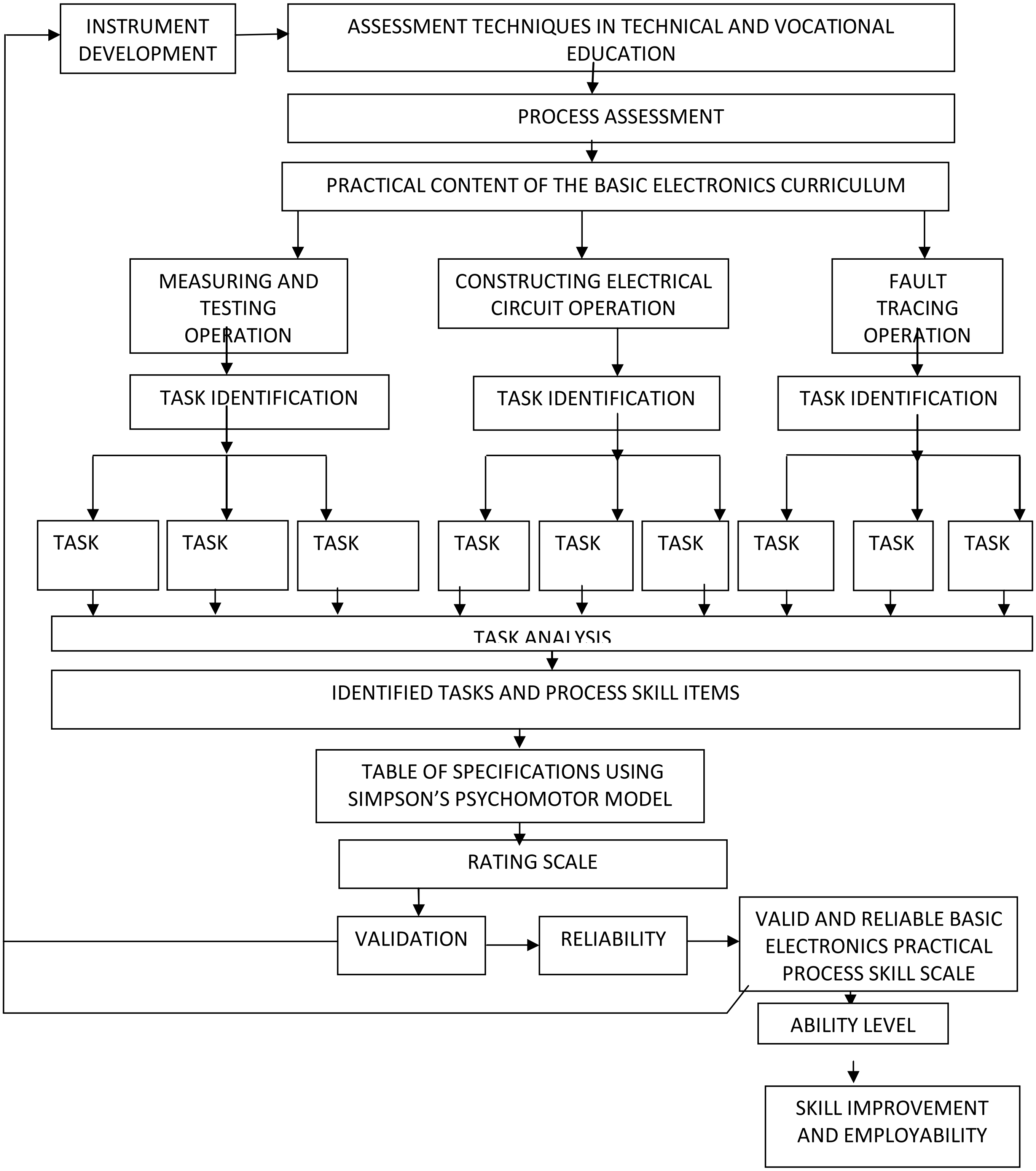

Figure 1: Conceptual Framework of Basic Electronics Process Skills Assessment Instrument

Schema of Conceptual Framework

To develop the instrument, the major techniques used in assessing practical work in technical and vocational education ware considered and a deliberate choice was made to use the process assessment technique. In furtherance of that choice, a process skills assessment instrument was developed. The practical content of the basic electronics curriculum for senior secondary schools features three major operations ï measuring and testing operation, constructing electrical circuit operation and fault tracing and repair operation. Students are expected to be proficient in carrying out these operations before graduation. The three operations were subjected to task identification and task analysis to bring out the draft identified tasks and the process skill items for each task. The use of Simpsonôs taxonomy of the psychomotor domain in developing the table of specifications ensure that the items were properly distributed to cover the six levels of perception, set, guided response, mechanism, complex overt response and adaptation. A 5-point rating scale was then added to the draft instrument before it was subjected to validation by experts and the reliability coefficient was determined before use. When used to assess basic electronics students of various ability levels, it leads to skill improvement and increased prospects of employment.

Theoretical Framework

The theoretical framework of this study is based on the item response theory, the classical test theory, and the classification theories of the psychomotor domain.

Item Response Theory (IRT)

Item Response Theory is also known as Latent trait theory, Strong Theory and Modern Mental Theory (Thomas and Nelson, 1996). The pioneering work of IRT took place in the 1950ôs and 1960ôs. Some of the pioneers were Fredrich M. Lord a psychometrician at Educational Testing Service, New Jersey, USA; a Danish mathematician ï George Rasch, and an Austrian sociologist Paul Lazerfield. They carried out parallel research on aspects of the subject matter independently. Other key figures in the progress of IRT include Benjamin Drake Wright and David Andrich. Item response theory became widely used in the 1980ôs by which time personal computers had given researchers access to the computing power necessary for information and communication technology (Kaplan and Saccuzo, 2009). Hambleton, Swaminathan and Rogers (1991) described IRT as a body of logically related statements describing the application of mathematical models to data from questionnaires and tests as a basis for measuring abilities, attitudes, skills or other variables.

According to item response theory, each item on the test has its own item characteristic curve (ICC) that describes the probability of getting each particular item right or wrong, given the ability level of each examinee. The items can be sampled with the computer and the specific range of items where the examinee begins to have difficulty can be identified (Bolt, 2003; Schmidt and Embretson, 2003). Thus, the examiner can make an ability judgment without subjecting the examinee to all the test items. IRT is based on the principle that it is possible to measure single, specific latent traits, abilities or attributes that themselves are not observable. The theory assumes a relationship between personôs possession or particular trait ability or attribute and his/her response to a test item.

Gall and Borg (2007) described item responses theory as an approach to test construction that is based on the following assumptions: an individual's performance on any single test item reflects a single ability, individuals with different amount of that ability will perform differently on the item and the relationship between the variables of ability and item performance can be represented by a mathematical function. Cohen, Manion and Morrison(2007) added that IRT is based on the view that it is possible: to identify objective levels of difficulty of an item, e.g. the Rasch mode; to devise items that will be able to discriminate effectively between individuals; to describe an item independently of any particular sample of people who might be responding to it, i.e. is not group dependent (i.e. the item difficulty and item discriminability are independent of the sample); to describe a testeeôs proficiency in terms of his or her achievement of an item of a known difficulty level; to describe a person independently of any sample of items that has been administered to that person (i.e. a testeeôs ability does not depend on the particular sample of test items); to specify and predict the properties of a test before it has been administered; for traits be one-dimensional (single traits are specifiable, e.g. verbal ability, mathematical proficiency) and to account for test outcomes and performance; for a set of items to measure a common trait or ability; for a testeeôs response to any one test item not to affect his or her response to another test item; that the probability of the correct response to an item does not depend on the number of testees who might be at the same level of ability; to identify objective levels of difficulty of an item; to calculate a statistic that indicates the precision of the measured ability for each testee, and that this statistics depends on the ability of the testee and the number and properties of the test items.

The technical advantages of item response theory are many. It builds on the traditional models of item analysis and can be used to obtain information on item functioning, the value of specific items, and the reliability of a scale (Kaplan and Saccuzo, 2009). The score of an examinee is no longer defined by the total number of items correctly answered but instead by the level of difficulty of items that he or she has answered correctly. The most attractive advantage of tests based on IRT is that one can easily adapt them for computer administration. The computer can identify items that required to assess a particular ability level. Consequently, examinees do not have to suffer the embarrassment of attempting multiple items beyond their ability. Conversely, they do not need to waste time and effort on items far below their capability. Furthermore, each examinee may get different items to answer, greatly reducing the chances of cheating (Kaplan and Saccuzo, 2009). Schmidt and Embretton (2003) suggested that computer-adaptive testing holds the promise of increasing efficiency by fifty percent or more by reducing the amount of time each examinee spends responding to the questions.

The use of item response theory as an approach to item construction and analysis has two important features: it provides information about the amount of construct measured by each item. Second, student performance on a given item provides information about how much of the construct each student has so far. With IRT, the item bank would have several worthwhile uses: The first is that testing for students of different ability levels can be customized. For example, suppose we give a student several first-level items to answer. If the student cannot answer any of them, we need not frustrate him, and extend the testing time unnecessarily, by administering second-level items. Secondly many different parallel tests can be constructed, each of equivalent difficulty. For example, we can go into our item bank and randomly select two items of each level to construct a six-item test. We can then repeat the procedure and construct a parallel test of equivalent difficulty. Thirdly measurement error for a particular individual can be reduced by administering only items within the range of those he/she is likely to answer correctly. For example, if a student scores very high on the first level items, we can administer many second-level items in order to determine the student's ability more precisely, (increasing the number of items in a test reduces measurement error). There is no point administering first-level items, which are too easy for this student or third-level items, which would be too difficult.

Item response theory uses mathematical models to define the relationship between an observed behavior (i.e. performance on a given test item) and the ability that is presumed to under lie that performance. An item characteristic curve is a mathematical function that is created to show the relationship between test-item performance and the presumed underlying ability.

IRT utilizes three logistic models. These models are: the one-parameter model or Rasch model, the two-parameter model and the three ïparameter model. Choosing a model to be used in a particular situation should be carefully done. Factors to be considered in making a choice include how relative the assumption of the different model are and the extent to which application of a model is robust to violations of its assumptions. (Croacker and Algina, 2008). The researcher observed that item response theory is the testing model of choice for many high stake examinations including the Graduate Record Examination (GRE), the Scholastic Aptitude test (SAT), Test of English as a foreign Language (TOEFL) and the University Matriculation examination (UME). Even then, it has limited application in this study since the study is not on the development of multi-choice test items. This necessitated the use of other relevant theories.

Classical Test Theory

Classical test theory came into being in the early 20th century. In 1904, Charles Spearman figured out how to correct a correlation coefficient for alternation due to measurement error, and how to obtain the index of reliability needed in making the correlation. Spearmanÿs achievement is often regarded as the beginning of classical test theory (Traub, 1997). No one person propounded classical test theory. Others who contributed to the development of classical test theory include George Udny Yale, Trueman Lee Kelly, Louis Guttman and Harold Gullikson. The culmination of classical test theory was realized in the systematic treatment it received from Novik (1966). The final classical work was published in the late 1960s (Lord and Novik, 1968).

Classical test theory, according to Gall, Gall and Borg (2007) is a body of related psychometric statements that are logically arranged and related to one another. These statements are used to predict the outcomes of psychological tests such as the difficulty of items and the ability of the test takers. The authors stressed that the classical test theory (CTT) is dependent exclusively upon the abilities of the examinees and the characteristics of the test. The theory is founded on the preposition that measurement error, a random latent variable is a component of the observed score and random variable. Secondly, the error variable has a zero covariance with the true score variable. Thirdly, the error component of a measure is independent of the error components of other measures, either of the same characteristics or of different characteristics. Two of the outcomes of classical test theory are the coefficients of reliability and the standard error of measurement. It is essential to understand the secondary assumptions involved and experimental procedures followed in estimating these two variables (Traub 1997).

Classical test theory assumes that each observed score (X) contains a true score component (T) and an error component (E), meaning that X=T+E. CTT is concerned with the relations between the variables X, T and E in the population. The relations are used to say something about the quality of the test (De Klerk, 2008).Classical test theory operates largely with the concept of true scores and error of measurement which in turn embodies the reliability and validity of test items. CTT maintains that the forms of a particular test are in infinite numbers, each of these forms measures the same ability trait or characteristic. The mean, standard deviation, skewness and kurtosis of a classical test vary according to the characteristic of the test. Many testing practitioners use classical test theory, and their basic tools, according to Warm (1978), include: the P-value that is the proportion of examiners selecting an item alternative (also called item difficulty); the D-value that is point biserial correlation between the item alternatives and the test (also called item discrimination); and the mean of examiners scores. Others are the standard deviation of examinee scores; the skewness of the examinees scores and the reliability of the test, usually K-R20 (Kuder-Richardson reliability estimate formula 20). Inherent in the assumptions of classical test theory is the notion that item characteristics are situation or sample dependent. This means that the p-value, the mean and standard deviation and standard error, skewness and kurtosis and other indices are all dependent on the sample of examinees under study.

Developers attempt to construct tests that are highly reliable (i.e. free of measurement error) and that are not too easy or too difficult for the individuals being assessed. Many tests used in education have been developed within the framework provided by classical test theory. They are good tests but susceptible to the following problems: the reliability estimates for the test and various item statistics (e.g., indices of item difficult) depend on the sample from which they are derived. Thus, if a researcher uses the test with a sample that represents a different population from the one used in developing the test, its reliability and item characteristics may be different. The analysis of a test which is based on the above stated statistics uses classical test theory. Classical test theory is an influential theory of test scores.

CTT is applicable to the development and validation of basic electronics process skills assessment instrument because the scores obtained from the instrument would likely have error components. Therefore, it became imperative that the researcher should be conscious of expert advice on the stages of developing instruments for the assessment of psychomotor outcomes (Tuckman 1995; Igbo, 1997; UNESCO,2002; Ombugus,2013). The stages of development span from: isolation of the objectives of the assessment from the curriculum to identification of psychomotor skills area in the basic electronics curriculum; through development of a tables of specifications to generation of tasks and process skill items. Other stages include content validation of the draft assessment instrument, trial testing of the instrument to determine validity and reliability; development of a rating scale for the process skills assessment instrument, final selection of process skill items, use of standard test administration procedures, use of appropriate marking strategy, to interpretation of test scores. The researcher adhered religiously to this sequence of developmental stages, that are based on expert advice, to ensure that the observed scores approximated their true scores, thus eliminating or minimizing their error components.

Classification Theories of the Psychomotor Domain

A classification theory is an orderly classification of a field of study (e.g. botany, animal kingdom, anthropology) according to the natural relationships within the field. Such classifications allow different researchers to study and discuss the same field of study using shared terminology. According to Encyclopedia Britannica (2015), a classification theory embodies the principles governing the organization of objects into groups according to their similarities and differences or their relation to a set of criteria. Classification theory has applications in all branches of knowledge, especially the biological and social sciences.

In 1956, Benjamin Bloom and others classified educational objectives into three primary learning domains ï the cognitive, the affective, and the psychomotor domains. (Clark 2000; Okoro,2002), The cognitive domain is concerned with learning related to knowledge - from simple recognition and memory to complex problem solving and evaluation; the affective domain covers learning related to attitudes, feelings and emotions; while the psychomotor domain is concerned with learning related to actions and motor skills - from simple actions to complex choreography(Thomas, 2004).

An activity or task can span more than one domain. For instance performing a task with a computer system will require aspects from both the cognitive domain (navigation, button function, field entry formats etc.) as well as the psychomotor domain (manipulating the mouse and using the keyboard). Where such is the case, the terminal objective should focus on the dominant domain. (Thomas, 2004) In the case of the computer system, knowledge of the system navigation, button functions, and field entry formats would be dominant over the use of the mouse and the keyboard. The psychomotor domain addresses skill development relating to manual tasks and physical movements. In addition, it covers modem day business and social skills such as communication and operation of information technology equipment (Davis, 2004).

There are several published classification theories of the psychomotor domain. Presented in this literature review are three of the primary classifications of the psychomotor domain as developed separately by Dave, Harrow and Simpson (Huitt, 2003).

Dave's classification theory

In 1970, R. H. Dave published a classification theory of the psychomotor domain which he had earlier presented at a Berlin Conference in 1967. (Dave, 1970; Clark, 2000; Huitt, 2003; Thomas, 2004). The classification has five levels as follows:

Level 1: Imitation – At this level, the learner can observe a skill and attempt to repeat it, or see a finished product and attempt to replicate it while attending to an exemplar. Keywords, that is, verbs which describe the activity to be carried out include attempt, copy, duplicate, imitate, mimic.

Level 2: Manipulation – Perform the skill or produce the produce in a recognizable fashion by following general instructions rather than observation. Possible verbs include complete, follow, play, perform, and produce. Example: creating work on oneȇs own after taking lessons or reading about it.

Level 3: Precision – Independently performs the skill or produces the product, with accuracy, proportion, and exactness, at an expert level.

Possible verbs include: achieve automatically, excel expertly and perform masterfully. Example: working and reworking something so that it will be just right.

Level 4: Articulation – Modify the skill or product the product to fit new situations, combine more than one skill in sequence with harmony and consistency. Possible verbs: adapt, alter customize, originate. Examples: producing a video that involves music, drama, colour, sound, etc.

Level 5: Naturalization – Two or more skills combined, sequenced, and performed consistently and with ease. The performance is automatic with little physical or mental exertion. Possible verbs: naturally, perfectly. Example: Michael Jordon playing basketball or Nancy Lopez hitting a golf ball, etc

Dave classified the psychomotor domain in terms of stages in building perfection. Even though it focuses on stages involved in building perfection of skills, the classifications fails to incorporate some important stages such as observation, perception and motivation. The model to some extent seems applicable to achieving the goals of vocational and technical education at the pre-vocational training level in Nigeria. (Chijioke, 2013).

Harrow's classification Theory

Anita Harrow in 1972 developed a classification theory of the psychomotor domain. The taxonomy was organized into six levels as follows: (Harrow, 1972; Huitt, 2003; Thomas, 2004);

Level 1: Reflex Movements- Are actions elicited without learning in response to some stimuli. Examples include: flexion, extension, stretch, postural adjustments, segmental, inter-segment, and supra-segmental reflexes. Possible verb: Respond.

Level 2: Basic Fundamental Movements – Are inherent movement patterns which are formed by combining reflex movements and are the basis for complex skilled movements. Examples are: walking, running, pushing, twisting, gripping, grasping, manipulating. These are grouped into locomotors, non locomotors and manipulative movements.

Level 3: Perceptual Abilities – Refers to interpretation of various stimuli that enable one to make adjustments to the environment: visual, auditory, kinesthetic, or tactile discrimination. Suggest cognitive as well as psychomotor behavior. Examples include; coordinated movements such as jumping rope, punting, or catching.

Level 4: Physical activities – Require endurance, strength, vigor, and agility which produces a sound, efficiently functioning body. Examples are: all activities which require a) strenuous effort for long periods of time; b) muscular exertion; c) a quick, wide range of motion at the hip joints; and d) quick, precise movements.

Level 5: Skilled Movements – Are the result of the acquisition of a degree of efficiency when performing a complex task. Possible verbs ï assemble, calibrate, construct, dissect. Examples are: all skilled activities obvious in sports, recreation, and dance.

Level 6: Non-Discursive Communication – Is communication through bodily movements ranging from facial expressions through sophisticated choreography. Possible verbs ï arrange, compose, create, originate, and design. Examples include: body postures, gestures, and facial expressions efficiently executed in skilled dance movement and choreography. According to Thomas (2004), this taxonomy is better suited to assessing ability to perform a task or activity or to sports and recreation activities than to the typical physical activities performed in the workshop.

Simpson's classification theory

The taxonomy developed by Elizabeth Simpson in 1966 is focused on the progression of a skill from guided response (i.e. doing what you are told to do) to reflex or habitual response (i.e. not having to think about what you are doing). It includes origination at the highest level (i.e. invention of a new way to perform a task) (Simpsons, 1972; Thomas, 2004.). The seven- level classifications are as follows:

Level 1: Perception: (5 ï 10% of the total test items).

The ability to use sensory cues to guide motor activity. This ranges from sensory stimulation, through cue election to translation. Illustrative verbs include associate, compare, feel, hear, identify, scan, select, smell, taste, listen, notice (Thomas, 2004)

Choose, describe, detect, differentiate, distinguish, identify, isolate, relate, separate, recognize, notice, touch, hear, feel.

Level 2: Set: (5 -10% of the total items)

Readiness to act: requires the learner to demonstrate an awareness or knowledge of the behavior needed to carry out the skill. (Sometimes called mindsets).Illustrative verbs include: Begin, display, explain, move, proceed, react, respond, demonstrate, show, start and volunteer (Okeme, 2011). Also included are adjust, arrange comprehend, identify, locate, organize, recognize, respond, select (Thomas 2004)

Examples: Having a farm tool ready to work, showing eagerness to mount a coupled implement to perform a task and explain the use of a farm implement.

Level 3: Guided response: (20 ï 30% of the total test items)

This is the early stage of learning a complex skill that involves imitation and trial and error. Over behavioral act of an individual under guidance of an instructor, or following model or set criterion may include imitation of another person, or trial and error until appropriate response is obtained (Okeme 2011).

Illustrative verbs include: assemble, build, calibrate, construct, dismantle, display, dissect, fasten, fix, grind, heat, manipulate, measure, mend, mix and organize, melt, set-up, shape. Others are: adopt, correct, imitate, match, practice, repeat, reproduce and simulate (Thomas, 2004).

Examples: follow instructions to build a model, using the prismatic compass after watching an expert demonstrate its use and using the planter to drop seeds after watching an expert demonstrate it.

Level 4: Mechanism: (20 ï 30% of the total test items)

This is the intermediate stage in learning a complex skill. Learned responses have become habitual and the movements can be performed with some confidence and proficiency. The act becomes part of the learnerôs repertoire of possible responses to stimulus and demands of situations.

Illustrative verbs include: assemble, build, calibrate, construct, dismantle, display, dissect, fasten, grind, heat, manipulate, measure and mend. Also includes mix, mould, set up and shape

Examples: demonstrate the ability to use tractor mounted implement to make ridges 70 percent of the time, use the Candler to test the viability of an egg and repair a faulty tractor carburetor.

Level 5: Complex overt response: (20 ï 25% of the total test items)

The skilled performance of motor acts that involves complex movement patterns. Proficiency is indicated by a quick, accurate and highly coordinated performance, requiring a minimum of energy. This category may include resolution of uncertainty i.e. done without hesitation and automatic performance, finely coordinated with great ease and muscle control. Illustrative verbs include: assemble, build, calibrate, construct, display, dismantle, dissect, fasten, fix, grind, heat, manipulate, measure, mend, mix, organize and sketch (Okeme, 2011). Also included are adjust, combine, coordinate, integrate manipulate, regulate (Thomas, 2004).

Examples: dismantling and reassembling various components of the planter with no error, maneuvering a tractor with mounted implements through obstacles and displaying competence while dissecting a bird.

Level 6: Adaption: (5 ï 10% of the total test items)

Skills are well developed and the individual can modify movement patterns to fit special requirement or a new situations. Illustrative verbs include: adapt, alter, change, rearrange, revise, reorganize and vary (Okeme, 2011). Also included are adjust, convert, correct, integrate, order, standardize (Thomas, 2004)

Examples: performing a task with a machine that it was not originally intended to do modifies instruction to meet the needs of the learners, using a plough for harrowing and using fertilizers sprayer o plant seeds.

Level 7: Origination: (5 ï 10 of the total test items)

The ability to develop an original skill that replaces the skill as initially learned. Creating new movement pattern to fit a particular situation or specific problem. Learning outcomes emphasizes creativity based upon highly developed skills. Illustrative verbs include: arrange, combine, compose, construct, create and originate (Okeme; 2013). Also included are create, develop, formulate and invent (Thomas, 2004).

Examples: designing a more efficient way to perform an assembly line task, developing a new and comprehensive training programme, and creating a new performance routine.

Apart from the classification theories of the psychomotor domain developed by Simpson, Harrow and Dave, other developed classifications of the same domain include those by Hauenstein, Fitts and Posner, Seymour, and Crafty (Okoro 2002). Hauenstein developed a five ï stage model as follows: observing, initiating, manipulation, performing and perfecting. Crafty divided the psychomotor domain into simple movement, compound task, and complex movement and skill families. Seymour suggested the division into handwork, handwork with tools, single purpose machines, group purpose machines and non-repetitive work. Fits and Posner recognized two major categories of physical skills namely: language skills and perceptual motor skills. Perceptual motor skills were further divided into gross bodily skills, manipulative skills and perceptual skills. The various classes of the Fitts and Posner model are interrelated. For example a student must perceive the controls on a machine before he can use it, and gross bodily skills (or gross motor skills) are necessary if manipulative skills are to be used (Okoro, 2002).

From the review carried out above, Simpsonôs classification theory of the psychomotor domain was adopted for use in this study. Simpsonôs taxonomy was found appropriate for classifying the educational objectives of the basic electronics curriculum at the senior secondary level because the illustrative verbs tally with those of the basic electronics practical objectives. The model was also comprehensive and fulfilled the expectation that a psychomotor objective should contain an element of cognitive and affective domains. Simpsonôs classification theory therefore guided the researcher in developing the table of specifications. The table of specifications was developed for the following six levels of Simpsonĝs classification ï perception, set, guided response, mechanism, complex overt response, and adaptation. The seventh level ï origination was beyond the scope of the basic electronics curriculum for senior secondary schools. In conclusion, the review of the classification theories of the psychomotor domain helped the researcher to select the particular classification theory on which the development of the table of specification was based. Process skills items were then developed that closely fitted the table of specifications. By so doing it was ensured that items were appropriately spread over the various level of the psychomotor domain

Related Empirical Studies

Assessment instruments in the psychomotor and non ï psychomotor domains have been developed and validated by many researchers. A review of some of such studies is presented in this section.

Okeme (2011) conducted a study on development and validation of psycho-productive skills multiple choice test items for students of agricultural science in secondary Schools in Kogi state. The study adopted the instrumentation design and was carried out in Kogi State. The population for the study was 13,925 senior secondary three students in 239 public schools. The sample for the study was 675 students comprising three ability groups (201 high, 314 average and 160 low abilities). Multistage sampling technique was adapted. Purposive sample was used to select 15 schools with a population of 2,793. Systematic sampling was used to select 675 SS 3 students from the students' population of the 15 schools. A 148 psycho-productive skills test items was developed and utilized by the study. The instrument was subjected to face, content and criterion referenced validation. Face and content validation was carried out by five experts. The psychometric properties of the items were first determined by:-administering the instrument to a pilot sample of 40 drawn outside the sample. The criterion- referenced validation was also carried out by utilizing the scores of the pilot sample with the use of cut score. The reliability of the items was determined by using split-half technique and Rudder-Richard son K-20. This yielded co-efficiency of 0.87 for animal production, 0.86 for crop production and 0.88 for agricultural technology with overall coefficient of 0.87. Percentages, formulae of difficulty index, discrimination index, distractor index and K-R20 were utilized to answer the research questions. The analysis of variance (ANOVA) was utilized to test the null hypothesis at 0.05 level of significance. It was found out that the items had CVR of between 0.333 and 1.000, difficulty indices of between 0.30 and 0.70, discrimination of not less than 0.20, positive (+) distraction and criterion referenced validity of 50% and above. It was also found that there were significant differences in the mean scores of the three ability groups (high ability, average ability and low ability). Scheffe test for multiple comparison revealed that there were significant difference in the mean scores of the high and low abilities but no significant difference in the mean scores of the high and average abilities. It was therefore recommended that external examination bodies (WAEC and NECO) should adopt the psycho-productive skills multiple choice test items in their examination for certification of the students. It was also recommended that teachers should be encouraged to make use of psycho-productive skills multiple choice test items during teaching and assessing productive learning aspect of agricultural science in students. The two studies are related because they are all on development and validation of instrument for the assessment of psychomotor outcomes. However, there is a difference because while the reviewed study developed a multi -choice test items on agriculture science, the present study is on the development of process skill items in basic electronics.

Azizi-Ur-Rehman (2007) conducted a study on the development and validation of objective test items in physics for class nine in Rawalpindi city, Pakistan. The main objective of the study was to provide an instrument for measuring the achievement of students in physics in class nine in Rawalpindi City. The researcher used the instrumentation design to carry out the study. Six boy's schools were selected out of the 29 in Rawalpindi city. The instructional objectives were designed and a table of specifications was used to construct the items. The instrument was validated content wise by six experts in physics with the use of table of specifications after which the instrument was administered to the students. After administration, the scripts were scored objectively and interpreted by finding the difficulty index and discrimination index of each item by applying the formulae. The findings of the study were as follows most of the items had difficulty indices of between 1.0 and 2.0 (good standard),only few of the items were too easy or too difficulty with discrimination indices of between - 1.0 to 2.0., one fourth of the items had difficulty indices of 1.5 and above (ideally good range); the mean, median, and mode values for the HA group fall close to one another. The researcher therefore recommended that too easy and too difficult items make a test invalid and unreliable and should be avoided, catchy or dodgy items were always deceptive and promote guessing or cheating so should not be included in the options, the instructional objectives, table of specifications, construction of test items, scoring and interpretation of data should be in this order and a complete harmony among them, a valid test should contain items which are very difficult, difficult, normal or easy in good proportion. The researcher suggested that 20% of the item should be very difficult or difficult, 70% should be normal and the remaining 10% should be easy. The two studies are related because they all on development and validation of instruments for senior secondary school. However there is difference because the reviewed study developed objective test items in physics while the present work is on the development of process skill item in basic electronics. Some of the study were however considered for this study.

Bukar (2006) conducted a study on development and validation of laboratory-based tests for assessing practical skills of higher national diploma students in electronic maintenance and repairs. The research was designed to develop and validate laboratory-based tests in electronic maintenance and repairs that will improve the method of teaching and assessing students in the course. Three research questions and one hypothesis were formulated to guide the study. Twenty work station-based tasks and 462 practical skills were generated through a process of performance assessment revealed through review of the literature. A table of specification was constructed based on the

Padelford (1984) model of psychomotor domain to ensure balance in assessment of the six levels of the psychomotor domain. Three experts carried out content validation of the tasks and practical skills and thereafter 24 lecturers and technologists from 24 polytechnics offering electronic maintenance and repairs were used for item-by-item content validation. Based on the results of the item-by-item content validation, laboratory based tests of 20 works station-based tasks and 462 practical skills were constructed. The constructed laboratory tests were used in assessing 48 HND students in the department of Electrical Engineering, Kaduna Polytechnic during 2002/2003 academic session. The data generated were analyzed using Cronbach alpha, product moment correlation, centroid method of factor analysis, Kendall coefficient of concordance and F-Ratio Test. The result of the data analysis relating to factorial validity of the laboratory based tests revealed that 77.01%, 65.5% and 83.79% of the variance of the three sub-tests respectively were due to General factor. The internal consistency of the tests on measuring instruments and testing, Fault finding and repairs and alignment are 0.71, 0.55 and 0.47 respectively. The inter-rater reliability coefficient of the laboratory based tests was 0.41 and there was significant relation between five rater's ratings of the practical skills of some HND students in the tests. Based on these results, therefore it was recommended to National Board for Technical Education (NBTE) that the laboratory based tests be adopted in all the polytechnic running Higher National Diploma (HND) in Electronic Communication Technology). The instrument was constructed for teaching and assessing performance of students, in electronic maintenance and repairs. Unlike the reviewed study whose focus was on assessment electronics maintenance skills at the HND level, the focus of this study is on assessment of process skills in basic electronics students at the senior secondary level. The design of the study and some of the steps in the methodology were relevant for this study and were utilized.

Ezeudu (1992) developed instruments for evaluating learning outcomes in senior secondary school geography curriculum. The study was conducted in Nsukka local government area of Enugu sate. Six single sex schools (four girlsô and two boysô schools) with a total of 760 students comprised the sample for the study. The study had five purposes, namely, to develop projects for use in SS2 and SS3 geography, to develop rating scales for scoring each project based on the cognitive, affective, and psychomotor performance of the students and to find out if there was a difference in performance between the sexes in the schools surveyed. The other purposes were to determine the validity and reliability of the projects and to inter-correlate the performances of students on cognitive, affective, and psychomotor rating scales.

The findings of the study showed that student performance scores on the projects were quite high. The scores ranged from 62.2 to 73.3 percent for cognitive 67.3 to 77.9 percent for affective and 58.9 to 67.77 percent for psychomotor. Secondly, the mean performance for female and male students on the three dimensions of the projects showed that the girls performed better than the boys. Thirdly, the interrater reliability coefficients based on the two-way ANOVA ranged from 0.85 to 095 on cognitive, while that of the psychomotor dimension ranged from 0.88 to 0.96. Finally, the inter-correlational coefficients for the cognitive and psychomotor range from 0.61 to 071. These coefficients were all significant at the 5 percent level ($P<0.05$).

The major finding of this study was that the cognitive, affective and psychomotor rating scales were found to be useful in evaluating students learning outcomes in geography among the sample that was used. The investigator recommended the use of the instrument in other schools nationwide to further ascertain the findings. There is a relationship between the reviewed study and the present one because the two studies are all on development and validation of assessment instruments for senior secondary schools. However there is a difference because the reviewed study was on development and validation of instruments for assessing geography project in the three domains while the present study is limited to the development and validation of an instrument for assessment of psychomotor outcomes in basic electronics.

Adikwu (2004) carried out a study to develop and standardize achievement test in geography for senior secondary schools in Benue State. The purpose of the study was to develop and standardize a geography achievement test capable of obtaining valid and reliable data in respect of senior secondary school geography achievement. The study involved 48 selected secondary schools out of which 1,781 senior secondary class three geography students were used for the study. Random and stratified sampling techniques were employed in drawing up the standardization sample for the study. A 200-item test was developed (after the first and second trial test) based on the national geography curriculum to answer the seven research questions and five hypotheses postulated for the study. Data obtained from the test (in form of studentsô scores) were analyzed using item analysis, variance, correlation analysis, mean and standard deviations. The first four hypotheses of the study were tested using multiple classification of analysis of variance (ANOVA) while the fifth hypothesis was tested using the t-test of significance of correlation coefficient. All the hypotheses were tested at the 0.05 level of significance. The study among other things revealed that 99% of the items of the Standardized Achievement Test in Geography (SATG) were of satisfactory facility and discrimination capacity. Also, the Average Test facility (0.41) was found to be close to the optimum value (0.50) for an achievement test and Total Test Variance of (73.98) which was sufficiently high. The subscales correlated highly and positively among themselves and individually with the SATG. The reliability of the SATG was 0.94 while those of the subscales ranged from 0.70 to 0.91. These values are admittedly high. The standard error of measurement of the SATG was 6.72 while those of the subscale range from 2.15 to 4.71. These values are admittedly low. In addition grade, gender and location norms obtained for SATG were high. Gender and school location were significant factors in students geography achievement while content area were found not to be significant. Gender X content area and gender X location interaction effect were found to be significant while content area X location; were found not to be significant. Furthermore, the inter-correlations between the SATG and its subscales were found significant. These findings have implications for geography teachers and school administrators. Recommendations were made, limitations of the study were identified and suggestions for further study were made. The study under review has relevance for present study because the two of them are on instrument development for assessing students. However the reviewed study developed an achievement test in geography while the present study is on the development for assessing psychomotor skills in basic electronics.

Kathleen, Glenn, Andrea, God and Dhruv (2007) developed and validated a multidimensional service convenience scale. They conceptualized service convenience as a second-order, five-dimensional construct that reflects consumersô perceived time and effort in purchasing or using a service. Service convenience dimensions are salient at different stages of the purchase decision process. Given this conceptualization, the study presented the development and validation of the SERVCON scale, a comprehensive instrument for measuring service convenience. The five dimensions are independent within a nomological network that illustrates distinct antecedent and consequent effects, and the results reinforce the multidimensional representation, offering insight into the distinctive relationships between each service convenience dimension and its antecedents, such as competitive intensity, and consequences, such as repurchase behavior. The findings help researchers and managers understand a fully conceptualized convenience construct and facilitate the measurement of convenience in future empirical studies. Developed and validated multidimensional service convenience scale was recommended for measuring service convenience. The reviewed studies and the present one are both on instrument development. However, the instrument developed in the reviewed study was for assessment of service convenience while the instrument to be developed in the present study is for assessment of practical skills in senior secondary basic electronics.

Effiong (2006) carried out a study on development and validation of alternative to practical test for measuring skills in. electronic devices and circuits in technical colleges. The purpose of the study was to develop and validate alternative to practical tests to measure skills possessed by students in electronic devices and circuits -a component of radio, television and electronics trade offered in technical colleges. The study had five specifics purposes, five research questions and three null hypotheses. Instrumentation research design was employed. The study was carried out in Akwa-Ibom State of Nigeria. The population of the study comprised of 93 final year radio, television and electronics students in four technical colleges in the state. The whole population was used. A table of specifications was prepared and two tests comprising 100 multiple choice items (Test A) and 30 short answer items (Test B) were developed. Dave's model of psychomotor Domain was used. Content and face validation of the tests was done by 11 experts. Pilot testing employing test re-test method was carried out on 52 final year radio, television and electronics students in Cross River State technical colleges. Weak and poor items were either improved or replaced after validation and reliability testing. Thereafter, the tests developed were administered concurrently with a practical test set by NABTEB at National *Technical* Certificate (NTC) examination level. Data collected through field testing were analyzed using K-20 formula, item analysis, Pearson Product Moment Correlation Technique and t-test at 0.05 level of significance. Items with poor psychomotor properties were dropped. Findings were that 87 multiple choice items and 30 short answer items were valid, reliable and suitable for inclusion in the final version of the tests developed. The tests developed in the study and the practical test set by NABTEB had high correlation coefficients ranging from 0.88 to 0.91, and the three null hypotheses showed that there was no significant difference in students' performances in the tests developed in that study and the practical test developed by NABTEB. Recommendations were made based on the findings and suggestions for further studies were stated. Effiong's study was on assessment of skills in electronic devices and circuits as taught in technical colleges while this study is on assessment of process skills in basic electronics taught in senior secondary schools. Aspects of the design and methodology of the above study that were relevant guided the researcher in this study.

Amuka (2002) carried out a study on development and validation of an instrument for assessing the affective work competencies of industrial technical education students. The purpose of the study was to develop an instrument for assessing the affective work competencies of industrial technical education students. For this purpose, five research questions and one hypothesis were formulated to guide this study. The 78 final year industrial technical education students from three Federal Colleges of Education (Technical) located at Asaba, Omoku and Umunze in the South-South and South-East geo-political zones of the Federal Republic of Nigeria were used for the study. The study had instrumentation design. One hundred and twenty test items initially generated were submitted to 10 experts in industrial technical education for face validation. The result of the exercise showed that 83 test items survived the exercise and 37 test items were regarded to be defective and unacceptable for the purpose. Consequently the 83 test items were subjected to Q-sort Allocation Technique by five valuatorsô selected by balloting from the 10 experts for further improvement on the validity of the instrument. In all, 68 test items that survived the exercise became the 68 items of the affective work competencies instrument for Industrial Technical Education Students (AWCIITES).

The instrument was trial tested using 18 final year industrial technical education students of F.C.E (T) Akoka. The data generated were analyzed; the internal consistency, reliability coefficient of the AWCIITES was 0.8395 and the internal constancies reliability coefficient of the clusters ranged from 0.244 to 0.830. They were computed using Cronbach Alpha formula. The inter-correlations among the clusters and the instrument were determined using Pearson-Product Moment Correlation Machine Formula. Data were analyzed using percentages, mean statistics and one way analysis of variance (ANOVA). The hypothesis was tested at 0.05 level of significance.

The findings revealed that: the 68 test items of the AWCIITES that resulted from the face validation and Q-Sort Allocation Technique was suitable for the purpose of the study, the reliability coefficient of the instrument was fairly high (0.5395), the internal consistencies of reliability coefficient of the 15 clusters of the instrument ranged from 0.244 to 0.830. The cluster that had the least coefficient reliability was "careful" cluster and "friendly/pleasant" cluster the highest coefficient of reliability, the inter-correlations among the 15 clusters of the AWCIITES were both negative and positive in magnitude and directions and low (-0.5358) to high (0.6966), the correlation between the 15 clusters and the entire test (AWCIITES) ranged from low (-0.1808) to high (0.7084).The student of Federal College of Education (Technical), Umunze recorded the highest mean scores in most of the 15 clusters of the instrument than FCE (Technical), Omoku and FCE (Technical), Asaba. There were no significance differences in the mean scores of the students in the three institutions in 12 out of 15 clusters of the instrument. However, there were significant differences in the mean scores of the entire students in the three of the 15 clusters of the instruments. It was concluded that the AWCIITES have been developed and validated. The reviewed study and the present one are similar because both are on development and validation of assessment instruments. However, there are differences as they are focus on two different domains of learning. While the former is on assessment of effective work competencies, the latter is on assessment of psychomotor skills

Odu (2001) conducted a research on development and validation of an instrument for assessing students' psycho-performance in block-laying and concreting. The study was conducted, with the major purpose of developing and validating an instrument for assessing students' psycho-performance in block-laying and concreting in technical colleges. The researcher determined the validity and reliability of the instrument and established its usability. Five research questions were considered and two null hypotheses tested. The instrumentation design was used for the study. Eighteen block-laying and concreting operations from the National Technical Certificate (NTC) curriculum which were amenable to a table of specifications were selected for which 133 test items were generated. A total of 153 block laying and concreting teachers, consisting the population were used to rate 580 block laying and concreting students on the entire test items. Appropriate statistical tools such as mean, grand mean, Person product moment correlation coefficient, Cronbach alpha, F-ratio, and Scheffees multiple ranges tested were sued for analyses of data. It was found that:114 items out of 133 items developed were considered suitable for use in the instrument, the instrument had sufficient content and face validity and the reliability coefficients of items related to various operations ranged from 0.60 to 0.91 for the whole instrument and the one-way analysis of variance used to test hypothesis, one revealed that there was no significant difference in the mean scores of the teachers on the students psycho-performance on cavity wall construction, while there was significant difference in the mean scores of the teachers on the students psycho-performance on the other 17 block laying and concreting operations, hypothesis two revealed that there was no significant difference in the mean scores of the teachers on students psycho-performance in all the test items at 0.05 level of significance.

The major findings of the study were as follows: First, the sixteen block laying and concreting operations were selected by the teachers for the instrument. Secondly, 114 test items out of the 133 items were selected for the instrument. Thirdly, the instrument possessed high content and face validity. Finally reliability of the whole instrument was

0.86 and that of the sub-scales ranged from 0.60-0.91 the instrument had a high reliability.

On the basis of the findings, the researcher recommended that block laying and concreting teachers should use this instrument for assessing studentôs psycho-performance in blocks laying and concreting operations. Secondly, to avoid future differential rating on student psycho-performance by raters, workshops and seminars were recommended for the teachers to enable them familiarize themselves with the techniques of using the instruments. The study reviewed above and the present study are related in the sense that both of them are on instrument development. However, while this study is on assessing skills in basic electronics at the senior secondary level, Odu's study was on assessing skills of students in block laying and concreting at the national technical certificate level. The design and some statistical tools employed in Odu (2001) guided the researcher in this study.

Yallams (2001) conducted a research on the development and validation of metal work process evaluation scheme. The purpose of the study was to develop and validate a scheme, which could be used by metal work lecturers at the Nigerian certificate of Education (NCE) level for evaluating students skills during practical metal work instructions, specifically, the study addressed five research questions which boarded on identifying the major fitting and machine operations often carried out by NCE metal work students, the basic skills and competencies which lecturers often value and assess in their students during practical metal work instructions, an appropriate rating scale, the validity and reliability of the developed schemes. Through review of the National commission for colleges of education (NCE) curriculum for metalwork, a task specification table was developed. Based on this table, 18 major task clusters were identified and further expanded into 164 sub-tasks, which termed the number of items of the scheme. Furthermore, 13 assessable competencies and a 4-point descriptive rating scale with various response categories were developed and cooperated into the scheme. Draft copy of the scheme was face validated by a total of 210 metalwork lecturers drawn from the 41 NCE (Technical) awarding institutions all over the country. The scheme was tried out on 40 NCE final year metal work students randomly sampled from 5 of the 41 different institutions. In each of the institutions used for the try out, four mental work lecturers were used as a 4-man panel of assessors for observing and assessing the students as they carry out specific given tasks within the scheme during the try-out. The reliability of the scheme was established after analyzing data obtained from the try-out. In analyzing the data, each of the four assessors' ratings for each of the items were paired into six set and correlated. The Pearson Product Moment Correlation formula was used through Mini-Tab computer software for the analysis. Results of the analysis revealed that all the 164 items of the scheme were highly reliable for inclusion in the final copy of the scheme. There is relationship between the two studies because they are all on development and validation of instrument. However, there is difference because the reviewed work was on mental work process evaluation scheme while the present work is on development and validation of process skill assessment instrument on basic electronics for senior secondary schools.

Uzoagulu (1995) developed and standardized achievement test on introductory technology for secondary schools in Nigeria. Instrumentation design was adopted. The test was called Introductory Technology Achievement Test (ITAT) and it originally contained 185 multiple choice items. The items passed through 124 experts for face and content validation. The inter-rater reliability coefficient was calculated to be 0.682. Pilot testing was carried out and 130 test items emerged. The reliability coefficient of the instrument was 0.879 using split halves and Kuder Richardson formula (K ï R 20). The 130 items were finally tested on a sample population of 3,280 JS 3 students and scores were obtained. Mean, standard deviation, critical ratio, t-test and analysis of variance were used to answer research questions and test hypotheses at 0.05 level of significance. Result showed the norm for the ITAT to be 38.67 with standard deviation of 13.13. A total of 130 ITAT items were found to have satisfactory item facility and discriminating quality and were suitable for use as test items for introductory technology achievement test. The reviewed study is related to the present one because both of them are on development and validation of assessment instrument for use in secondary school. However, there is a gap to the filled as the reviewed study developed in achievement test in introductory technology while the present study seeks to developed an instruction for assessing practical skills in basic electronics.

Nworgu and Habor - Peters (1990) developed and validated a Physics Achievement Test (PAT) for evaluating studentsô cognitive achievement in secondary school physics. An initial pool of 130 test items was developed using a table of specification but the final format of PAT was made up of 65 items each, with 5 -option multiple choice type. The table of specification covered the first four cognitive levels of Bloomôs taxonomy of educational objectives, namely knowledge, comprehension, application and analysis. The sample consisted of 564 subjects randomly drawn by stratification along and location from 16 secondary schools in Anambra State. Data were analyzed which yielded the following results: (1) Almost all the items in the PAT possessed satisfactory psychometric properties. (2)The average test facility (TF), and the total test variance (TTV) of the PAT were both satisfactory. (3)A high content validity was also reported. (4) The reliability of the PAT using the K - R formula yielded coefficients ranging from 0.41 to 0.66 for the sub-tests and 0.81 for the total test. They further recommended that the PAT could serve as a standard for use in evaluating physics achievement of senior secondary school students in the location it was validated. There is a relationship between the reviewed study and the present study because both of them sought to develop and validate assessment instruments for use in secondary schools. However there is difference: while the reviewed study developed an achievement test in physics, the present study is developing a process skills assessment instrument in basic electronics.

Uday and Ronald (2011) conducted a study on development and validation of knowledge management capability assessment model. A knowledge management capability assessment (KMCA) methodology for determining the capability levels of an organization in various knowledge areas was presented. The KMCA defines the knowledge capability areas and a five-level metric for assessing capabilities within each area. The results of an empirical study conducted to validate the ability of the KMCA methodology to correctly ascertain capability levels within knowledge areas were presented. The validation consists of two different tests: The first test, called the absolute test, validates the five-level metric within the KMCA by showing that a lower capability level is a prerequisite for achieving the next higher level. The second test, called the relative test, demonstrates the ability of the KMCA to compare relative capabilities (1) across knowledge areas within a single organization and (2) across multiple organizations for a given knowledge area. The KMCA was developed in concert with a leading manufacturing company in the semiconductor industry. The data for this study was collected from over 700 knowledge workers from multiple large organizational units within the company. The results show that the KMCA is robust, in that it is able to correctly estimate the capabilities of the knowledge areas it was designed to measure. The developed and validated knowledge management capability assessment model was recommended for use.

Ugochukwu (1991) conducted a study on the development and standardization of an instrument to measure task performance in nursing. A 68 ï item rating instrument was developed and the instrument was pilot-tested. Content and face validity of the instrument were determined by 8 experts. Item analysis and reliability testing were carried out using data obtained from pilot study. This resulted in 55 items which were assembled for final testing. The instrument was then administered to 318 third year nursing students in 11 schools of nursing in eight states of Nigeria. Data collected were analyzed and findings were that: the test instrument possessed sufficient content and face validity; the reliability coefficient of the instrument was 0.93 while those of the subscales ranged from 0.4 to 0.64; item correlation of the instrument ranged from 0.24 to 0.55 while the inter-correlation among the six skills was positive and moderately high ranging from 0.45 to 0.65. The instrument was then recommended for use in measuring task performance in nursing. The reviewed study and the present one both sought to develop instruments to assess skills. However, they differ in the subject area and level of education. While the study under review was on nursing skills as taught in schools of nursing, the present study is on basic electronics practical skills as taught at the senior secondary school.

Ogwo (1993) developed and validated an instrument for assessing secondary `school studentsô aptitude necessary for success in mechanical technology areas in Nigerian technical colleges. Instrumentation design was adopted for the study. Four research questions guided the study. Initially 158 copies of the instrument were pilot-tested using the draft copies of the instrument which had 74 items. After analysis of data obtained from pilot study the items dropped to 62. The final copy of the instrument was administered to 651 JSS III students in the then Anambra State of Nigeria. A multi-stage stratified random sampling according to sex and an educational zone was done. Data were collected and analyzed using relevant statistical tools. The major findings obtained were that 45 of the 62 items were found to have suitable difficulty and discrimination indices; 18 out of the 62 items required no further modification; 8 items were found to be very difficult and 9 others could not discriminate effectively. The reliability of the whole instrument using Kuder Richardson formula (K ï R 21) yielded a high coefficient of 0.94 while coefficients for the subsections ranged from 0.80 to 0.84 and the unit reliability estimate which determined the relative reliability standing of one item to the whole instrument was calculated to be 0.20. Those of the various subjects ranged from 0.17 to 0.19. Finally, the instrument was considered fit for use in evaluating secondary school students for selection into the technical college mechanical technology area. There are a similarities between the two studies as both sought to develop and validate assessment instrument. The reviewed study developed and validated an instrument for assessing aptitude for success in mechanical technology at NTC level, while the present study is on developing and validating an instrument for assessing process skills in basic electronics at the senior secondary level. The design and methodology used in the reviewed study were relevant and were employed in the present study.

Fatunsin (1996) carried out a study on development and standardization of performance-based test for assessing students in agriculture in secondary schools in Ondo state. The study determined the validity and reliability of the test and established other psychometric properties. Five research questions were answered and two hypotheses tested. The study used both instrumentation and developmental research designs. The study isolated two performance objectives from the curriculum, developed psycho-productive activities in the seven areas of the secondary school agricultural science curriculum that lent themselves to table of specifications from where 150 performance-based tests were generated. A total number of 600 students participated in responding to the test developed. The psychometric properties of the test were determined using reliability validity estimates and item analysis (difficulty, discrimination and distractor indices).Appropriate statistical tools such as point-biserial correlation, Cronbach alpha, t-test were involved to enhance analysis of data. It was found out that the instrument had high point-biserial correlation of 0.71 and reliability coefficient of .94,making the test valid and reliable; there were 134 out of 150 items that satisfied all the psychometric properties; the t-test analysis revealed that the male and female student maintained similar difficulty and discrimination levels on the test items. If the result of this study is implemented, it will be of great benefit to the students, for improvement in agriculture and also help to boost agricultural productivity in the nation. Therefore, the researcher recommended the test to schools and examining bodies for adoption. This study is on the development and validation of process skills assessment instrument for assessing students in basic electronics, while the study reviewed above developed a performance-based multiple choice test in agricultural science. However, the reviewed study's design and methodology were relevant and were utilized for this study.

Garba (1993) conducted a study on development of an instrument for evaluating projects in woodwork. The purpose was to develop and validate the instrument and to determine reliability coefficient of the instrument. The instrument was trial ï tested on selected studentsô projects so as to ascertain their different performances. All the 84 woodwork lecturers in 24 technical teacher education departments of tertiary institutions in the Northern States of Nigeria formed the population of the study. Sixteen lecturers were purposefully sampled. A survey instrument was developed. The initial draft of the instrument contained 55 items. The instrument was fashioned into a 5 ï point rating scale with response rating of highly appropriate (5 points), appropriate (4 points), moderately appropriate (3 points), inappropriate (2) and highly inappropriate (1 point).

The initial copy of the draft instrument was validated by four experts in industrial Technical/Vocational Education and two others in measurement and evaluation area; all with the Faculty of Education of the University of Nigeria, Nsukka. The instrument was pilot ï tested with a sample of 16 subjects in order to determine whether further improvement was necessary and to determine the reliability of the instrument. Data collected were analyzed and the reliability of the instrument tested by using Cronbach Alpha ($\propto$) formula. The reliability test yielded internal consistency coefficient of 0.91 for the whole instrument while the coefficient of the sub-sections ranged from 0.56 to 0.81. Final testing was conducted and scores obtained were analyzed. Findings revealed that all the 61 items in the instrument were found suitable for use in evaluating studentsô projects. Also, the instrument was found to be valid and reliable. The study under review and the present one are related as both are on the development and validation of instrument for assessing practical skills. However they differ in the subject area and the type of educational institution. While the reviewed study was on woodwork as taught in colleges of education in Nigeria, the present study is on basic electronics in the senior secondary schools

Enya (1995) conducted a study on development and preliminary validation of an Electricity Achievement Test (ELAT) for technical colleges. Instrumentation design was adopted for the study. The areas of study comprised Akwa Ibom State and Cross River State. Population for the study was 150 final class students drawn from 8 technical colleges in the two states. A set of 120 five-option multiple choice test items was developed. Trial testing was carried out on 72 students selected from technical colleges in Enugu and Anambra States. Data obtained were tested for reliability. 100 items were found suitable for inclusion in the final test. Final testing was carried out and the scores obtained, were analyzed using relevant statistical tools. The following findings were made; the ELAT yielded a reliability coefficient of 0.90; the best performance was recorded in Basic Electricity component of the subject as 60.06 percent with standard deviation of 15.15. The lowest performance of 53.08 percent with standard deviation of 14.53 was recorded in Winding of Electric Machines. The instrument was found suitable, valid and reliable and recommended for evaluating technical college studentsô achievement in Electricity. The study under review and the present one are similar because the two studies are on development and validation of assessment instrument. However, there are differences because the study reviewed was on development of an achievement test at the technical college level while the present study is on development of a practical skills test in basic electronics at the senior secondary level.

Achusi (1997) conducted a study on development and validation of an instrument for the assessment of practical work in block laying and concreting in government technical colleges. Two research questions guided the study. One null hypothesis was formulated and tested at 0.05 level of significance. A 5-point, 52 item instrument was developed, validated by experts and administered to 40 practicing block laying and concreting instructors in government technical colleges in Anambra, Enugu and Ebonyi states. The reliability of the instrument was established using Cronbach Alpha formulae and reliability coefficient of 0.93 was obtained. Kendall coefficient of concordance results revealed a significant ($p>0.05$) relationship among the rankings. It was recommended that practicing block laying and concreting instructors should always use developed and validated instrument for assessing studentsô practical work in block laying and concreting in technical colleges. Achusiôs work and the present study are similar to the extent that both of them are on development and validation of instrument for the assessment of psychomotor outcomes. However they differ to the extent that Achusiôs work was on block laying and concreting at the technical college level while the present study is on basic electronics at the senior secondary level.

A study was carried out by Igbo (1997) on development and validation of a psycho-productive skill test for assessing senior secondary school students in clothing and textiles. This study was designed to develop, validate and try out on instrument for assessing student's psycho-productive skills in the area of clothing and textile at the senior secondary level. Six research questions and null hypotheses guided the study. In order to develop the instrument, performance objectives were isolated from the senior secondary school (SSS) clothing and textile curriculum. The performance objectives were utilized to develop a detailed table of specifications based on Simpsonȏs seven levels of the psych-motor domain. The table of specifications was utilized to develop 170test items. The items were validated and 164 items were found adequate and then pilot tested. Item analysis was carried out and 160 items were finally selected. The selected items were field tested on 204 SSS III students of clothing and textiles students from Lagos and Akwa Ibom States who registered for clothing and textiles at the Senior Secondary Certificate Examination (SSCE) for the 1995/96 session. Reliability of the instrument was established using Kuder-Richardson formula (K-R21). Data collected from the field were analyzed using mean, point biserial correlation coefficient, item analyses techniques and t-test at 0.05 level of significance. The findings of the study were:152 item psycho-productive skill test (PST), PST point-biserial coefficient range of 0.05 to 0.86, PST reliability coefficient of 0.80, PST difficulty index range of 0.20 to 0.79, PST discrimination index range of 0.40 to 0.78. The t-test revealed similar difficulty and discrimination levels for students of both states. The major implication of the findings of the study is that the PST is valid and reliable and can be used to assess SS students in clothing and textiles. It was therefore recommended that PST should be adopted either in part or whole or modified for the assessment of SSS clothing and textiles students. Igboõs study and the present study are similar because both are on development and validation of instrument for assessing psychomotor outcomes at senior secondary level. However they differ to the extent that while Igboõs work was on clothing and textiles, the present study is on basic electronics.

Summary of Review of Related Literature

Literature reviewed covered conceptual framework, theoretical framework and related empirical studies. Under conceptual framework, concepts such as validity, reliability, test instrument development, basic electronics and process assessment were reviewed. Item response theory, Classical test theory and classification theories of psychomotor domain were reviewed under theoretical framework. The literature reviewed on conceptual framework guided the researcher to obtain and maintain activities within the schematic diagram. The theoretical framework which covers theories and models of the psychomotor domain helped the researcher in developing step by step procedures, wording and arrangement of the process skill items for basic electronics at the senior secondary level.

Furthermore, literature on taxonomy of the psychomotor domain and test item development provided information on the levels of the skill items to be developed, their characteristics, appropriate key concepts that represent the nature of the skill for each level, and guidelines to follow when developing the items. These guided the researcher in developing the process skills assessment instrument covering the following levels of Simpsonôs taxonomy: perception, set, guided response, mechanism, complex-overt response, and adaptation, and their appropriate weighting in the table of specification in the operational areas of measuring and testing, constructing electrical circuits, and fault tracing and repair.

Literature on types of validation and reliability guided the researcher on the various methods to use to obtain the psychometric properties (validity and reliability) of the assessment instrument. This enabled the researcher to determine whether the items were good enough and suitable for assessing the manipulative skills of the students in basic electronics. The goal was to bridge the existing gap created by the absence of a valid and reliable instrument for assessing studentôs practical skills in basic electronics in senior secondary schools so that the students could acquire the necessary skills for use after graduation.

Literature on types of rating systems and rating scales enabled the researcher to select the appropriate rating scale for use in developing the process skills assessment instrument. Literature reviewed on relevant empirical studies guided the researcher in designing the study and provided information for discussing the findings of the study.

The review of related literature revealed the weakness of the present approach used in assessing practical skills of basic electronics students. It also revealed that process skills assessment instruments (by whatever name called) have been developed and validated for other vocational subjects including automobile mechanics, block laying and concreting wood work, and mechanical engineering craft practice, at National Technical Certificate level. However, no study known to the researcher has been carried out on the development and validation of process skills assessment instrument for basic electronics in senior secondary schools. To the best of the researcherôs knowledge literature search has revealed that no such instrument currently exists. Hence, the compelling need for this study.

CHAPTER THREE

METHODOLOGY

This chapter describes the procedures used in carrying out the study under the following sub-headings: design of the study, area of the study, population for the study, sample and sampling techniques, instrument for data collection, validation of the instrument, reliability of the instrument, method of data collection and method of data analysis.

Design of the Study

The study adopted instrumentation design. Instrumentation is the type of design which aims at developing and certifying the efficacy of an instrument for the measurement of a given behavior or construct. Instrumentation research, according to Ali and Ndomi (2000), deals with the process of developing an instrument for assessing performance of students or obtaining data for decision making. A study belongs to instrumentation research if the purpose of the study is to produce a new instrument or material for educational practices (Ali, 2006). The study made use of instrumentation design because it was aimed at developing and validating a process skills instrument for assessing studentsô performance in practical basic electronics in senior secondary schools.

Area of the Study

The area of the study was Lagos State. The state is located in south western Nigeria. Lagos is the industrial and economic hub of the country. The city of Lagos, located within the state of Lagos was the political capital of Nigeria until it was moved to

Abuja. The choice of the area was informed by the appreciable increase in the demand for repairs and maintenance of electronic appliances. This was partly due to the influx of people into Lagos state from all parts of Nigeria. The resultant huge cosmopolitan population has made electronic servicing and repairs more lucrative. In Lagos state, there were 25 schools that offered basic electronics up to senior secondary three (SS 3) level.

Population for the Study

The population for this study consisted of 188 subjects made up of 158 basic electronics students in senior secondary III and all the 30 teachers teaching basic electronics in the 25 senior secondary schools in Lagos State that offered basic electronics as a subject up to senior secondary III in 2014/2015 school year (see Appendix D). The choice of senior secondary III students of basic electronics was based on the premise that they had received instruction for three years following the basic electronics curriculum. The teachers participated in identifying the tasks and the skills needed to perform each task while the students performed the tasks in order to generate data from the development of the basic electronics process skills assessment instrument.

Sample and Sampling Technique

The sample size for the study was 30 which comprised of five teachers that taught basic electronics and 25 students that offered basic electronics in Federal Science and Technical College (FSTC), Yaba, Lagos State. Purposive sampling technique was used to select FSTC, Yaba, Lagos State from the 25 schools that taught basic electronics up to SS3 (See Appendix D). This choice was made because the school had a well equipped basic electronics laboratory, all the teachers were qualified and experienced when compared to other schools, and the school was easily assessable for test administration purposes.

Instrumentation

Basic electronics process skills assessment instruction (BEPSAI) was used as instrument for data collection. The development of the assessment instrument consisting of operations, tasks, process skill items and a rating scale involved the following stages that are characteristic of instrumentation design as applicable to assessment of psychomotor outcomes:

Isolation of objectives of assessment from the curriculum
↓
Identification of psychomotor skills areas in the basic electronics curriculum
↓
Development of table of specifications
↓
Generation of tasks and process skill items
↓
Content validation of the draft assessment instrument
↓
Development of rating scale for the process skills assessment instrument
↓
Trial testing of instrument to determine validity and reliability
↓
Final selection of process skill items

A careful analysis of the curriculum by the researcher showed that at the end of the course, the basic electronics students should be able to:

1. build and test simple electronic devices;
2. develop skills in fault tracing and repairs;

3. apply simple electronic devices in the construction of electronic systems.

Consequently, the process skills instrument was developed to assess these objectives. The three broad objectives were transformed into operations and tasks using textbooks on electronics including Gates (2012), Mchter and Mchter (2008), Salawu (2007), Schutz (2011) and Torley (2007). Task analysis was used to generate process skill items from the identified operations and tasks. The generated process skill items were subjected to factor analysis to enable the researcher select those suitable for inclusion in the instrument. The selected process skill items were arranged and grouped according to six of the levels identified by Simpson (1972): perception, set, guided response, mechanism, complex overt response and adaptation. The seventh level ï origination was not considered, as it was beyond the scope of the curriculum. The exercise helped in distributing the test items based on the domain levels in the table of specifications as recommended by Simpson: perception: 5 ï 10% of items, set: 5-10% of items, guided response: 20 ï 30%of items, mechanism: 20 ï 30%of items, complex overt response: 25-30%of items, adaptation: 5 ï 10% of items.

The process skill items were written as statements. A four point scale of Very Important (VI), Averagely Important (AI), and Slightly Important (SI) And Not Important (NI) was written against each. This was to enable the teachers to carry out item by item content validation.

Validation of the Instrument

To determine their importance for inclusion in the final instrument, the skill items were subjected to factor analysis, using 0.50 in factor loading at 10% overlapping variance (Ashley et al, 2007). A table of specifications was developed based on the curriculum content giving due consideration to the six levels of Simpsonô̂s model of psychomotor domain. This helped in ensuring that the process skill items were adequately distributed across the levels of the domain. The table of specifications, the draft process skills assessment instrument and the basic electronics curriculum for senior secondary schools were submitted for validation to a total of six experts: two of the experts who specialized in technical education were lecturers in tertiary institutions, two experts in basic electronics were teaching at the secondary level of education, while the remaining two were experts in measurement and evaluation in Nigerian universities. The experts assessed the instrument for proper wording, consistency, and representativeness. Suggestions and corrections made by them were utilized to improve the instrument.

Reliability of the Instrument

The internal consistency of the basic electronics process skills assessment instrument that contains three operational clusters was determined using Cronbach alpha reliability method. 25 students of S- Triumph International School Ojo, were randomly selected to take part in pilot testing the instrument. The result of the25 students involved in the pilot test was computed using statistical package for social science (SPSS) 16 version. The reliability coefficients of the instruments were expressed according to the three operations (measuring and testing, circuit constructing and fault tracing) that make up the basic electronics practical process skill scale. The scores of these students were analyzed using Kendall coefficient of concordance (Tau) and the inter-rater reliability coefficient of the process skill instrument was determined.

Procedures for Administration of the Instrument

The basic electronics practical process skills assessment instrument (BEPSAI) was administered on a class of 25 students with the help of five teachers (research assistants) in Federal Science and Technical College, Yaba, Lagos State. The students were to carry out practical activities 3 times per week. The teachers rated the students while carrying out the different tasks within a total period of 8 weeks. Each of the teachers was guided by the practical process skills assessment instrument developed by the researcher. The five teachers who also served as research assistants were trained by the researcher. The purpose of the training was to ensure that they understood the general requirements of the study and the modalities for using the instrument to rate the students (see Appendix L for operational guidelines on how to use the BEPSAI). Materials and tools required for administering the BEPSAI were organized according to tasks in the electronics workshop of Federal Science and Technical College, Yaba by the research assistants and numbered with the task numbers. The researcher and the college authority made sure that there was a standby generator to provide electrical power to the workshop in case of power failure.

Method of Data Collection

All the five research assistants used the basic electronics practical process skills assessment instrument to assess the performance of the students. The instrument was administered on basic electronic students in the SS 3 class under examination condition. Within each contact period a minimum of one and a maximum of three tasks were assessed. The students were briefed on how to undergo the assessment. Thereafter, each student was assigned to a work station and instructed to carry out the tasks starting with task one. Each task was given a specified time of between 20minutes and 1 hour. The raters rated the students and submitted the rated instrument to the principal of the school. The researcher was going to Federal Science and Technical College, Yaba weekly to retrieve the used copies of the basic electronics practical process skills scale from the Principal of the college. The ratings of the students were used as data for answering the research questions and for testing the hypotheses. The performance of the students in carrying out the tasks was used to group them into three ability levels as recommended by Adesoji (2003) and Adeyemo (2010). Students with scores within the top 33 percent of all scores were grouped into high ability level, while those with scores within the bottom 33 percent of all scores constituted the low ability level. Students whose scores fall within the middle 34 percent of all scores made up the medium or average ability level.

Method of Data Analysis

To answer research questions 1 and 2, the identified tasks and process skill items were subjected to factor analysis.

In answering research question 3, content validity was ensured through the use of a table of specifications that was based on Simpsonǿs taxonomy of the psychomotor domain in generating the items. In addition, comments of experts in technical education, in electronics and in measurement and evaluation were used to ensure face and content validity of the skill items. To answer research question 4, Cronbach alpha coefficient was used to determine the reliability coefficient of the basic electronics process skills assessment instrument. Mean and standard deviation were used to answer research question 5 in order to determine the ability levels of the senior secondary III students of basic electronics. Analysis of variance (ANOVA) was employed to test the three null hypotheses formulated for the study at 0.05 level of significance.

For selecting the tasks and process skill items that are suitable for inclusion in the Basic Electronics Process Skill Assessment Instrument (BEPSAI), 0.50 was utilized as factor loading at 10% overlapping (Ashley, Boyale & Haile-Gabriel, 2007). Tasks and process skill items with factor loading of 0.50 and above were considered suitable for inclusion in the instrument, while tasks and process skill item with factor loading less than 0.50 were considered not suitable for inclusion in instrument. Similarly, to determine the ability groups of the students, a test of three tasks was administered to them. The students were then listed according to their scores from highest to lowest.

Using Adeyemo (2010)ĝs ability levels identification method, for a class of D students (where D be the number of students in the class) the high ability group will constitute 33% of the class resulting in the frequency count of 33 ÷ 100 X D. The low ability group will constitute 33% of the class resulting in the frequency count of 33 ÷ 100 X D. Similarly, the average ability group will constitute 34% of the class resulting to a frequency count of 34 ÷ 100 X D.

CHAPTER FOUR

PRESENTATION AND ANALYSIS OF DATA

In this chapter, the data collected for the study were analyzed to provide answers to the research questions and test the null hypotheses. The findings were also presented based on the research questions and hypotheses tested. Discussions of the findings are also incorporated into the presentation.

Research Question 1

What practical tasks are suitable for inclusion in the Basic Electronics Practical Process Skill scale?

The practical content of the basic electronics curriculum features three operations viz ï measuring and testing, constructing electronic circuit and fault tracing and repair. When subjected to task identification, a total of 32 tasks were identified from these 3 operations as follows: 16 tasks under measuring and testing, 10 tasks under constructing electronic circuit and 6 tasks under fault tracing and repair. To confirm which of the 32 tasks are suitable for inclusion in the instrument, all the 32 tasks were subjected to factor analysis using 0.50 as loading factor at 10% overlapping variance (Ashley, Boyale & Haile-Gabriel, 2007). Any task with factor loading of 0.50 and above was to be considered suitable for inclusion in the Basic Electronics Process Skills Assessment Instrument while any task with factor loading less than 0.50 was to be considered unsuitable. The outcome of the factor analysis is shown in Table 1.

Table 1

Factor analysis on the identified basic electronics practical tasks to determine their suitability for inclusion in the instrument.

S/N	Basic Electronics Practical Tasks	Factor loading at 0.05	Remark
1	Measuring current using ammeter	0.841	Required
2	Measuring voltage with voltmeter	0.810	Required
3	Measuring resistance with ohmmeter	0.913	Required
4	Measuring power using single phase wattmeter	0.910	**Required**
5	Measuring power using three phase wattmeter	0.824	Required
6	Using multimeter to measure DC Voltage (DC, V)	0.844	Required
7	Using multimeter to measure AC Voltage (AC, V)	0.888	Required
8	Using multimeter to measure DC Current (DC, A)	0.913	Required
9	Using multimeter to measure AC Current (AC, A)	0.900	Required
10	Measuring resistance using multimeter	0.824	Required
11	Using multimeter to measure voltage of a battery	0.854	Required
12	Using multimeter for continuity test	0.888	Required
13	Using oscilloscope to measure electrical quantities e.g amplitude, frequency, period	0.863	Required
14	Determining waveform shapes of electronic components using oscilloscope	0.904	Required
15	Maintaining electronic measuring instrument	0.901	Required
16	Performing simple experiments such as ohmôs law		
17	Constructing step down transformer	0.765	Required
18	Constructing simple circuits using semi conductor devices such as diode, transistor, resistor etc.	0.787	Required
19	Constructing electric bell	0.782	Required
20	Constructing half wave rectifier	0.608	Required
21	Constructing full wave rectifier	0.778	Required
22	Constructing simple analogue ohmmeter	0.63	Required
23	Carrying out forward biasing of a diode	0.741	Required
24	Carrying out reverse biasing of a diode	0.810	Required
25	Carrying out wiring of electrical circuit	0.700	Required
26	Constructing a simple common emitter transistor amplifier	0.824	Required
27	Dismantling of electrical/electronic circuit or unit	0.813	Required
28	Identifying bad components/faults in the circuit	0.842	Required
29	Removing bad components from the circuit	0.808	Required
30	Fixing in good electronic components in the circuit	0.652	Required
31	Coupling the maintained circuit/unit	0.904	Required
32	Testing the unit or equipment for functionality	0.901	Required

Data in Table 1 reveal that 32 basic electronic practical tasks had their factor loading ranged from 0.608 to 0.913 and were all greater than factor loading of 0.50 at 10% over lapping variance with three component matrix. This indicated that all the 32 basic electronics practical tasks satisfied the criteria for inclusion in the final copy of instrument for secondary school students of basic electronics.

Research Question 2

What process skill items are suitable for inclusion in the Basic Electronics Process Skills Assessment Instrument?

The procedure used to determine which process skill items were suitable for inclusion in the instrument involved:

(1) Developing a table of specifications based on Simpsonôs taxonomy of the psychomotor domain (See Appendix B, page 229).

(2) Generating process skill items which closely fit the table of specifications and subjecting 245 process skill items to factor analysis using 0.50 as factor loading at 10% overlapping variance (Ashley et-al, 2007). Consequently, any process skill with factor loading of 0.50 and above was to be included in the final copy of the Basic Electronics Process Skills Assessment Instrument, while process skill items with a loading factor less than 0.50 were not to be included. The result of the factor analysis on the 245 process skill items is shown in Table 2.

The data for answering research question 2 are presented in Table 2.

Table 2

Factor Analysis on the identified basic electronics practical process skill items to determine their suitability for inclusion in the instrument

S/N	Basic Electronics Practical Process Skill Items	Factor loading at 0.50	Remarks
	Task 1-Measuring current using ammeter		
1.	Determining the type of ammeter to use	0.626	Required
2.	Considering the capacity or current rating	**0.302**	Not Required
3.	Adjusting the pointer of the meter to zero if using analogue ammeter	0.894	Required
4.	Setting the selector knob to a higher scale first	0.903	Required
5.	Setting the selector knob down to the applicable current range i.e. milliampere or microampere	0.865	Required
6.	Connecting ammeter in series with the circuit	0.867	Required
7.	Connecting the positive lead (RED) of the ammeter to the positive terminal of the voltage supply	**0.206**	Not Required
8.	Connecting the negative lead (BLACK) of the ammeter to the negative terminal of the voltage supply.	0.862	Required
9.	Switching on the power supply	0.766	Required
10.	Place the meter perfectly on a horizontal surface	0.771	Required
11.	Viewing the pointer from directly above such that the pointer coincides with the calibrating point. (to avoid parallax error)	0.865	Required
12.	Taking and recording the ammeter reading	0.867	Required
13.	Recording the ammeter reading	0.826	Required
	Task 2-Measuring voltage with voltmeter		
14.	Selecting and using appropriate voltmeter	0.766	Required
15.	Considering the value of voltage to be measured	0.771	Required
16.	Setting the pointer of voltmeter to zero position	0.780	Required
17.	Setting the range selector to the highest range scale first	0.655	Required
18.	Reducing the range selector as needed to the lower ranges	0.796	Required
19.	Connecting the positive lead (+, red) of the voltmeter to the positive terminal of the battery	0.719	Required
20.	Connecting the negative lead (-, black) of the meter to the negative terminal of the battery or source	0.838	Required
21.	Connecting the voltmeter across or in parallel with the component voltage to be measured	0.810	Required
22.	Ensuring that the meter is placed perfectly on a horizontal surface to avoid parallax error	0.719	Required
23.	Viewing the pointer from directly above such that the pointer coincides with the calibrated point (to avoid parallax error)	0.779	Required
24.	Taking and recording the voltmeter reading	0.816	Required
	Task 3-Measuring resistance with ohmmeter		
25.	Identifying appropriate ohmmeter	0.668	Required
26.	Placing the meter horizontally	0.768	Required
27.	Inserting the two lead or probes correctly	0.800	Required

S/N	Basic Electronics Practical Process Skill Items	Factor loading at 0.50	Remarks
28.	De-energizing the live circuit	0.912	Required
29.	Removing the resistor or material to be measured	0.877	Required
30.	Short-circuiting the two leads of the meter	0.810	Required
31.	Setting the pointer of the ammeter to zero	**0.213**	**Not Required**
32.	Avoiding to touch the bare metal parts of the probes or resistor leads.	0.878	Required
33.	Placing red lead on the positive side of the circuit	0.903	Required
34.	Placing black lead on the negative side of the circuit	0.779	Required
35.	Reading off the resistance indicated by the scale	0.810	Required
36.	Multiplying by 1, 10, 100, 1000, or more as applicable	0.719	Required
	Task 4-Measuring power using single phase wattmeter		
37.	Selecting appropriate wattmeter	0.779	Required
38.	Connecting wattmeter across the appropriate location in the circuit	0.816	Required
39.	Adjusting the pointer of the meter to zero.	0.668	Required
40.	Placing the leads on supply terminals	0.768	Required
41.	Taking the readings and recording it	0.800	Required
	Task 5-Measuring power using three phase wattmeter		
42.	Selecting three phase wattmeter	0.912	Required
43.	Connecting wattmeter to appropriate location in the circuit	0.877	Required
44.	Adjusting the pointer of the meter to zero	0.810	Required
45.	Placing the leads on supply terminals	0.823	Required
46.	Taking the reading and record it	0.878	Required
	Task 6-Using multimeter to measure DC Voltage		
47.	Setting the range selector to DC,V range	0.865	Required
48.	Connecting the red lead to the positive terminal	0.867	Required
49.	Connecting the black lead on the negative terminal	0.826	Required
50.	Reading the value on the scale and recording it	0.862	Required
	Task 7-Using multimeter to measure AC Voltage		
51.	Setting the range selector to AC,V	0.766	Required
52.	Connecting the test leads to the circuit under test regardless of the polarities	0.771	Required
53.	Reading the measured value on the scale and recording it	0.780	Required
	Task 8-Using multimeter to measure DC Current		
54.	Setting the range selector to DC, A range position	0.655	Required
55.	Connecting the red test lead to the positive polarity	0.796	Required
56.	Connecting the black test lead to the negative polarity	0.719	Required
57.	Reading and recording the value on the scale	0.838	Required
	Task 9-Using multimeter to measure AC Current		
58.	Setting the range selector to AC,A range position	0.807	Required
59.	Connecting the red test lead to the circuit regardless of the polarities	0.840	Required
60.	Reading and recording the value on the scale	0.827	Required

S/N	Basic Electronics Practical Process Skill Items	Factor loading at 0.50	Remarks
	Task 10-Measuring resistance using multimeter		
61.	Setting the range selector to a prescribed range position (n x 1kn x 10 or n x 1)	0.680	Required
62.	Short circuiting the test leads	0.642	Required
63.	Turning ohm adjustment to set the pointer to zero ohm position	**0.147**	**Not Required**
64.	Removing the resistor from the motherboard before testing	0.710	Required
65.	Connecting the test leads to the resistor under test	0.778	Required
66.	Reading the value on the ohm scale and recording the same	0.552	Required
	Task 11-Using multimeter to measure voltage of a battery		
67.	Setting the range selector to DC or BATT position	0.741	Required
68.	Connecting the positive test lead to the positive terminal of the battery	0.688	Required
69.	Connecting the negative test lead to the negative terminal of the battery	0.745	Required
70.	Reading the value on the DC or BATT scale and recording the same	0.668	Required
	Task 12-Using multimeter for continuity test		Required
71.	Setting the range selector to the OHM position	0.768	Required
72.	Connecting the test leads to the circuit under test	0.800	Required
73.	Confirming the continuity of the circuit.	0.912	Required
	Task 13-Using oscilloscope to measure electrical quantities		
74.	Ensuring that the intensity control is not set at a high level for a long time (it can burn the phosphor on the screen)	0.877	Required
75.	Placing the oscilloscope where there is no strong local magnetic field (to avoid unwanted deflection of electron beam)	0.810	Required
76.	Placing the oscilloscope on horizontal platform /table	0.823	Required
77.	Connecting the oscilloscope to power supply	0.878	Required
78.	Connecting the leads to the circuit to be measured	0.912	Required
79.	Ensuring that a bright spot does not stay on the display for a long time (this may burn the phosphor on the screen)	0.877	Required
80.	Allowing the signals to be steady before calibration	0.810	Required
81.	Adjusting the overall gain of the Y-amplifier using the VOLTS/DIV control	0.823	Required
82.	Using the trigger circuit to delay the time base waveform	0.878	Required
83.	Changing the scales of the X-axis and Y-axis to allow many different signals to be displayed	0.850	Required
84.	Adjusting the Y-POS to allow the zero level on the Y-axis to be changed	0.872	Required
85.	Dividing the oscilloscope screen into squares to allow the horizontal scale to be expressed in seconds, milliseconds or microseconds per division (s/DIV, ms/DIV, µs/DIV).	0.894	Required
86.	Using the TIME/DIV control to change the scale of the X-axis as appropriate.	0.903	Required
87.	Pressing Quick Measure to display the readings for various electrical quantities	0.779	Required

S/N	Basic Electronics Practical Process Skill Items	Factor loading at 0.50	Remarks
88.	Reading and recording the values for amplitude, frequency, period, etc	0.810	Required
89.	Noting the scales on the X and Y axes	0.719	Required
90.	Noting the parameter of the waveform that corresponds to the electrical quantity to be measured	0.779	Required
91.	Converting accordingly using the scale applicable to the particular axis	0.816	Required
	Task 14-Determining waveform shapes of electronic components using oscilloscope		
92.	Connecting the leads to the circuit to be analyzed	0.668	Required
93.	Adjusting the overall gain of the Y-amplifier using the VOLTS/DIVControl	0.768	Required
94.	Using the trigger circuit to delay the time base waveform	0.800	Required
95.	Changing the scales of the X-axis and Y-axis to allow many different signals to be displayed	0.912	Required
96.	Adjusting the Y-POS to allow the zero level on the Y-axis to be changed	0.877	Required
97.	Dividing both sides of the screen into equal number of parts. Drawing both horizontal and vertical line through the divisions to make small squares on the screen	0.810	Required
98.	Expressing the horizontal scale in seconds, milliseconds or microseconds per division (s/DIV, ms/DIV, µs/DIV	0.823	Required
99.	Using the TIME/DIV control to change the scale of the X-axis	0.878	Required
100.	Powering up the circuit to be analyzed	0.803	Required
101.	Pressing the button for the channel on which to view the waveform	0.894	Required
102.	Recording the displayed waveform	0.905	Required
	Task 15-Maintaining electronic measuring instrument		
103.	Opening the instrument	0.802	Required
104.	Checking the internal battery or cell	0.836	Required
105.	Replacing the battery (if necessary)	0.758	Required
106.	Checking the fuse	0.802	Required
107.	Replacing the fuse if blown or burnt	0.824	Required
108.	Checking the leads for open circuit	0.688	Required
109.	Inserting the probes into proper socket	0.779	Required
110.	Checking that the dial circuit is correct	0.792	Required
111.	Adjusting zero adjustment knob	0.902	Required
112.	Cleaning the inner parts of the instrument	0.867	Required
113.	Reassembling/closing the instrument	0.792	Required
114.	Sending for repairs (if necessary)	0.795	Required
	Task 16-Performing simple experiments such as ohm's law		
115.	Selecting the right materials and tools for the experiment including measuring instruments	0.860	Required
116.	Using low current for measurement (To minimize heating effect of currents)	0.761	Required
117.	Using a smoothed DC voltage supply (To avoid complications)	0.880	Required

S/N	Basic Electronics Practical Process Skill Items	Factor loading at 0.50	Remarks
118.	Connecting components on the board as required	0.909	Required
119.	Soldering the components correctly	0.905	Required
120.	Determining the readings on the scale of the instrument and recording the same	0.802	Required
	Task 17-Constructing step down transformer		
121.	Determining the grade (SWG) of the coil for the construction and the primary/secondary turns needed.	0.836	Required
122.	Cutting the iron core of the transformer to specification	0.758	Required
123.	Laminating the iron core	0.802	Required
124.	Making the correct number of turns of coil on primary side	0.824	Required
125.	Making appropriate number of turns of coil on secondary side of the transformer	0.688	Required
126.	Coupling the transformer with laminated iron core	0.779	Required
127.	Terminating the construction with appropriate diameter of flexible cable	0.792	Required
128.	Carrying out continuity test on selected coils	0.902	Required
129.	Applying a known value of AC voltage to the primary side of the transformer.	0.909	Required
130.	Reading the output voltage from the secondary side.	**0.205**	**Not Required**
131.	Comparing/contrasting the input and the output	0.802	Required
	Task 18- Constructing simple circuits using semi conductor devices		
132.	Selecting appropriate materials and tools for the construction	0.836	Required
133.	Selecting adequate semi conductors such as transistors, diodes, integrated circuit, etc.	0.758	Required
134.	Testing each semi conductor device before use	0.802	Required
135.	Inserting the leads of each semi conductor device unto the vero board	0.824	Required
136.	Connecting the components as needed in the circuit diagram	0.688	Required
137.	Soldering the joints correctly and avoiding dry joints	0.779	Required
138.	Ensuring that the soldering iron does not stay too long on the devices (to avoid burning them)	0.792	Required
139.	Terminating the circuit	0.902	Required
140.	Testing the constructed circuit using appropriate methods and instruments	0.867	Required
	Task 19-Constructing electric bell		
141.	Selecting gong or bell of appropriate size	0.792	Required
142.	Selecting a strip of metal striker	0.795	Required
143.	Selecting a coated wire of appropriate gauge	0.860	Required
144.	Selecting two iron core	0.860	Required
145.	Carrying out winding on the iron core appropriate number of items, connecting one turn to the other serially	0.881	Required
146.	Fastening the coils to the insulated board parallel to each other	0.945	Required
147.	Fixing the metal striker close to the end of two coils	0.909	Required
148.	Terminating the leads of the two coils	0.905	Required

S/N	Basic Electronics Practical Process Skill Items	Factor loading at 0.50	Remarks
149.	Checking for continuity of coils	0.802	Required
	Task 20-Constructing half wave rectifier		
150.	Selecting appropriate diodes for half wave rectifier	0.836	Required
151.	Selecting appropriate transformer	0.758	Required
152.	Identifying primary and secondary sides of the transformer correctly using multimeter or by observing the leads	0.802	Required
153.	Selecting appropriate capacitor and resistor	0.824	Required
154.	Making the configuration of rectifier on the mother board	0.688	Required
155.	Soldering the components to specification	**0.418**	**Not Required**
156.	Avoiding dry joints and overheating of components during soldering	0.792	Required
157.	Terminating the construction correctly	0.902	Required
	Task 21-Constructing full wave rectifier		
158.	Selecting appropriate diodes for the full wave rectifier	0.867	Required
159.	Selecting appropriate transformer	0.792	Required
160.	Identifying primary and secondary sides of the transformer correctly using multimeter or by observing the leads	0.795	Required
161.	Selecting appropriate capacitor	0.860	Required
	Task 22-Constructing simple analogue ohmmeter		
162.	Determining tools for the construction	0.909	Required
163.	Selecting appropriate components for the construction	0.905	Required
164.	Interpreting the circuit diagram correctly	0.802	Required
165.	Cutting vero board to correct size	0.836	Required
166.	Configuring the components using circuit diagram provided	0.758	Required
167.	Soldering all the joints in the construction neatly	0.802	Required
168.	Inserting the battery or cell in the component	0.824	Required
169.	Inserting the probes correctly	0.688	Required
170.	Making the configuration of rectifier on the vero board	0.779	Required
171.	Soldering the components	0.792	Required
172.	Avoiding dry joints and overheating of components during soldering	0.902	Required
	Task 23-Carrying out forward biasing of a diode		
173.	Determining components to be used for the biasing	0.867	Required
174.	Identifying the different terminals of the diode.	0.792	Required
175.	Connecting diode and battery in forward bias	0.795	Required
176.	Measuring current in forward bias circuit	0.860	Required
177.	Measuring resistance in forward bias	0.836	Required
178.	Confirming whether resistance is high or low	0.909	Required
	Task 24-Carrying out reverse biasing of a diode		
179.	Determining components to be used for the biasing	0.905	Required
180.	Identifying the terminals of the diode	0.802	Required
181.	Connecting diode and battery in reverse bias	0.836	Required
182.	Measuring and record current in reverse bias	0.758	Required

S/N	Basic Electronics Practical Process Skill Items	Factor loading at 0.50	Remarks
183.	Measuring and record resistance in reversed bias	0.802	Required
184.	Confirming whether the resistance is high or low	0.824	Required
	Task 25-Carrying out wiring of electrical circuit		
185.	Identifying materials for wiring	0.688	Required
186.	Laying out the cables on the wiring board	0.779	Required
187.	Connecting all the electrical components correctly	0.792	Required
188.	Terminating all joints appropriately	0.902	Required
189.	Taping all the naked joints with insulation tape	0.867	Required
190.	Covering the joint boxes	0.792	Required
191.	Connecting the switch to the circuit	0.795	Required
192.	Test- running the wiring circuit	0.860	Required
	Task 26-Constructing A Simple Common emitter Transistor Amplifier		
193.	Selecting the components needed for the amplifier circuit (Transistor, resistor , capacitor etc)	0.515	Required
194.	Identifying the collector pin, the base pin and the emitter pin of the transistor	0.909	Required
195.	Laying out on the vero board, all the components needed for the circuit	0.905	Required
196.	Soldering each component in turn.	0.802	Required
197.	Ensuring that the components are not exposed to excessive heat from the soldering iron or using a low wattage soldering iron	0.836	Required
198.	Cutting the excess lengths of pins after soldering	0.758	Required
199.	Applying from a signal generator, a small input signal (in the millivolts, or milliampere range) at the input of the circuit.	0.802	Required
200.	Confirming using an oscilloscope that there is a gain at the output	0.824	Required
	Task 27-Dismantling of electrical/electronic circuit or unit		
201.	Selecting appropriate tools for the task	0.688	Required
202.	Ensuring that the device is not connected to a power source	0.779	Required
203.	Placing the unit horizontally	0.792	Required
204.	Handling components with care to avoid damage	0.902	Required
205.	Turning the unit upside down	0.867	Required
206.	Unscrewing the unit or circuit	0.792	Required
207.	Inserting appropriate screw driver into screw slot	0.795	Required
208.	Turning the screw driver in anticlockwise direction (to loosen the screws)	0.860	Required
209.	Removing all the screws	0.792	Required
210.	Keeping the screws safely(for later use)	0.902	Required
211.	Opening the unit or equipment	0.867	Required
212.	Disconnecting all wiring	0.792	Required
	Task 28-Identifying bad components/faults in the circuit		
213.	Selecting functional electronic tester or meter for the task	0.860	Required
214.	Connecting the tester to each suspected component in turn	0.940	Required

S/N	Basic Electronics Practical Process Skill Items	Factor loading at 0.50	Remarks
215.	Taking the reading of the component(s)	0.909	Required
216.	Detecting open or short circuit in the component or equipment	0.905	Required
217.	Observing any physical damage in the unit or equipment	0.802	Required
	Task 29-Removing bad components from the circuit		
218.	Turning selector of multimeter to ohm range	0.836	Required
219.	Turning the circuit board upside down	0.758	Required
220.	Locating the tags of the components	0.802	Required
221.	Placing the bit of the hot soldering iron on it for a few seconds to melt the solder	0.824	Required
222.	Avoiding prolonged soldering iron contact with the component (to avoid burning of the components)	0.688	Required
223.	Removing the components from the board gently	0.779	Required
224.	Placing the leads of the meter on tips of the component	0.792	Required
225.	Testing or reading for functionality	0.902	Required
	Task 30-Fixing in good electronic components in the circuit		
226.	Identifying the bad component	0.867	Required
227.	Placing the bit of the hot soldering iron for a few seconds to melt and remove the solder from the hole where the bad component is fixed	0.792	Required
228.	Identifying appropriate replacement	0.795	Required
229.	Inserting the good component through the hole	0.860	Required
230.	Turning the vero board upside down	0.909	Required
231.	Soldering the tags of the component for two seconds	0.905	Required
232.	Cutting out excess tags	0.802	Required
233.	Removing excess solder with lead sucker	0.836	Required
234.	Avoiding prolonged soldering iron contact with the component (to avoid burning of the component)	0.758	Required
	Task 31-Coupling the maintained circuit/unit		
235.	Packing all the flexible wires in the equipment together with rubber clips	0.802	Required
236.	Screwing the mother board firmly with the container	0.824	Required
237.	Coupling the equipment	0.688	Required
238.	Aligning the container	0.779	Required
239.	Inserting the screws correctly	0.505	Required
240.	Inserting appropriate screw driver	0.709	Required
241.	Turning the screw driver in a clockwise direction to tighten the screws	0.805	Required
	Task 32-Testing the unit or equipment for functionality		
242.	Switching off the socket outlet	0.812	Required
243.	Plugging the equipment to the socket outlet	0.836	Required
244.	Switching on the socket outlet to power the equipment	0.781	Required
245.	Observing the equipment for functionality	0.811	Required

Data in Table 2 reveal that 239 basic electronic practical skill items had their factor loading ranged from 0.515 to 0.912 and were all greater than factor loading of 0.50 at 10% over lapping variance with three component matrix. This indicated that all the 239 out of 245 basic electronic practical process skill items are to be included in the basic electronic process skill instrument for assessing senior secondary III students. Six practical process skill items are not to be included in the instrument because they have their factor loading below 0.50 at 10% over lapping variance. These were, two items in task one, one in task 3, one in task 10, one in task 17, one item in task 20 and they were discarded from basic electronic process skill assessment instrument. This finding agreed with Giachino and Gallington (1977) that if content has no components of non ï loading items, it is assumed that the factorial validity of the tasks or content is high.

Research Question 3

What is the validity of the basic electronics process skills assessment instrument for senior secondary III students?

The data for answering research question three are presented in Table 3.

Table 3

Validated Tasks and Practical Process Skill Items in Measuring and Testing, Construction of Electrical/Electronic Circuit and Faults Tracing and Repair Operations

S/N	Basic Electronics Practical Tasks	No of items	Remarks
A	**Measuring and testing operation**	**119**	**Valid**
1	Measuring current using ammeter	12	Valid
2	Measuring voltage with voltmeter	11	Valid
3	Measuring resistance with ohmmeter	12	Valid
4	Measuring power using single phase wattmeter	5	Valid
5	Measuring power using three phase wattmeter	5	Valid
6	Using multimeter to measure DC Voltage	4	Valid
7	Using multimeter to measure AC Voltage	3	Valid
8	Using multimeter to measure DC Current	4	Valid
9	Using multimeter to measure AC Current	3	Valid
10	Measuring resistance using multimeter	6	Valid
11	Using multimeter to measure voltage of a battery	4	Valid
12	Using multimeter for continuity test	3	Valid
13	Using oscilloscope to measure electrical quantities e.g amplitude, frequency, period	16	Valid
14	Determining waveform shapes of electronic components using oscilloscope	11	Valid
15	Maintaining electronic measuring instrument	12	Valid
16	Performing simple experiments such as ohmôs law	6	Valid
B	**Constructing Electrical/Electronic Circuit operator**	**81**	**Valid**
17	Constructing step down transformer	11	Valid
18	Constructing simple circuits using semi conductor devices such as diode, transistor, resistor etc.	9	Valid
19	Constructing electric bell	9	Valid
20	Constructing half wave rectifier	8	Valid
21	Constructing full wave rectifier	4	Valid
22	Constructing simple analogue ohmmeter	10	Valid
23	Carrying out forward biasing of a diode	6	Valid
24	Carrying out reverse biasing of a diode	6	Valid
25	Carrying out wiring of electrical circuit	8	Valid
26	Constructing a simple common emitter transistor amplifier	8	Valid
C	**Fault Tracing and Repair Operation**	**42**	**Valid**
27	Dismantling of electrical/electronic circuit or unit	12	Valid
28	Identifying bad components/faults in the circuit	5	Valid
29	Removing bad components from the circuit	8	Valid
30	Fixing in good electronic components in the circuit	9	Valid
31	Coupling the maintained circuit/unit	7	Valid
32	Testing the unit or equipment for functionality	4	Valid
	Grand Total	**245**	

The table of specifications constructed based on Simpsonôs (1972) model of psychomotor domain revealed that out of 245 process skill items, 8.57% comprising 21 process skill items were assessing the perception level; 8.16% comprising 20 process skill items were assessing the set level; 24.5% comprising 60 process skill items were assessing the guided response level, 23.26% comprising 57 process skill items were assessing the mechanism level; 26.5% comprising 69 process skill items were assessing the complex overt response level and 7.34% comprising 18 process skill items were assessing the adaptation level (see Appendix B). The origination level of Simpsonôs model was not involved in the study because it was not in the senior secondary school curriculum. These results show that six levels of the domain were adequately covered by the assessment instruction. This means that all the 245 process skill items were valid for inclusion in the basic electronics process skill instrument.

The draft copies of the instrument were subjected to face and content validation carried out by five experts: two of the experts who specialized in technical education were lecturers in tertiary institutions, one expert in electronics were teaching at the secondary level of education, while the remaining two were experts in measurement and evaluation in Nigerian Universities. The experts were to review, reword, and advice on the appropriateness and clarity of the tasks, add other tasks which were suitable but had not been included in the draft instrument, and remove tasks which were considered not suitable, ambiguous or redundant. On the whole, as shown in Table 3, there were still 32 tasks with 245 corresponding process skill items to be included in the basic electronics process skills assessment instrument.

Research Question 4

What is the reliability of the basic electronics process skills assessment instrument for senior secondary 3 students?

The data for answering research question four are presented in Table 4.

Table 4

Reliability Estimates for Basic Electronic Practical Task to be used for assessing Students in Senior Secondary Schools

S/N	Basic Electronics Practical Tasks	Cronbach alpha coefficient	No of items	Remarks
1	Measuring current using ammeter	0.83	14	Highly Reliable
2	Measuring voltage with voltmeter	0.81	11	Highly Reliable
3	Measuring resistance with ohmmeter	0.88	12	Highly Reliable
4	Measuring power using single phase wattmeter	0.78	6	Highly Reliable
5	Measuring power using three phase wattmeter	0.77	5	Highly Reliable
6	Using multimeter to measure DC Voltage (DC,V)	0.72	4	Highly Reliable
7	Using multimeter to measure AC Voltage (AC,V)	0.76	3	Highly Reliable
8	Using multimeter to measure DC Current (DC, A)	0.67	4	Highly Reliable
9	Using multimeter to measure AC Current (AC,A)	0.68	3	Highly Reliable
10	Measuring resistance using multimeter	0.88	6	Highly Reliable
11	Using multimeter to measure voltage of a battery	0.78	4	Highly Reliable
12	Using multimeter for continuity test	0.73	3	Highly Reliable
13	Using oscilloscope to measure electrical quantities e.g amplitude, frequency, period	0.89	18	Highly Reliable
14	Determining waveform shapes of electronic components using oscilloscope	0.69	12	Highly Reliable
15	Maintaining electronic measuring instrument	0.81	12	Highly Reliable
16	Performing simple experiments such as ohmôs law	0.72	6	Highly Reliable
17	Constructing step down transformer	0.81	11	Highly Reliable
18	Constructing simple circuits using semi conductor devices such as diode, transistor, resistor etc.	0.68	9	Highly Reliable
19	Constructing electric bell	0.79	9	Highly Reliable
20	Constructing half wave rectifier	0.82	8	Highly Reliable
21	Constructing full wave rectifier	0.74	4	Highly Reliable
22	Constructing simple analogue ohmmeter	0.79	14	Highly Reliable
23	Carrying out forward biasing of a diode	0.81	6	Highly Reliable
24	Carrying out reverse biasing of a diode	0.68	6	Highly Reliable
25	Carrying out wiring of electrical circuit	0.88	8	Highly Reliable
26	Constructing a simple common emitter transistor amplifier	0.79	8	Highly Reliable
27	Dismantling of electrical/electronic circuit or unit	0.83	12	Highly Reliable
28	Identifying bad components/faults in the circuit	0.84	5	Highly Reliable
29	Removing bad components from the circuit	0.81	8	Highly Reliable
30	Fixing in good electronic components in the circuit	0.74	9	Highly Reliable
31	Coupling the maintained circuit/unit	0.77	7	Highly Reliable
32	Testing the unit or equipment for functionality	0.64	4	Highly Reliable
	Reliability coefficient for entire instrument	**0.772899**		**Highly Reliable**

Analysis in Table 4 reveals that each of the 32 basic electronics tasks contained in the instrument had a high reliability coefficient ranging from 0.64-0.88. Also, the reliability coefficient of the entire test was computed to be 0.77 which indicated that the assessment instrument was a refined test in consonance with the recommendation of Uzoagulu (2011) which stated that acceptable reliability of test used in education is generally in the range of 0.50 to 0.95. Therefore, given the high reliability coefficients for various tasks in the instrument, the answer to the research question about the reliability of the test would be in the affirmative. Thus, the items in the instrument for assessing the practical process skills of students in basic electronics at the senior secondary level were reliable. In order to establish the inter-rater reliability in the process skill items, a field testing was conducted using 25 SS3 students of basic electronic and five teachers as raters. Data obtained from the field testing was analysed using Kendall coefficient of concordance, Tau to find out if there is significant relationship between the five raters scoring in the basic electronic practical process skill assessment instrument. The degree of agreement or coefficient of concordance among the raters on the scoring was therefore computed. The inter rater reliability coefficient of the five raters were found to be 0.781, 0.701, 0.861 and 0.706 for raters 1and 2, 2 and 3, 3 and 4, 4 and 5 respectively. Consequently, the inter-rater reliability for the five raters is 0.75. These values were in agreement with the recommendation by Cohen, Manion and Marrison (2011) that a coefficient ranging from 0.51 to 1.00 indicate high degree of agreement between 2 or more examiners.

Research Question 5

What are the ability groups of the senior secondary III students of basic electronics?

The data for answering research question five are presented in Table 5

Table 5

Ability Groups of 25 students in Test of 3 Tasks with their Corresponding Practical Process Skill Items

Ability Group	Percentage (%) of Students in each Group	Number of Students in each Group (frequency count)
High Ability Group	33 ÷ 100 X D	8
Average Ability Group	34÷ 100 X D	9
Low Ability Group	33÷ 100 X D	8
Total	**100**	**25**

To answer research question 5, a test of three tasks (One task from each operation) with their corresponding practical process skill items was used. The test was administered to 25 SSIII students in Federal science and technical college Yaba before the field testing. The studentsô rated scores were computed and ranked from highest to lowest. Using Adeyemo (2010)ôs ability levels identification method, 8 students fell under high ability representing the first 33% of the students with the highest scores; 8 students fell under low ability representing 33% of students with the least scores and 9 students belong to average ability representing 34% of the students with the middle scores.

Testing of Hypotheses

Hypothesis 1

There is no significant difference in the mean ratings of students on measuring and testing operation, based on their ability levels, when using the process skills assessment instrument.

Data for testing hypothesis one are presented in Table 6

Table 6
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	2.357	2	1.178	1.230	0.312	0.05	**NS**
Within Groups	21.083	22	0.958				
Total	23.440	24					

Data presented in table 6 revealed a P-value of 0.312 which is greater than 0.05 at degree of freedom 2 and 22. This indicated that there was no significant difference in the mean scores of students on measuring and testing operation, based on their ability levels, when using the process skills assessment instrument. Therefore, the null hypothesis of no significant difference between the three groups of students on measuring and testing operations, based on their ability levels, when using the process skills assessment instrument was accepted. The results further indicated that practical process skill items in measuring and testing operation were not too difficult for high, average and low ability groups of students.

Hypothesis 2

There is no significant difference in the mean rating of students on constructing electrical circuit operation, based on their ability levels, when using the process skills assessment instrument.

Data for testing hypothesis two are presented in Table 7

Table 7
Summary of ANOVA Utilized for Testing Null Hypothesis Two

Sources of Variance	Sum of Squares	Df	Mean Square	f-cal	P Value	Level of Sig.	Rmks
Between Groups	2.253	2	1.126	0.914	0.416	0.05	NS
Within Groups	27.107	22	1.232				
Total	29.360	24					

Data in Table 7 reveal the F-ratio of the mean ratings of teachers on studentsô performance on skill items in constructing electrical circuit operation. The data also reveal a P-value of 0.416 which is greater than 0.05 at degree of freedom 2 and 22. This indicated that there was no significant difference in the mean rating of students on constructing electrical circuit operations, based on their ability levels, when using the practical process skills assessment instrument. Therefore, the null hypothesis of no significant difference between the three groups of students on constructing electrical circuit operation, based on their ability levels, when using the process skills assessment instrument was accepted. The results further indicated that practical process skill items in constructing electrical circuit operation were not too difficult for high, average and low ability group of students.

Hypothesis 3

There is no significant difference in the mean ratings of students on fault tracing and repairs operation, based on their ability levels, when using the process skills assessment instrument.

Data for testing hypothesis three are presented in Table 8.

Table 8
Summary of ANOVA Utilized for Testing Null Hypothesis Three

Sources of Variance	Sum of Squares	Df	Mean Square	f-cal	P-Value	Level of Sig.	Rmks
Between Groups	1.686	2	0.843	0.962	0.398	0.05	NS
Within Groups	19.274	22	0.876				
Total	20.960	24					

Data in Table 8 reveal the F-ratio of the mean ratings of teachers on studentsô performance on skill items in fault tracing and repair operation. The data also reveal a P-value of 0.398 which is greater than 0.05 at degree of freedom 2 and 22. This indicated that there was no significant difference in the mean rating of students on fault tracing and repair operation, based on their ability levels, when using the process skills assessment instrument. Therefore, the null hypothesis of no significant difference between the three groups of students on fault tracing and repair operation, based on their ability levels, when using the process skills assessment instrument was upheld. The results further indicated that process skill items in fault tracing operation 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. The relevant tasks to be performed by senior secondary three students of basic electronics

It was found out from the study that 32 tasks were relevant for inclusion in the basic electronics practical process skill assessment instrument

1. Measuring current using ammeter
2. Measuring voltage with voltmeter
3. Measuring resistance with ohmmeter
4. Measuring power using single phase wattmeter
5. Measuring power using three phase wattmeter
6. Using multimeter to measure DC Voltage (DC,V
7. Using multimeter to measure AC Voltage (AC,V)
8. Using multimeter to measure DC Current (DC, A)
9. Using multimeter to measure AC Current (AC,A)
10. Measuring resistance using multimeter
11. Using multimeter to measure voltage of a battery
12. Using multimeter for continuity test
13. Using oscilloscope to measure electrical quantities e.g amplitude, frequency, period
14. Determining waveform shapes of electronic components using oscilloscope

15. Maintaining electronic measuring instrument
16. Performing simple experiments such as ohmôs law
17. Constructing step down transformer
18. Constructing simple circuits using semi conductor devices such as diode, transistor, resistor etc.
19. Constructing electric bell
20. Constructing half wave rectifier
21. Constructing full wave rectifier
22. Constructing simple analogue ohmmeter
23. Carrying out forward biasing of a diode
24. Carrying out reverse biasing of a diode
25. Carrying out wiring of electrical circuit
26. Constructing a simple common emitter transistor amplifier
27. Dismantling of electrical/electronic circuit or unit
28. Identifying bad components/faults in the circuit
29. Removing bad components from the circuit
30. Fixing in good electronic components in the circuit
31. Coupling the maintained circuit/unit
32. Testing the unit or equipment for functionality

Based on these findings, a basic electronics process skills assessment instrument consisting 32 tasks was developed.

B. The relevant process skill items for inclusion in the basic electronic practical process skill instrument for senior secondary school three

It was found out from the study that 239 process skills were relevant for inclusion in the basic electronic process skills assessment instrument

Task 1-Measuring current using ammeter

1. Determining the type of ammeter to use
2. Adjusting the pointer of the meter to zero if using analogue ammeter
3. Setting the selector knob to a higher scale first
4. Setting the selector knob down to the applicable current range i.e. milliampere or microampere
5. Connecting ammeter in series with the circuit
6. Connecting the negative lead (BLACK) of the ammeter to the negative terminal of the voltage supply.
7. Switching on the power supply
8. Place the meter perfectly on a horizontal surface
9. Viewing the pointer from directly above such that the pointer coincides with the calibrating point.
10. Taking and recording the ammeter reading
11. Recording the ammeter reading

Task 2-Measuring voltage with voltmeter

1. Selecting and using appropriate voltmeter
2. Considering the value of voltage to be measured

3. Setting the pointer of voltmeter to zero position
4. Setting the range selector to the highest range scale first
5. Reducing the range selector as needed to the lower ranges
6. Connecting the positive lead (+, red) of the voltmeter to the positive terminal of the battery
7. Connecting the negative lead (-, black) of the meter to the negative terminal of the battery or source
8. Connecting the voltmeter across or in parallel with the component voltage to be measured
9. Ensuring that the meter is placed perfectly on a horizontal surface to avoid parallax error
10. Viewing the pointer from directly above such that the pointer coincides with the calibrated point (to avoid parallax error)
11. Taking and recording the voltmeter reading

Task 3-Measuring resistance with ohmmeter

1. Identifying appropriate ohmmeter
2. Placing the meter horizontally
3. Inserting the two lead or probes correctly
4. De-energizing the live circuit
5. Removing the resistor or material to be measured
6. Short-circuiting the two leads of the meter
7. Placing red lead on the positive side of the circuit

8. Placing black lead on the negative side of the circuit
9. Reading off the resistance indicated by the scale
10. Multiplying by 1, 10, 100, 1000, or more as applicable

Task 4-Measuring power using single phase wattmeter

1. Selecting appropriate wattmeter
2. Connecting wattmeter across the appropriate location in the circuit
3. Adjusting the pointer of the meter to zero.
4. Placing the leads on supply terminals
5. Taking the readings and recording it

Task 5-Measuring power using three phase wattmeter

1. Selecting three phase wattmeter
2. Connecting wattmeter to appropriate location in the circuit
3. Adjusting the pointer of the meter to zero
4. Placing the leads on supply terminals
5. Taking the reading and record it

Task 6-Using multimeter to measure DC Voltage (DC,V)

1. Setting the range selector to DC,V range
2. Connecting the red lead to the positive terminal
3. Connecting the black lead on the negative terminal
4. Reading the value on the scale and recording it

Task 7-Using multimeter to measure AC Voltage (AC,V)

1. Setting the range selector to AC,V

2. Connecting the test leads to the circuit under test regardless of the polarities
3. Reading the measured value on the scale and recording it

Task 8-Using multimeter to measure DC Current

1. Setting the range selector to DC, A range position
2. Connecting the red test lead to the positive polarity
3. Connecting the black test lead to the negative polarity
4. Reading and recording the value on the scale

Task 9-Using multimeter to measure AC Current

1. Setting the range selector to AC,A range position
2. Connecting the red test lead to the circuit regardless of the polarities
3. Reading and recording the value on the scale

Task 10-Measuring resistance using multimeter

1. Setting the range selector to a prescribed range position (n x 1kn x 10 or n x 1)
2. Short circuiting the test leads
3. Removing the resistor from the motherboard before testing
4. Connecting the test leads to the resistor under test
5. Reading the value on the ohm scale and recording the same

Task 11-Using multimeter to measure voltage of a battery

1. Setting the range selector to DC or BATT position
2. Connecting the positive test lead to the positive terminal of the battery
3. Connecting the negative test lead to the negative terminal of the battery
4. Reading the value on the DC or BATT scale and recording the same

Task 12-Using multimeter for continuity test

1. Setting the range selector to the OHM position
2. Connecting the test leads to the circuit under test
3. Confirming the continuity of the circuit.

Task 13-Using oscilloscope to measure electrical quantities e.g amplitude, frequency, period

1. Ensuring that the intensity control is not set at a high level for a long time (it can burn the phosphor on the screen)
2. Placing the oscilloscope where there is no strong local magnetic field (to avoid unwanted deflection of electron beam)
3. Placing the oscilloscope on horizontal platform /table
4. Connecting the oscilloscope to power supply
5. Connecting the leads to the circuit to be measured
6. Ensuring that a bright spot does not stay on the display for a long time (this may burn the phosphor on the screen)
7. Allowing the signals to be steady before calibration
8. Adjusting the overall gain of the Y-amplifier using the VOLTS/DIV control
9. Using the trigger circuit to delay the time base waveform
10. Changing the scales of the X-axis and Y-axis to allow many different signals to be displayed
11. Adjusting the Y-POS to allow the zero level on the Y-axis to be changed

12. Dividing the oscilloscope screen into squares to allow the horizontal scale to be expressed in seconds, milliseconds or microseconds per division (s/DIV, ms/DIV, µs/DIV).
13. Using the <u>TIME/DIV</u> control to change the scale of the X-axis as appropriate.
14. Pressing Quick Measure to display the readings for various electrical quantities
15. Reading and recording the values for amplitude, frequency, period, etc
16. Noting the scales on the X and Y axes
17. Noting the parameter of the waveform that corresponds to the electrical quantity to be measured
18. Converting accordingly using the scale applicable to the particular axis

Task 14-Determining waveform shapes of electronic components using oscilloscope

1. Connecting the leads to the circuit to be analyzed
2. Adjusting the overall gain of the Y-amplifier using the <u>VOLTS/DIV</u>
3. control
4. Using the trigger circuit to delay the time base waveform
5. Changing the scales of the X-axis and Y-axis to allow many different signals to be displayed
6. Adjusting the Y-POS to allow the zero level on the Y-axis to be changed
7. Dividing both sides of the screen into equal number of parts. Drawing both horizontal and vertical line through the divisions to make small squares on the screen

8. Expressing the horizontal scale in seconds, milliseconds or microseconds per division (s/DIV, ms/DIV, µs/DIV)
9. Using the TIME/DIV control to change the scale of the X-axis
10. Powering up the circuit to be analyzed
11. Pressing the button for the channel on which to view the waveform
12. Recording the displayed waveform

Task 15-Maintaining electronic measuring instrument

1. Opening the instrument
2. Checking the internal battery or cell
3. Replacing the battery (if necessary)
4. Checking the fuse
5. Replacing the fuse if blown or burnt
6. Checking the leads for open circuit
7. Inserting the probes into proper socket
8. Checking that the dial circuit is correct
9. Adjusting zero adjustment knob
10. Cleaning the inner parts of the instrument
11. Reassembling/closing the instrument

Task 16-Performing simple experiments such as ohm's law

1. Selecting the right materials and tools for the experiment including measuring instruments
2. Using low current for measurement

3. Using a smoothed DC voltage supply
4. Connecting components on the board as required
5. Soldering the components correctly
6. Determining the readings on the scale of the instrument and recording the same

Task 17-Constructing step down transformer

1. Determining the grade (SWG) of the coil for the construction and the primary/secondary turns needed.
2. Cutting the iron core of the transformer to specification
3. Laminating the iron core
4. Making the correct number of turns of coil on primary side
5. Making appropriate number of turns of coil on secondary side of the transformer
6. Coupling the transformer with laminated iron core
7. Terminating the construction with appropriate diameter of flexible cable
8. Carrying out continuity test on selected coils
9. Applying a known value of AC voltage to the primary side of the transformer.
10. Comparing/contrasting the input and the output.

Task 18-Constructing simple circuits using semi conductor devices such as diode, transistor, resistor etc.

1. Selecting appropriate materials and tools for the construction
2. Selecting adequate semi conductors such as transistors, diodes, integrated circuit, etc.
3. Testing each semi conductor device before use

4. Inserting the leads of each semi conductor device unto the vero board
5. Connecting the components as needed in the circuit diagram
6. Soldering the joints correctly and avoiding dry joints
7. Ensuring that the soldering iron does not stay too long on the devices (to avoid burning them)
8. Terminating the circuit
9. Testing the constructed circuit using appropriate methods and instruments

Task 19-Constructing electric bell

1. Selecting gong or bell of appropriate size
2. Selecting a strip of metal striker
3. Selecting a coated wire of appropriate gauge
4. Selecting two iron core
5. Carrying out winding on the iron core appropriate number of items, connecting one turn to the other serially
6. Fastening the coils to the insulated board parallel to each other
7. Fixing the metal striker close to the end of two coils
8. Terminating the leads of the two coils
9. Checking for continuity of coils

Task 20-Constructing half wave rectifier

1. Selecting appropriate diodes for half wave rectifier
2. Selecting appropriate transformer

3. Identifying primary and secondary sides of the transformer correctly using multimeter or by observing the leads
4. Selecting appropriate capacitor and resistor
5. Making the configuration of rectifier on the mother board
6. Avoiding dry joints and overheating of the component during soldering
7. Terminating the construction correctly

Task 21-Constructing full wave rectifier

1. Selecting appropriate diodes for the full wave rectifier
2. Selecting appropriate transformer
3. Identifying primary and secondary sides of the transformer correctly using multimeter or by observing the leads
4. Selecting appropriate capacitor

Task 22-Constructing simple analogue ohmmeter

1. Determining tools for the construction
2. Selecting appropriate components for the construction
3. Interpreting the circuit diagram correctly
4. Cutting vero board to correct size
5. Configuring the components using circuit diagram provided
6. Soldering all the joints in the construction neatly
7. Inserting the battery or cell in the component
8. Inserting the probes correctly
9. Making the configuration of rectifier on the vero board

10. Soldering the components
11. Avoiding dry joints and overheating of components during soldering
12. Terminating the construction correctly
13. Adjusting the pointer using zero adjustment knob
14. Test-running the constructed ohmmeter

Task 23: Carrying out forward biasing of a diode

1. Determining components to be used for the biasing
2. Identifying the different terminals of the diode.
3. Connecting diode and battery in forward bias
4. Measuring current in forward bias circuit
5. Measuring resistance in forward bias
6. Confirming whether resistance is high or low

Task 24: Carrying out reverse biasing of a diode

1. Determining components to be used for the biasing
2. Identifying the terminals of the diode
3. Connecting diode and battery in reverse bias
4. Measuring and record current in reverse bias
5. Measuring and record resistance in reversed bias
6. Confirming whether the resistance is high or low

Task 25-Carrying out wiring of electrical circuit

1. Identifying materials for wiring
2. Laying out the cables on the wiring board

3. Connecting all the electrical components correctly
4. Terminating all joints appropriately
5. Taping all the naked joints with insulation tape
6. Covering the joint boxes
7. Connecting the switch to the circuit
8. Test- running the wiring circuit

Task 26-Constructing a simple Common emitter Transistor Amplifier

1. Selecting the components needed for the amplifier circuit (Transistor, resistor , capacitor etc)
2. Identifying the collector pin, the base pin and the emitter pin of the transistor
3. Laying out on the vero board, all the components needed for the circuit
4. Soldering each component in turn.
5. Ensuring that the components are not exposed to excessive heat from the soldering iron or using a low wattage soldering iron (To avoid burning the components).
6. Cutting the excess lengths of pins after soldering
7. Applying from a signal generator, a small input signal (in the millivolts, or milliampere range) at the input of the circuit.
8. Confirming using an oscilloscope that there is a gain at the output

Task 27-Dismantling of electrical/electronic circuit or unit

1. Selecting appropriate tools for the task
2. Ensuring that the device is not connected to a power source
3. Placing the unit horizontally

4. Handling components with care to avoid damage
5. Turning the unit upside down
6. Unscrewing the unit or circuit
7. Inserting appropriate screw driver into screw slot
8. Turning the screw driver in anticlockwise direction (to loosen the screws)
9. Removing all the screws
10. Keeping the screws safely(for later use)
11. Opening the unit or equipment
12. Disconnecting all wiring

Task 28-Identifying bad components/faults in the circuit

1. Selecting functional electronic tester or meter for the task
2. Connecting the tester to each suspected component in turn
3. Taking the reading of the component(s)
4. Detecting open or short circuit in the component or equipment
5. Observing any physical damage in the unit or equipment

Task 29-Removing bad components from the circuit

1. Turning selector of multimeter to ohm range
2. Turning the circuit board upside down
3. Locating the tags of the components
4. Placing the bit of the hot soldering iron on it for a few seconds to melt the solder
5. Avoiding prolonged soldering iron contact with the component (to avoid burning of the components)

6. Removing the components from the board gently
7. Placing the leads of the meter on tips of the component
8. Testing or reading for functionality

Task 30-Fixing in good electronic components in the circuit

1. Identifying the bad component
2. Placing the bit of the hot soldering iron for a few seconds to melt and remove the solder from the hole where the bad component is fixed
3. Identifying appropriate replacement
4. Inserting the good component through the hole
5. Turning the vero board upside down
6. Soldering the tags of the component for two seconds
7. Cutting out excess tags
8. Removing excess solder with lead sucker
9. Avoiding prolonged soldering iron contact with the component (to avoid burning of the component)

Task 31-Coupling the maintained circuit/unit

1. Packing all the flexible wires in the equipment together with rubber clips
2. Screwing the mother board firmly with the container
3. Coupling the equipment
4. Aligning the container
5. Inserting the screws correctly
6. Inserting appropriate screw driver

7. Turning the screw driver in a clockwise direction to tighten the screws

Task 32-Testing the unit or equipment for functionality

1. Switching off the socket outlet
2. Plugging the equipment to the socket outlet
3. Switching on the socket outlet to power the equipment
4. Observing the equipment for functionality

Based on these findings, the developed instrument at this stage had 32 tasks and 245 process skill items

Validity of basic electronics practical process skills assessment instrument consisting of 32 tasks and 245 process skill items

Factoral analysis, face validation and content validity were carried out to determine the validation of the basic electronic practical process skills instrument. Factoral analysis conducted discarded six process skill items with factor loading below 0.50 altogether in five tasks to be performed by students. The process of content validation of the basic electronics practical process skill items was done by constructing a table of specification based on the six levels of psychomotor domain of Simpson (1972) and this showed that out of 245 process skills, 8% comprising 20 skill items were psychomotor domain, 8% comprising 20 practical skill items were assessing the perception level; 8% comprising 20 practical skill items were assessing the set level; 25% comprising 61 practical skill items were assessing the guided response level, 25% comprising 61 practical skill items were assessing the mechanism level; 26.5% comprising 65 practical skill items were assessing the complex overt response level and

8% comprising 20 practical skill items were assessing the adaptation level. The origination level of Simpsonôs model was not involved in the study because it was not in the senior secondary school curriculum.

The result of the face validation of the basic electronic practical skill instrument by involving six experts from the Department of Teacher Education and Science Education of the University of Nigeria, Nsukka to critique the arrangement and adequacy of the items under each operation and task, wording and wording revealed that 32 tasks and 242 skill items were well worded and clear enough to be included in the basic electronic practical process skills assessment instrument for senior secondary schools.

Reliability of the basic electronic practical process skill instrument consisting of 32 tasks and 245 process skill items

It was found out that 1-32 tasks and 245 corresponding practical process skill items had their internal consistency ranged from 0.64 to 0.88while the entire item had reliability coefficient value of 0.77. This means that all the tasks and their items are reliable enough to be included in the basic electronic practical process skill instrument.

Findings on the Hypotheses Tested

$H0_1$: It was found out that there were no significant differences in the mean scores of students offering basic electronics in senior secondary three on measuring and testing operation based on their ability levels when using process skill assessment instrument.

$H0_2$: It was found out that there were no significant differences in the mean scores of students offering basic electronics in senior secondary three on construction of electrical circuit operation based on their ability levels when using process skills assessment instrument.

$H0_3$: It was found out that there were no significant differences in the mean scores of students offering basic electronics in senior secondary three on fault tracing and repair operation based on their ability levels when using process skill assessment instrument.

Discussion of findings

The discussion of findings was based on the research questions answered and the hypotheses tested.

The tasks to be performed by senior secondary three students in basic electronics

The finding that 32 tasks were relevant to be performed by senior secondary school three students of basic electronics was supported by the opinion of Ombugus (2013), Okoro (2003), Olaitan (2003) and Garba (1993). The authors noted that items that satisfied all psychometric properties with high loading factors are relevant and worthy for inclusion in the assessment instruments. All the tasks were found relevant to be performed by students offering basic electronic in SS III class and were found relevant enough to be included in the assessment instrument. Some of the major tasks in the three different operations of basic electronics include measuring current using ammeter, measuring voltage with voltmeter, measuring resistance with ohmmeter, measuring power using single phase wattmeter, measuring power using three phase wattmeter, using multimeter to measure DC Voltage (DC,V, using multimeter to measure AC Voltage (AC,V), using multimeter to measure DC Current (DC, A), using multimeter to measure

AC Current (AC,A), measuring resistance using multimeter, using multimeter to measure voltage of a battery and using multimeter for continuity test. That is, all the 32 tasks in three major operations were relevant and satisfied all the psychometric properties of good items and therefore worthy of inclusion in the basic electronic process skills assessment instrument. Inclusion of relevant tasks in assessment instrument helps in measuring the stated objectives adequately. In the Psychomotor domain are objectives two and four of basic electronic are measurable through Simpson's taxonomy classified into: Perception, Set, Guided response, Complex overt response, Mechanism, Adaptation and Origination, (Simpson in Olaitan, 2003). According to Ogwo and Oranu (2006), a combination of these three domains - cognitive, affective and psychomotor in any assessment instrument would reveal observable results for the achievement of the entire objectives of basic electronics. This could improve students' interest in electronic occupations and careers for a competence -based vocational education programme like the basic electronics.

The relevant process skill items for inclusion in the basic electronic process skill assessment instrument for senior secondary school

It was found out from the study that 239 practical process skills are relevant for inclusion in the basic electronic process skills assessment instrument for senior secondary schools and prominent among these practical process skills are: determining the type of ammeter to use, considering the capacity or current rating, adjusting the pointer of the meter to zero if using analogue ammeter, setting the selector knob to a higher scale first, setting the selector knob down to the applicable current range i.e. milli-ampere or microampere, selecting and using appropriate voltmeter, considering the value of voltage to be measured, setting the pointer of voltmeter to zero position, setting the range selector to the highest range scale first, reducing the range selector as needed to the lower ranges, connecting the positive lead (+, red) of the voltmeter to the positive terminal of the battery, identifying appropriate ohmmeter, placing the meter horizontally, inserting the two lead or probes correctly, de-energizing the live circuit, removing the resistor or material to be measured, short-circuiting the two leads of the meter, setting the pointer of the ammeter to zero, placing red lead on the positive side of the circuit, placing black lead on the negative side of the circuit, reading off the resistance indicated by the scale, multiplying by 1, 10, 100, 1000, or more as applicable, selecting appropriate wattmeter, connecting wattmeter across the appropriate location in the circuit, adjusting the pointer of the meter to zero, placing the leads on supply terminals, taking the readings and recording it, selecting three phase wattmeter, connecting wattmeter to appropriate location in the circuit, adjusting the pointer of the meter to zero and placing the leads on supply terminals. These findings are in agreement with the findings of Ombugus (2013) who developed and validated workshop based process skill tests in mechanical engineering craft for assessing students in technical colleges in Nasarawa State, Nigeria and found 305 process skill items relevant for inclusion in the process skill instrument because their factor loading were above 0.50. The findings of the study are in agreement with the opinion of Lasis (2011) who included practical process skill items such as selection of appropriate of tools, manipulation of tools, care of tools among others in the competency based assessment guide developed for technical college instructors. The findings of the study also agreed with the submission of Okoro (2003), Olaitan (2003) and Garba (1993) that items that satisfied all psychometric properties are relevant and worthy for inclusion in the assessing instrument.

Validity of basic electronics process skills assessment instrument

Findings of the study reveal valid 32 tasks and 245 process skill items. These were ascertained by involving experts to validate the instrument. These experts were given the copies of the instrument to vet and indicate how relevant the skill items were for assessing the students in carrying out practical activities in basic electronic. This is called face validation and is the first stage of instrument development process, and this is in agreement with the opinion of Bakare (2014) who stated that in face validity or validation, the experts are hired to vet, remove, reword and replace any irrelevant item(s) of the instrument with useful ones. The finding also agreed with opinion of Olaitan (2003) that face validity of psychomotor learning activity could be pursued by submitting the list of skill items drawn up for use to experts for review so as to yield compromise or consensual agreement on the importance of the items and such was the case in this study.

To ascertain the content validity of basic electronics process skill assessment instrument, a table of specifications was constructed based on six levels of Simpsonös taxonomy of the psychomotor domain and this showed that out of 245 process skills, 8.57% comprising 21 practical skill items were assessing the perception level; 8.16% comprising 20 practical skill items were assessing the set level; 24.5% comprising 60 practical skill items were assessing the guided response level, 23.26% comprising 57 practical skill items were assessing the mechanism level; 28.16% comprising 69 practical skill items were assessing the complex overt response level and 7.54% comprising 18 practical skill items were assessing the adaptation level.

The findings are in agreement with the finding of Amuka (2002) who established content validity from detailed and comprehensive table of specification and comments of some experts in vocational education at the University of Nigeria, Nsukka. Also, the finding of the study was in consonance with the finding of Ombugus (2013) who developed and validated workshop based process skill tests in mechanical engineering craft for assessing students in technical colleges in Nassarawa State and found out 40 tasks and 305 skill items valid by using table of specification. Okeme (2011) who developed and validated psycho-productive skills multiple choice items for students in agricultural science in secondary schools, achieved content validity by carrying out task analysis related to the area of study and getting experts in agricultural education to comment on how relevant the items were for use in the developed instrument. Garba (1993) added that job/task analysis helps in building validity in an instrument.

In addition to face and content validation of the basic electronics process skills assessment instrument, factorial validity test was conducted using factor analysis where 32 tasks and 239 skill items were found valid enough for inclusion in the basic electronics process skills assessment instrument. The findings agreed with the findings of Bakare (2014) who employed factor analysis in his study and found 140 out of 143 tasks valid for the development of cell phone maintenance training modules for national diploma students.The finding of the study was supported by the conclusions of Balogun and Mustapha (2014) and Ugbalu(2012). In their various studies, the authors concluded that test items that have high factor loading and satisfy other psychometric properties are important for selection.

Reliability of the basic electronics practical process skill instrument

It was found out that 32 tasks and 242 corresponding practical process skill items had their internal consistency ranged from 0.64 to 0.88 while the entire item had reliability coefficient value of 0.77. This means that all the tasks and their process skill items are reliable enough to be included in the basic electronics process skills assessment instrument. These findings are in agreement with the findings of Ombugus (2013) in a study on development and validation of workshop-based process skilltest in mechanical engineering craft practice for assessing students in technical Colleges where it was ascertained that the reliability of the WBPST is 0.76. The inter-rater reliability coefficient of the WBPST was 0.57. Also these findings agreed the findings of Bukar (2006) who conducted a study on development and validation of laboratory based tests for assessing practical skills of higher national diploma students in electronic maintenance and repairs where it was found out the reliability coefficient values of the tests on measuring instrument and testing, fault finding and repairs and alignment are 0.71, 0.55 and 0.47 respectively.

Hypotheses Tested

It was found out that there were no significant differences in the mean scores of students offering basic electronics in senior secondary III on measuring and testing, construction of electrical circuit and fault tracing and repair operations based on their ability levels when using process skill assessment instrument. Hence the null hypotheses of no significant difference were accepted. The implication of the result is that the basic electronics process skills assessment instrument in measuring and testing, construction of electrical circuit and fault tracing operations did not discriminate between high, average and low ability groups in their performance on the test which is a measure of the validity of the test. The findings of the study agreed with the findings of Okeme (2011) in a study on development and validation of psycho-productive skill multiple choice test items for students in Agricultural science in secondary school, where it was found out that there were significant differences in the mean scores of the high and low abilities but no significant differences in the mean scores of the high and average abilities. The findings of the study were also in contrary against the findings of Ombugus (2013) who developed and validated workshop based process skill tests in mechanical engineering craft for assessing students in technical colleges in Nassarawa State and found out that there were significant differences in the mean performance of the three groups of students on the workshop based process skill test in grinding, drilling and fitting operation

CHAPTER FIVE

SUMMARY, CONCLUSION, RECOMMENDATION AND SUGGESTIONS FOR FURTHER RESEARCH

This chapter presents restatement of the problem, purpose of the study, a summary of procedures used in the study, the major findings of the study, the implications of the findings, and conclusion. Other sub topics include: recommendations and suggestions for further research.

Restatement of the Problem

The current assessment practices with regard to basic electronics in senior secondary schools in Lagos state leave much to be desired. The curriculum of basic electronics for senior secondary schools does not provide any standardized assessment tools for use. There is a dearth of valid and reliable instruments for assessing the skills acquired by senior secondary studentsô during practical work in basic electronics. Assessment of practical work can be vulnerable to subjectivity if not carefully carried out using valid and reliable instruments. Lack of valid and reliable instrument is one of the major problems facing assessment in basic electronics.

Secondly, many technical and vocational teachers do not possess the knowledge and skills needed for developing good assessment instruments. Many simply adopt the product assessment technique used by the examination bodies in the assessment of practical work in electronics ï a technique that is not suitable for teaching and learning.

For instance, the senior school certificate examination in basic electronics consists of three test papers ï a multi-choice objective test, a short answer (essay) test and a practical test. The multi-choice and short answer tests are based almost exclusively on the cognitive domain to the exclusion of the psychomotor domain. The practical paper also has a several short comings. Firstly, the paper features only two questions that do not cover comprehensively, the tasks and competencies in the curriculum (see appendix A). Secondly, what is usually assessed is the end product itself to the exclusion of the process. The students are not observed and rated while carrying out the practical tasks. Rather, they are assessed on the accuracy of the value obtained in the measurement of circuit parameters, on graphs plotted using these values, and on interpretation of the graphs including the calculation of slopes. Obviously, a student can estimate values for current and voltage use the estimated values to plot a graph, and calculate the gradient without necessarily being able to connect the circuit components in the proper way. No wonder then that, many secondary school graduates who offered electronics in the senior secondary certificate examination and passed at credit level could not demonstrate the manipulative skills they are expected to possess (Effiong, 2006).

No serious effort is made to assess the quality or character of individual practical work by developing a definite procedure of assessment. Basic electronics teachers who have adopted the pattern of assessment used by the external examination bodies teach the students through this pattern to enable them do well in the terminal examination.

These assessment approaches used for basic electronics in schools in Lagos state do not serve the best interest of teaching and learning for several reasons. First, the students are not led to acquire the necessary skills. Consequently, the main objective of practical work could not be achieved. Secondly, where the teachers have no definite procedure of assessment and assess projects by taking a cursory look at them, the students become dissatisfied with marks awarded to them and often complain because the assigned grades may not reflect the quality of workmanship of their projects. Thirdly, the inability to acquire adequate practical skills makes the students tend to lose interest in the field of study ï neither going for further studies in the same field of study nor putting their practical skills into use on the job.

Because of the absence of valid and reliable assessment instruments, and the inability of many basic electronics teachers to develop appropriate assessment instruments, there is a clear and compelling need for an instrument to be developed and validated for use in assessing process skills in basic electronics as embedded in the senior secondary school curriculum.

Purpose of the Study

The major purpose of this study was to develop and validate a process skills assessment instrument in basic electronics for assessing practical skills of basic electronics students in senior secondary schools.

Specifically, the study determined:

1. the practical tasks suitable for inclusion in the Basic Electronics Process Skills Assessment Instrument;
2. the process skill items suitable for inclusion in the basic electronics practical process skills assessment instrument;
3. the validity of the basic electronic process skill assessment instrument for senior secondary 3 students;

4. establish the reliability of the basic electronics process skills assessment instrument for senior secondary 3 students;
5. the ability groups of the senior secondary 3 students of basic electronics.

Summary of the Procedures Used

The study adopted instrumentation design and was carried out in Lagos State of Nigeria. The population for the study was 281 subjects, made up of 30 teachers and 251 SS 3 students offering basic electronics in the 25 secondary schools offering basic electronics up to SS 3 class in Lagos State. Purposive sampling technique was used to select Federal Science and Technical College, Yaba with 25 students and five teachers as raters or assessors. The instrument containing 245 process skill items was developed and used to collect data for the study. A 5-point scale with rating values of 5, 4, 3, 2 and 1 was included in the assessment instrument. Review of related literature and the relevant empirical studies on the development and validation of assessment instruments provided the necessary guide and information for the development and validation of the basic electronics practical process skills scale for senior secondary schools. The curriculum for basic electronics was reviewed and a table of specifications task was designed from it. The instrument was validated by six experts, and the reliability coefficient of the instrument was determined by using Cronbach alpha reliability method. Five teachers of basic electronics who served as research assistants administered the instrument on the students in order to collect data. Mean, standard deviation and factor analysis were employed to answer research questions while ANOVA was used to test the null hypotheses at 0.05level of significance.

Major Findings of the Study

1. Thirty two identified basic electronics practical tasks were found suitable for inclusion in the basic electronics practical process skills scale.
2. Two hundred and thirty-nine basic electronics practical process skill items out of 245 were found suitable for inclusion in the practical process skill instrument for assessing senior secondary III students with factor loading above 0.05 in result of factor analysis.
3. Six process skill items were discarded from the instrument because of low factor loading
4. Face and content validation carried out by six experts revealed that the 32 tasks and the 239 practical process skill items were adequate for assessing senior secondary school students in basic electronics
5. Thirty two tasks and 239 practical process skill items were found reliable for inclusion in the practical process skills instrument for SS 3 students
6. The inter rater reliability coefficient of the basic electronics practical process skill instrument was 0.762
7. There was a significant relationship between the five research assistants who rated the performance of the students using the basic electronics process skills assessment instrument.
8. There were no significant differences in the mean scores of the ability groups in measuring and testing, constructing electric circuits, and fault tracing and repair operations.

Implications of the Findings of the Study

The findings of the study have implications for curriculum planners, examination bodies, teachers, students of basic electronics and book writers. For effective use of the process skill assessment instrument, the teachers must be knowledgeable and ready to work hard. This has implications for motivation as poorly motivated teachers would not show the level of commitment needed to carry through the new assessment techniques. Students equally have to be ready to work hard to carry out practical activities more often than when practical work did not matter. There is the need for a change of attitude on the part of other stakeholders including government agencies operating the school system in the various states. The electronic workshops in the schools have to be adequately equipped for practical work to be carried out. Use of process assessment techniques will require additional funding to ensure that training materials are available as and when needed and that provision is made for alternative sources of power in case of power failure from the public electricity supply.

Conclusion

The study set out to develop and validate a basic electronics process skills assessment instrument for use in assessing the practical skills of senior secondary students of basic electronics. The study was guided by Six research questions and three null hypotheses were tested at 0.05 level of significance six process skill items were discarded from the instrument because of low factor loading. Face and content validations also carried out by five experts revealed that the six process skill items were adequate for assessing the practical skills of senior secondary III students of basic electronics. The same 32 tasks and 239 process skill items were found reliable enough for inclusion in the instrument. There was a significant relationship between the five research assistants who rated the performance of the students using the basic electronics process skills assessment instrument. There was no significant differences in the mean scores of the ability groups in measuring and testing, constructing electric circuit, and fault tracing and repair operations. All the necessary procedures needed for the development and validation of the assessment instrument were followed to ensure that the gap that was created by the lack of process assessment instrument is properly filled.

Recommendations

The study recommended the following:

1. The external examination bodies (WAEC and NECO) should include process skills assessment in their examination scheme for certification of the students in basic electronics.
2. Government should organize seminars and workshops for teachers of basic electronics on how to make use of the developed basic electronics practical process skills instrument
3. Teachers of basic electronic should be encouraged to make use of the developed basic electronic practical process skills instrument for assessing students in basic electronics
4. Functional materials and facilities that will make the use of basic electronics practical process skills instrument possible in secondary schools should be provided by government and parentsô teachersô associations

Suggestions for further Research

The following suggestions are made for further research:

1. Development and validation of practical process skills instrument in other technical/vocational subjects at the senior secondary school level.
2. Development and validation of instruments that combine process and product assessment techniques in the assessment of students practical work in technical/vocational subjects.

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APPENDICES

Appendix A

BASIC ELECTRONICS
FOR
SENIOR SECONDARY SCHOOLS CURRICULUM

Published By:

NIGERIAN EDUCATIONAL RESEARCH AND DEVELOPMENT COUNCIL (NERDC) Sheda, Abuja.

ISBN 978-054-540-9

INTRODUCTION

The present drivers of world economy, social political practices which are globalization, information and communication technology are hinged to electronics, as such,, it is an important subject in todayôs world, secondary school students should be well exposed to basic electronics, this will enable the students face the challenges of 21st century which no doubt needs problem, solving skills, critical and analytical thinking skills and creativity. These among others form the focus of the present curriculum.

Specifically, the goals of the curriculum are to:

- Provide understanding of the fundamental electronic components and circuits
- Lay good foundation for communication system and control system
- Provide foundation for creativity and technological development in electronics
- Stimulate, develop and enhance entrepreneurial skills in electronics

The curriculum was developed around twelve (12) themes:

1. Electrical quantities
2. Electronic components and circuits
3. Basic electrical theory
4. Thermionic devices
5. Semi conductor devices
6. Power supply
7. Communication system
8. Measuring instruments and tools
9. Transducers and sensors
10. Digital basics
11. Control systems
12. Entrepreneurship in electronics

The content of the curriculum is structured using spiral and thematic approach, the content of the curriculum will be better implemented if the following teaching methods and strategies are employed: Demonstration, Scaffolding, Mastery learning and Field trip. Competency-based evaluation is highly recommended, Evaluations should be through project activities, practical activities (where necessary), observations, essay and objective questions. Through these the studentȏs psychomotor, cognitive and effective skills will be evaluated. Eighty minutes (1 hr 20 min) per week is recommended as minimum instruction time.

To implement this curriculum successfully, the following are pre-requisites:

- Well trained and motivated teachers
- Text books written to the level of the students
- Adequate hand tools and measuring instruments

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THEME 4: THERMIONIC DEVICES

THEME 5: SEMI CONDUCTOR DEVICES

SSII

THEME 1: ELECTRONICS COMPONENTS AND CIRCUITS

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2. Power in AC circuit

THEME2: SEMICONDUCTOR DEVICES

1. Transistors

2. Integrated Circuits (IC|) and Microprocessors.

THEME 3: POWER SUPPLY

Power Supply Unit

THEME 4: INTRODUCTION TO COMMUNICATION SYSTEM

1. Radio Transmission and Reception

2. Television Receiver

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THEME 1: DIGITAL BASICS

1. Number System
2. Logic Gates

THEME 2: ELECTRONIC COMPONENTS AND CIRCUITS

1. Satellite
2. Information and Communication Technology (ICT)

THEME 3: COMMUNICATION SYSTEM

1. Amplifier
2. Feedback Circuits

THEME 4: CONTROL SYSTEM

1. Control Circuits
2. Servo ï Mechanism,

THEME 5: ENTREPRENEURSHIP IN ELECTRONICS

1. Entrepreneurship in Electronics

SS I

THEME: ELECTRICAL QUANTITIES

TOPIC	PERFORMANCE OBJECTIVE	CONTENT	ACTIVITIES		TEACHING AND LEARNING MATERIALS	EVALUATION GUIDE
			TEACHER	STUDENTS		
1. Electric Current	Students should be able to: 1. Explain the structure of Atom. 2. Define conductors and insulators. 3. State uses of conductors and insulators. 4. Distinguish between direct and alternating current 5. Explain the sources of direct and alternating current.	1. Structure of Atom 2. Conductors and insulators 3. Direct and Alternating Current. 4. Sources of Direct and Alternating Current	1. Explain the structure of atom 2. Defines and explains conductors and insulators. 3. Leads discussion on the use of conductors and insulators 4. Guides students to distinguish between direct and alternating current. 5. Explains sources of direct and alternating current	1. Draw the structure of atom (conductors and insulators). 2. Participate in class discussion 3. Ask and answer questions 4. Copy notes	Charts showing structure of an atom Copper wire Pieces of wood or rubber Dry cell Sources of an alternating current.	Students to: 1. Explain the structure of atom 2. Distinguish between conductors and insulators 3. State the uses of conductors and insulators 4. State the difference between direct and alternating current. 5. Mention two sources of alternating current.

SS I

THEME: ELECTRICAL QUANTITIES

TOPIC	PERFORMANCE OBJECTIVES	CONTENT	ACTIVITIES		TEACHING AND LEARNING MATERIALS	EVALUATION GUIDE
			TEACHER	STUDENTS		
2. Relationship between Voltage, Current and Resistance	Students should be able to: 1. Explain the following quantities: voltage, current and resistance. 2. State the units, symbols and instruments for measuring the quantities mentioned in (1) above. 3. State Ohmôs Law. 4. Perform a simple experiment to determine Ohmôs Law. 5. Calculate current, voltage and resistance in a given circuit.	1. Current, Voltage and Resistance 2. Ohmôs Law 3. Simple calculation of current, voltage and resistance.	1. Explains Current, voltage and Resistance 2. States and explains Ohmôs Law. 3. Perform an experiment to demonstrate Ohmôs Law. 4. Calculates Current, voltage and resistance in a given circuit.	1. State Ohmôs Law 2. Observe and perform the experiment to demonstrate ohmôs law 3. Calculate current, voltage and resistance in a given circuit.	Calculators Charts on Ohmôs Law Circuit boards for demonstration of ohmôs Law. Ammeter Ohmmeter Voltmeter.	Students to: 1. Define current, voltage and resistance. 2. State ohmôs Law. 3. Calculate voltage in a circuit where current of 5A flows and the circuit resistance is 10ohmôs.

SS I

THEME: ELECTRICAL QUANTITIES

TOPIC	PERFORMANCE OBJECTIVES	CONTENT	ACTIVITIES		TEACHING AND LEARNING MATERIALS	EVALUATION GUIDE
			TEACHER	STUDENTS		
Electrical power	Students should be able to: 1. Define electrical power. 2. State the unit and instrument for measuring electrical power 3. Explain the relationship between power, current and voltage. 4. Derive other formulae for power in a given circuit. 5. Calculate power in a given circuit	1. Concept of electric power. 2. Relationship between power, current and voltage 3. Other formulae for finding electrical power. 4. Calculation of electric power in given circuits.	1. Explains electrical power. 2. States the relationship between power, current and voltage ($P = IV$) 3. Derives other formulae for finding power, e.g. $P = I^2R$, etc. 4. Calculates power in given circuits	1. State the formulae for finding power. 2. Calculate power in given circuits	Calculator Charts containing power formulas	Students to: 1. Define electrical power 2. State the relationship between power, current and voltage. 3. State the units and instrument for measuring electric power 4. Calculate the power expended in a circuit of voltage 240 volts and current of 10 amps.

SSI

THEME: ELECTRONICS COMPONENTS AND CIRCUITS

TOPIC	PERFORMANCE OBJECTIVES	CONTENT	ACTIVITIES		TEACHING AND LEARNING MATERIALS	EVALUATION GUIDE
			TEACHER	STUDENTS		
1. Circuit Components	Students should be able to: 1. State the different types of resistors, capacitors. 2. State the symbols, signs and units of the components mentioned in (1) above. 3. Identify different colour coding and rating of resistors and capacitors.	1. Types of resistors, capacitors and inductors. 2. Symbols, signs and units 3. Color coding and rating of resistors and capacitors.	1. Explain types of resistors, capacitor and inductors. 2. Guides students to identify signs, symbols and units of the above components. 3. Explains color coding and rating of resistors and capacitors.	1. Listen attentively. 2. Participate in class discussion	Assorted resistors, Capacitors and inductors.	Students to: 1. State types of resistors, capacitors and inductors. 2. Draw the symbols and signs of the above components. 3. Find the values of different colour coded resistor and capacitors.

SS I

THEME: ELECTRONICS COMPONENTS AND CIRCUITS

TOPIC	PERFORMANCE OBJECTIVES	CONTENT	ACTIVITIES		TEACHING AND LEARNING MATERIALS	EVALUATION GUIDE
			TEACHER	STUDENTS		
2. Electric Circuit	Students should be able to: 1. Explain the meaning of electric circuit. 2. Identify types of circuit boards. 3. Explain different circuit arrangements 4. Calculate resistance in: i. Series ii. Parallel, and iii. Series-parallel.	1. Electric Circuit. 2. Circuit boards 3. Circuit arrangement: i. Series ii. Parallel iii. Series-parallel 4. Simple calculations on circuit arrangement	1. Explains electric circuit. 2. Explain different types of circuit boards 3. Perform simple calculations for different circuit arrangements.	1. Listen attentively. 2. Calculate resistance in: series, parallel and series-parallel arrangement. 3. Carry out wiring of different circuit arrangement	1. Different circuit boards e.g. Vero board, printed board, etcé 2. Charts showing different types of circuit arrangement.	Students to: 1. Define electric circuit 2. State types of circuit board. 3. Calculate resultant resistance in given circuits. 4. Carry out practical wiring of different circuit arrangement

SS I

THEME: BASIC EFLECTRICAL THEORY

TOPIC	PERFORMANCE OBJECTIVES	CONTENT	ACTIVITIES		TEACHING AND LEARNING MATERIALS	EVALUATION GUIDE
			TEACHER	STUDENTS		
1. Magnet and Magnetic field	Students should be able to: 1. Define the following terms: - magnetism - magnetic poles - magnetic field - magnetic materials 2. Differentiate between permanent and temporary magnets 3. Demonstrate the Law of attraction and repulsion of a magnet 4. State the applications of magnetism (e.g. Zip drive disk. Floppy disk, magnetic tape).	1. Definition of terms: *Magnetism *Magnetic poles *Magnetic field *Magnetic Materials 2. Permanent and Temporary magnets 3. Law of attraction and repulsion. 4. Applications of magnetism.	1. Explains the meaning of the following terms: *Magnetism *Magnetic poles *Magnetic field *Magnetic Materials 2. Leads discussion on the differences between permanent and temporary magnet. 3. Direct students to state the law of attraction and repulsion. 4. Guides students in the applications of magnetism (e.g. Zip drive disk, floppy disk, magnetic tape, etc).	1. Participate in class discussion 2. Demonstrate, using two bar magnets, the law of attraction and repulsion.	Bar magnets Iron filings Zip drive Magnetic tapes Floppy disk	Students to: 1. Define the terms: Magnetism Magnetic poles Magnetic field Magnetic materials 2. Mention the difference between permanent and temporary magnets. 3. Demonstrate the law of attraction and repulsion using two bar magnets. 4. List the applications of magnetism

SS I

THEME: BASIC ELECTRICAL THEORY

TOPIC	PERFORMANCE OBJECTIVES	CONTENT	ACTIVITIES		TEACHING AND LEARNING MATERIALS	EVALUATION GUIDE
			TEACHER	STUDENTS		
2. Electro-magnetism	Students should be able to: 1. Explain the terms: - electric field - electromagnetism - Inductance 2. State the applications of electromagnetism. (e.g. electric bell, relays, transformer, etc.) 3. Describe the principle of operation of a transformer	1. Explanation of terms: - electric field -electromagnet - electromagnetism - Inductance 2. Applications of electromagnetism (e.g. electric bell, relay, transformer, etc.). 3. Principles of operation of a transformer	1. Explains the terms: Electric field Electromagnetism Inductance 2. Shows the construction of electric bells, relays, transformer, etc. 3. Discusses the principles of operation of a transformer.	1. Construct an electromagnet. 2. Practice the construction of an electric bell, relay and transformer.	An electromagnet solenoid. Transformer. Electric bell, relay	Students to: 1. Define the terms - electric field - electromagnet -electromagnetism 2. Describe the construction of an electric bell, relay and transformer. 3. List the applications of electromagnetism. 4. State the principle of operation of a transformer

SS I

THEME: THERMIONIC DEVICES

TOPIC	PERFORMANCE OBJECTIVES	CONTENT	ACTIVITIES		TEACHING AND LEARNING MATERIALS	EVALUATION GUIDE
			TEACHER	STUDENTS		
1. Electron Emission	Students should be able to: 1. Distinguish among the four different types of electron emission. 2. State the application of the four types of electron emission	1. Thermionic emission 2. Photo emission 3. Secondary emission 4. Field emission 5. Applications: -thermionic valve - photo exposure Meters -photo sensors in Automatic door Openers and Particle counters -field emission Microscope	1. Explains different types of electron emission. 2. Discusses the applications of electron emission	1. Listen attentively 2. Participate in class discussion. 3. Copy notes	Different types of thermionic valves Charts Software	Students to: 1. Differentiate between the four types of electron emission 2. List three applications of electron emission.

SS I

THEME: SEMICONDUCTOR DEVICES

TOPIC	PERFORMANCE OBJECTIVES	CONTENT	ACTIVITIES		TEACHING AND LEARNING MATERIALS	EVALUATION GUIDE
			TEACHER	STUDENTS		
1. Semiconductor	Students should be able to: 1. Explain the concept of semiconductor 2. List different types of semiconductor materials. 3. Explain how doping of semiconductor is achieved. 4. Explain the process of formation of P ï type and n-type semiconductor. 5. Explain the forward and reverse biasing of semiconductors.	1. Concept of semiconductor. 2.Semiconductor materials ï (Silicon, germanium etc.). 3. Doping of semiconductors. 4. Formation of p ï type and n type semiconductors. 5. Forward and reverse Biasing of diodes.	1. Explain the concept of semiconductor 2. Guides students to identify semiconductor materials. 3. Explains how doping of semiconductor is achieved. 4. Discusses the process of formation of p ï type and n ï type semiconductor . 5. Explains the forward and reverse biasing of semiconductor	1. Participate in class discussion. 2. Ask and answer questions. 3. Copy notes	Pictures of semiconductor materials Software	Student to: 1. Explain the concept of semiconductor 2. List different types of semiconductor materials 3. Explain how doping of semiconductor is achieved. 4. Explain the process of formation of p ï type and n ï type semiconductor. 5. Explain the forward and reverse biasing of semiconductor

SS I

THEME: SEMICONDUCTOR DEVICES

TOPIC	PERFORMANCE OBJECTIVES	CONTENT	ACTIVITIES		TEACHING AND LEARNING MATERIALS	EVALUATION GUIDE
			TEACHER	STUDENTS		
2. Semi-conductor Diodes	Students should be able to: Explain the concept of diodes. 2. Differentiate between the types of diodes. 3. State the operational principles of semiconductor diodes 4. State the applications of the different types of diodes. 6. Construct simple circuits using semiconductor diodes.	1. Concept of diodes 2. Operational principles of Diodes 3. Types of diodes: i. p ï n junction diode ii. zener diode iii. tunnel diode iv. photo diode v. Light Emitted Diode (LED) 4. Diode rating ï voltage current and power 5. Application of Diodes i. Rectification ii. Detection iii. Instrument protection 6. Construction of simple circuits using semiconductor diodes.	1. Explain the concept of diodes 2. Guides students to differentiate between the types of diodes. 3. Directs discussion on the operational principles of semiconductor diodes 4. Explains the rating of diode 5. States the applications of the different types of diodes.	1. Listen to teacherôs explanations. 2. Participate in class discussion 3. Construct simple circuits using semiconductor diodes.	Assorted kind of semi-conductor diodes. Charts containing Pictures of different diodes. Software on semiconductor diodes.	Students to: 1. Explain the concept of diodes 2. Differentiate between the types of diodes 3. State the operational principles of semiconductor diodes. 4. State the rating of diodes 5. State the applications of the different types of diodes. 6. Construct simple circuits using semiconductor diodes.

SS II

THEME: ELECTRONICS COMPONENTS AND CIRCUITS

TOPIC	**PERFORMANCE OBJECTIVES**	**CONTENT**	ACTIVITIES		**TEACHING AND LEARNING MATERIALS**	EVALUATION GUIDE
			TEACHER	**STUDENTS**		
1. Alternating current circuit	Students should be able to: 1. Define the terms: - capacitive reactance - inductive reactance - Impedance 2. Explain RL and RC 3. Explain RLC circuit 4. Calculate inductive and capacitive reactance (XL and Xc). 5. Explain series and parallel resonance 6. Calculate series and parallel resonance.	1. Concept of capacitive reactance, inductive reactance and impedance. 2. RL and RC circuits. 3. Calculation of capacitive reactance (Xc) and inductive reactance XL. 4. Resonance Frequency.	1. Explains the concept of capacitive reactance. Inductive reactance and impedance. 2. Explains RL and RC circuits. 3. Demonstrate the operation of RL and RC circuits. 4. Calculates capacitive reactance and inductive reactance. 5. Explains resonance frequency. 6. Calculate series and parallel resonance.	1. Participate in class discussion. 2. Calculate capacitive and inductive reactance (Xc) and (XL) as directed by the teacher. 3. Calculates series and parallel resonance.	Calculator Resistors Inductors Capacitors AC source	Students to: 1. Define the following terms: - capacitive reactance, - inductive reactance and Impedance. 2. Explains RL and RC circuits. 3. Calculate XL in a circuit of frequency of 50 Hz and inductance of 20H. 4. Calculate Xc in a circuit of frequency 10Hz and capacitance of 100uf.

SS II

THEME: ELECTRONICS COMPONENTS AND CIRCUITS

TOPIC	PERFORMANCE OBJECTIVES	CONTENT	ACTIVITIES		TEACHING AND LEARNING MATERIALS	EVALUATION GUIDE
			TEACHER	STUDENTS		
2. Power in AC circuits	Students should be able to: 1. Explain power and power triangle. 2. Explain power factor and power factor correction. 3. State advantages and disadvantages of power factor correction. 4. Calculate power factor in a given AC circuit. 5. Explain Q-factor and band width.	1. Power and power triangle. 2. Power factor and its correction. 3. Advantages and disadvantages of power factor correction. 4. Calculation of power factor. 5. Q-factor and band width	1. Explains power and power triangle. 2. Explains power factor and power factor correction. 3. Calculates power factor. 4. Explains Q-factor and band width (fH and FL).	1. Participate in class discussion 2. Calculate power factor in a given AC circuit.	Calculator Chart on power triangle	Students to: 1. Explain power in AC circuits 2. Explain power factor in AC circuits. 3. Calculate power factor in a given AC circuit. 4. Explain Q-factor and bandwidth.

SS II

THEME: SEMICONDUCTOR DEVICES

TOPIC	**PERFORMANCE OBJECTIVES**	**CONTENT**	**ACTIVITIES**		**TEACHING AND LEARNING MATERIALS**	**EVALUATION GUIDE**
			TEACHER	**STUDENTS**		
1. Transistors	Students should be able to: 1. Explain the concept of a transistor 2. Explain biasing of a transistor 3. Explain bipolar transistor circuits 4. Explain types of transistors and symbols. 5. Explain applications of transistors	1. Concept of transistors 2. Biasing of transistors 3. Bipolar transistor circuit. 4. Types of transistors (e.g. bipolar, FET, JFET, MOSFET, etc) and symbols. 5. Applications of transistors.	1. Explains the concept of transistors 2. Leads discussion on biasing of a transistor. 3. Discusses basic bipolar transistor circuits 4. Explains types of transistors and symbols 5. State applications of transistors.	1. Draw transistor symbols 2. Draw transistor biasing arrangements. 3. Draw common emitter, collector and base circuits.	Transistors, e.g. bipolar, FET, JFET, MOSFET, etc. Charts on types of transistors, biasing arrangements and bipolar transistor circuits.	Students to: 1. Explain the concept of transistors. 2. Explain biasing arrangements 3. Draw and explain Common emitter, collector and base circuits. 4. State types of transistors and symbols. 5. State three applications of transistors.

SS II

THEME: SEMICONDUCTOR DEVICES

TOPIC	PERFORMANCE OBJECTIVES	CONTENT	ACTIVITIES		TEACHING AND LEARNING MATERIALS	EVALUATION GUIDE
			TEACHER	STUDENTS		
2. Integrated Circuits (IC) and Micro-processors.	Students should be able to: 1. Explain the concept of integrated circuit (IC). 2. State the advantages and disadvantages of IC. 3. State the applications of IC. 4. Explain the concept of microprocessor 5. Explain the following terms as related to microprocessor: RAM, ROM and EPROM. 6. Mention applications of microprocessor.	1. Concept of Integrated circuit (IC). 2. Advantages and dis-advantages of IC. 3. Applications of IC. 4. Concept of microprocessor. 5. Explanation of the following terms in microprocessor: RAM, ROM, EPROM. 6. Applications of microprocessor.	1. Explains the concept of integrated circuit (IC). 2. Discusses the advantages and dis-advantages of IC. 3. Leads discussion on the applications of IC. 4. Explains the concept of microprocessor. 5. Explains the following terms as related to microprocessor: RAM, ROM, EPROM 6. States applications of microprocessor.	1. Participate in class discussion. 2. Ask and answer questions 3. Copy notes.	ICs Microprocessors Software on ICs and Microprocessors. Charts on ICs and Microprocessors	Students to: 1. Define IC 2. State the active and passive components of IC 3. Mention three applications of IC. 4. Explain the concept of microprocessor. 5. Define: RAM, ROM and EPROM as they relate to microprocessor. 6. State three applications of microprocessor.

SS II

THEME: POWER SUPPLY

TOPIC	PERFORMANCE OBJECTIVES	CONTENT	ACTIVITIES		TEACHING AND LEARNING MATERIALS	EVALUATION GUIDE
			TEACHER	STUDENTS		
1. Power Supply Unit	Students should be able to: 1. Explain Rectification 2. Explain the differences between half wave and full wave rectification. 3. Explain how a.c. is converted to d.c. by the use of rectifiers. 4. State the meaning of voltage regulation. 5. Explain the operation of voltage regulators	1. Rectification 2. Regulation 3. Types of voltage regulators: - series voltage regulator - Transistorized electronics voltage regulator.	1. Explains rectification. 2. Guides discussion on the principles of operation of rectifier. 3. Guides students to state the differences between half wave and full wave rectification 4. Explains the principles of operation of voltage regulator 5. Lists and differentiates types of voltage regulator.	1. Listen attentively 2. Draw the circuit diagrams of half wave and full wave rectifiers.	Diodes Resistors Transistors Pictures of rectifiers and voltage regulators.	Students to: 1. Define rectification 2. Explain the use of rectifier in power supply unit. 3. State the differences between half wave and full wave rectifiers. 4. State the functions of voltage regulator in a power supply unit.

SS II

THEME: INTRODUCTION TO COMMUNICATION SYSTEM

TOPIC	PERFORMANCE OBJECTIVES	CONTENT	ACTIVITIES		TEACHING AND LEARNING MATERIALS	EVALUATION GUIDE
			TEACHER	STUDENTS		
1. Radio Transmission and Reception	The students should be able to: 1. Describe the principle of radio transmission and reception (AM and FM). 2. Explain each stage of a radio receiver (AM and FM). 3. State the relative advantage of FM over AM. 4. Demonstrate how to detect faults in a radio receiver.	1. Principles of radio transmission and reception. 2. Stages of a radio receiver (AM and FM). e.g. * Tuner * AF amplifier * Detector * Power supply 3. Comparison of AM and FM receivers. 4. Fault detection in radio receiver	1. Explains the concept of radio transmission and reception. 2. Describes the functions of each stage of AM and FM radio receivers. 3. Demonstrate how to detect faults in a radio receiver. 4. Take students on a field trip	1. Listen and participate in class discussion. 2. Carry out systematic fault detection in a typical radio receiver. 3. Go on field trip	Charts showing block diagram of radio transmission system Charts showing stages of a typical radio receiver. MultiMaters Oscilloscope	Students: 1. Describe the concepts of radio transmission and reception system 2. State the functions of each stage of AM and FM radio receivers. 3. State the advantages of FM receiver over AM. 4. Use a faulty radio and detect the fault.
2. Television receiver	Students should be able to: 1. Explain stages of a Television receiver using block diagram.	Block diagram of stages of a TV receiver.	Explains the stages of a TV receiver using a block diagram.	1. Listen and participate in the lesson.	Charts showing stages of a typical TV receiver	Students to: 1. Describe each stage of a TV receiver using block diagram.

SS II

THEME: MEASURING INSTRUMENTS AND TOOLS

TOPIC	PERFORMANCE OBJECTIVES	CONTENT	ACTIVITIES		TEACHING AND LEARNING MATERIALS	EVALUATION GUIDE
			TEACHER	STUDENTS		
1. Hand tools	Students should be able to: 1. Explain the meaning of hand tools 2. State types and uses of hand tools.	1. Meaning of hand tools. 2. Types and uses of hand tools e.g. soldering iron, combination pliers, long nose pliers, side cutter, electrician knife, brushes, screw drivers, etc.	1. Define hand tools. 2. Explains different hand tools and their uses.	1. Participate in class discussion. 2. Ask and answer questions. 3. Copy notes	Various hand tools Charts showing hand tools.	Student to: 1. Define hand tools. 2. List and state the uses of any ten hand tools.

SS II

THEME: MEASURING INSTRUMENTS AND TOOLS

TOPIC	PERFORMANCE OBJECTIVES	CONTENT	ACTIVITIES		TEACHING AND LEARNING MATERIALS	EVALUATION GUIDE
			TEACHER	STUDENTS		
2. Measuring Instruments	Students should be able to: 1. Explain the meaning of measuring instrument. 2. Differentiate between analogue and digital measuring instruments. 3. State different types of measuring instrument and their respective uses.	1. Concept of measuring instrument 2.Classification of measuring instrument ï analogue and digital. 3. Types and uses of measuring instrument, e.g. multimeter, voltmeter, ammeter, ohmmeter, wattmeter, Oscilloscope, etc.	1. Explain the concept of measuring instrument. 2. Explains the terms: analogue and digital measuring instrument. 3. Lists and explains the uses of measuring instruments. 4. Demonstrate the use of each of the instrument in measuring electronics quantities.	1. Listen to teacherôs explanations. 2. Participate in discussion. 3. Use measuring instruments to measure electrical quantities: Multimeter, ammeter, ohmmeter, wattmeter, oscilloscope, etc.	Various measuring instruments both analogue and digital. Charts showing measuring instruments. Circuit boards	Students to: 1. Define measuring instruments. 2. Differentiate between analogue and digital measuring instruments. 3. State any five measuring instruments and their uses.

SS II

THEME: TRANSDUCERS AND SENSORS

TOPIC	PERFORMANCE OBJECTIVES	CONTENT	ACTIVITIES		TEACHING AND LEARNING MATERIALS	EVALUATION GUIDE
			TEACHER	STUDENTS		
1. Transducers and sensors.	Students should be able to: 1. Explain the meaning of the following: i. transducer ii sensor 2. Discuss the principles of operation of a transducer. 3. Explain the principles of operation of a sensor. 4. State types of transducers and sensors. 5. Explain the uses of transducers and sensors	1. Explanation of terms: - Transducer - Sensor 2. Principles of operation of transducer 3. Principles of operation of a sensor. 4. Types and uses of transducers (e.g. acoustic, dynamic, electrostatic, electromagnetic, etc.). 5. Types and uses of sensors n(e.g. capacitive pressure sensor, photoelectric proximity sensor, etc.).	Explains the meaning of: - Transducer - Sensor 2. Describes the operation of a transducer. 3. Describes the operation of a sensor. 4. Explains types and uses of transducers. 5. Explain types and uses of sensors. 6. Demonstrate the use of sensors	1. Participate in class discussion. 2. Observe teacherôs demonstration. 3. Practice the use of sensor as demonstrated by the teacher.	Charts showing different types of transducers and sensors.	Students to: 1. Define transducers and sensors 2. Mention, accurately, the operation of transducers and sensors. 3. Mention types of transducers. 4. Mention types of sensors 5. Explain the uses of transducers. 6. Explain the uses of sensors.

SS II

THEME: TRANSDUCERS AND SENSORS

TOPIC	PERFORMANCE OBJECTIVES	CONTENT	ACTIVITIES		TEACHING AND LEARNING MATERIALS	EVALUATION GUIDE
			TEACHER	STUDENTS		
2. Acoustic transducers	Students should be able to: 1. Explai9n types of acoustic transducers. 2. State the applications of acoustic transducers.	1. Types of acoustic transducers e.g. Loudspeakers Microphone Earphone etc. 2. Application of acoustic transducers.	1. Explain the different types of acoustic transducers. 2. Explains the applications of acoustic transducers, e.g. tweeter, microphone, underwater speaker, etc.	1. Participate in class discussion. 2. Ask questions. 3. Copy notes	Loudspeakers Microphones Earphones Charts showing acoustic transducers.	Students to: 1. List different types of acoustic transducers. 2. Mention typical applications of acoustic transducers.

SS III

THEME: DIGITAL BASICS

TOPIC	PERFORMANCE OBJECTIVES	CONTENT	ACTIVITIES		TEACHING AND LEARNING MATERIALS	EVALUATION GUIDE
			TEACHER	STUDENTS		
1. Number system	Students should be able to: 1. Identify different number systems 2. Explain the basis of formation of different number systems. 3. Perform some additions and subtractions in binary numbers. 4. Convert from one base number to another	1. Different number system, e.g. binary, octal and hexadecimal. 2. Formation of different number system, e.g. binary octal, hexadecimal. 3. Simple calculation in binary number 4. Conversion of number system.	1. Explains different number system. 2. Explains formation of different number system. 3. Demonstrates addition and subtraction in binary numbers. 4. Converts from one base number to another.	1. Participate in the lesson. 2. Write sequentially in figure, different number system. 3. Perform simple calculation in binary number. 4. Convert from one number base to another.	Charts showing different number system. Logic modules.	Students to: 1. Mention different number system. 2. Write 10 given range of numbers sequentially in different number system. 3. Add 11102 and 10012 4. Subtract 11112 from 111112. 5. Convert octal to binary and vice-visa.

SS III

THEME: DIGITAL BASICS

TOPIC	PERFORMANCE OBJECTIVES	CONTENT	ACTIVITIES		TEACHING AND LEARNING MATERIALS	EVALUATION GUIDE
			TEACHER	STUDENTS		
2. Logic Gates	Students should be able to: 1. Explain logic gates 2. State different logic gates, OR, NOR, AND, and NAND. 3. Construct the TRUTH table for each of the above mentioned gates.	1. Concept of Logic Gates. 2. Types of Logic Gates, OR, NOR, AND and NAND. 3. Construction of TRUTH table.	1. Explains logic gates 2. Leads students to identify different types of logic gates. 3. Demonstrates the TRUTH table of the above logic gates.	1. Listen attentively. 2. Participate nin class discussion. 3. Construct the TRUTH tables of OR, NOR, AND sand NAND.	Charts showing different TRUTH tables Logic modules.	Students to: 1. Define logic gates. 2. State different types of logic gates. 3. Construct the TRUTH tables of OR, NOR AND and NAND

SS III

THEME: ELECTRONIC COMPONENTS AND CIRCUITS

TOPIC	PERFORMANCE OBJECTIVES	CONTENT	ACTIVITIES		TEACHING AND LEARNING MATERIALS	EVALUATION GUIDE
			TEACHER	STUDENTS		
1. Amplifier	Students should be able to: 1. Define amplifier 2. List the classes of amplifier 3. State the applications of amplifier.	1. Concept and principles of amplifier 2. Classes of amplifier. 3. Applications of amplifier: - Radio frequency - Audio frequency - Intermediate frequency	1. Defines and explains the principles of amplifier. 2. Discusses the classes of amplifier based on the operating characteristics: -(Class A, B, AB and C amplifiers) 3. Explains the types of amplifier: - direct current amp. - audio frequency amp. - Intermediate frequency amp. Etc. 4. States the applications of amplifier	1. Participate in discussion. 2. Ask and answer questions. 3. Copy notes	Pictures of amplifier circuits.	Students to: 1. Explain the basic principles of amplifier. 2. List the classes of amplifier 3. List the types of amplifier

SS III

THEME: ELECTRONIC COMPONENTS AND CIRCUITS

TOPIC	PERFORMANCE OBJECTIVES	CONTENT	ACTIVITIES		TEACHING AND LEARNING MATERIALS	EVALUATION GUIDE
			TEACHER	STUDENTS		
2. Feedback circuits	Students should be able to: 1. Explain the principles of feedback circuits. 2. List the types of feedback amplifier. 3. Explain the principles of oscillator. 4. List types of oscillator. 5. State the application of oscillator	1. Principles of feedback. 2. Types of feedback amplifier: - positive feedback - negative feedback 3. Concept of oscillator and feedback. 4. Types of oscillator: a. Tuned collector oscillator b. Hartley oscillator c. Colpitôs oscillator, etc. 5. Applications of oscillators: - telecom - alarm clock - Computer, etc.	1. Explains the principles of amplifier feedback. 2. Discusses types of feedback amplifier 3. Explains the principle of oscillator. 4. Explains the function of positive feedback in oscillator. 5. Lists and explains types of oscillator 6. Guide students to state the applications of oscillator.	1. Participate in class discussion. 2. Ask questions 3. Copy notes	Pictures or charts of diagrams of feedback circuits.	Students to: 1. State the principles of feedback circuits. 2. Explain the principles of oscillator. List types of oscillator

SS III

THEME: COMMUNICATION SYSTEM

TOPIC	PERFORMANCE OBJECTIVES	CONTENT	ACTIVITIES		TEACHING AND LEARNING MATERIALS	EVALUATION GUIDE
			TEACHER	STUDENTS		
1. Satellite	Students should be able to: 1. Explain concept of satellite communication 2. Explain principles of transmission and reception system. 3. Explain the principles of operation of: - Dish/LNB - Frequency changer - Video crystal decoder - MPU - Audio section 4. Explain types of satellite dish and LNB.	1. Concept or satellite communication. 2. Principles of transmission and reception system. 3. Principles of operation of satellite receiver sections: - Dish/LNB - Frequency change - Video crystal decoder - MPU - Audio section 4. Types of satellite dish and LBN	1. Explains concept of satellite communication. 2. Explains principles of transmission and reception system. 3. Explains the principles of operation of: - Dish/LNB - Frequency change - Video crystal decoder - MPU - Audio section 4. Leads discussion on types of satellite dish and LBN.	1. Listen attentively 2. Participate in discussion. Copy notes.	Charts showing satellite communication system. Satellite dish Decoder	Students to: 1. Explain concept of satellite communication 2. Explain principles of reception system. 3. Explain the principles of the following receiver section: - dish and LBN - MPU - Frequency changer, 4. State types of satellite dish and LBN

SS III

THEME: COMMUNICATION SYSTEM

TOPIC	PERFORMANCE OBJECTIVES	CONTENT	ACTIVITIES		TEACHING AND LEARNING MATERIALS	EVALUATION GUIDE
			TEACHER	STUDENTS		
2. Information and Communication Technology (ICT)	Students should be able to: 1. Explain the operations of telephone. 2. Explain the operations of internet system. 3. Explain the operations of Global System Mobile (GSM) phones.	1. Operation of telephone 2. Operation of internet system. 3. Operation of Global System Mobile (GSM) phones.	1. Explains the operations of telephone. 2. Explains the operations of internet system. 3. Explains the operations of Global System Mobile (GSM) phones.	1. Identify different sections of a telephone. 2. Draw the block diagram of GSM phone.	GSM phones Pictures of different GSM phones Pictures of web connection.	Students to: 1. Explain with appropriate illustrations the operation of telephone. 2. Explain the operation of internet system. 3. Use block diagram of GSM phone to explain its operation.

SS III

THEME: CONTROL SYSTEM

TOPIC	PERFORMANCE OBJECTIVES	CONTENT	ACTIVITIES		TEACHING AND LEARNING MATERIALS	EVALUATION GUIDE
			TEACHER	STUDENTS		
1. Control Circuits	Students should be able to: 1. Explain the concept of control circuits. 2. State types of control circuits 3. Explain principles of operation of control circuits.	1. Control circuits 2. Types of control circuits. 3. Principles of operations of control circuits	1. Explains the concept of control circuits. 2. States types of control circuits 3. Explains principles of operation of control circuits.	1. Participate in discussion.	1. Charts and software on control circuits.	Students to: 1. Explain the concept of control circuits. 2. Mention types of control circuits 3. State principles of control circuits
2. Servo ï mechanism	Students should be able to: 1. Explain the operations of servo-system. 2. Explain the applications of a servo-system.	1. Operations of servo-system. 2. Applications of servo-system, e.g. in car doors and boots; reflect photoelectric rays, etc.	1. Explains the operation of servo-system. 2. Explains applications of a servo-system e.g. car doors and boots; reflect photoelectric rays, etc.	1. Participate in discussion. 2. Ask and answer questions 3. Copy notes	Charts of objects that operate on the principles of servo systems e.g. car doors, boots and relays.	Students to: 1. Explain with illustrations the operation of servo-system. 2. Explain the application of servo mechanism.

SS III

THEME: ENTREPRENEURSHIP IN ELECTRONICS

TOPIC	PERFORMANCE OBJECTIVES	CONTENT	ACTIVITIES		TEACHING AND LEARNING MATERIALS	EVALUATION GUIDE
			TEACHER	STUDENTS		
1. Entrepreneurship in Electronics	Students should be able to: 1. Mention possible business opportunities in electronics. 2. Discuss sources of fund for business take off. 3. Explain budgeting. 4. Explain business management.	1. Business opportunities in Electronics. 2. Source of fund for business take off. 3. Budgeting. 4. Business management	1. Explains business opportunities in Electronics. 2. Explains source of fund for business take off. 3. Explains budgeting. 4. Explains business management	1. Listen attentively. 2. Ask questions. 3. Copy notes	Video clip. Business proposals. Visit to electronics business premises	Students to: 1. State three possible business opportunities in electronics. 2. Mention three sources of fund for business take off. 3. Explain budgeting. 4. Explain organizing, controlling and staffing as business management function.

TOOLS AND MEASURING INSTRUMENTS FOR ELECTRONICS CLASS

S/NO	TOOLS	QUANTITY
1.	Soldering Iron	
2.	Soldering Lead	
3.	Soldering paste	
4.	Electronic precision set (screw drivers)	
5.	Brush	
6.	Booster/ac adaptor	
7.	Long nose pliers	
8.	Side cutter	

Measuring Instruments

S/NO	TOOLS	QUANTITY
1.	Multimeter (Analogue and Digital	
2.	Voltage Regulator	
3.	Oscilloscope	
4.	Ammeter	
5.	Voltmeter	
6.	Ohmmeter	
7.	Galvanometer	

LIST OF WRITING TEAM

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Appendix B – TABLE OF SPECIFICATIONS

SENIOR SECONDARY BASIC ELECTRONICS CURRICULUM GOALS AND OBJECTIVES	**TASK NO.**	**PRACTICAL AREAS IN THE BASIC ELECTRONICS CURRICULUM**	**SIMPSON'S PSYCHOMOTOR DOMAIN LEVELS**						
The goals of the curriculum are to • Provide understanding of the fundamental electronic components and circuits • Lay good foundation for communication system and control system • Provide foundation for creativity and technological development in electronics • Stimulate, develop and enhance entrepreneurial skills in electronics To achieve these goals the students should attain the following practical objectives • Build and test simple electronic devices and systems • Demonstrate skills in fault tracing and repairs • Use electronic devices in the Construction of electronic systems		- Measuring and testing operation - Constructing electrical circuit operation - Fault tracing operation	**PERCEPTION (5-10%)**	**SET (5-10%)**	**GUIDED RESPONSE (20-30%)**	**MECHANISM (20-30%)**	**COMPLEX OVERT RESPONSE (25-30%)**	**ADAPTATION (5-10%)**	**NO. OF SKILL ITEMS**
	A: MEASURING AND TESTING OPERATION								
	1	Measuring current using ammeter	-	2	2	4	2	2	12
	2	Measuring voltage with voltmeter	-	2	2	3	3	1	11
	3	Measuring resistance with ohmmeter	2	1	3	1	4	1	12
	4	Measuring power with wattmeter	1	-	1	1	1	1	5
	5	Measuring power with three phase wattmeter	1	1	1	1	1	-	5
	6	Using multimeter to measure DC Voltage (DCV)	-	1	2	-	1	-	4

TASK NO.	TASK	SIMPSON'S PSYCHOMOTOR DOMAIN LEVELS						
		PERCEPTION (5-10%)	SET (5-10%)	GUIDED RESPONSE (20-30%)	MECHANISM (20-30%)	COMPLEX OVERT RESPONSE (25-30%)	ADAPTATION (5-10%)	NO. OF SKILL ITEMS
7	Using multimeter to measure AC	-	1	-	-	1	1	3
8	Using multimeter to measure DC current	-	1	2	-	1	-	4
9	Using multimeter to measure AC current	-	-	1	-	2	-	3
10	Measuring resistance using multimeter	-	1	1	2	2	-	6
11	Using multimeter to measure voltage of a	-	1	2	1	-	-	4
12	Using multimeter for continuity test	-	-	1	-	2	-	3
13	using oscilloscope to measure electrical quantities e.g. amplitude, frequency, period	-	2	4	4	4	2	16
14	Determining waveform shapes of electronics component using oscilloscope		1	4	1	3	2	11
15	Maintaining electronic measuring instrument	-	-	5	3	2	2	12

TASK NO.	**TASK**	**SIMPSON'S PSYCHOMOTOR DOMAIN LEVELS**						
		PERCEPTION (5-10%)	**SET (5-10%)**	**GUIDED RESPONSE (20-30%)**	**MECHANISM (20-30%)**	**COMPLEX OVERT RESPONSE (25-30%)**	**ADAPTATION (5-10%)**	**NO.OF SKILL ITEMS**
B: CONSTRUCTING ELECTRICAL CIRCUIT OPERATION								
16	Performing simple experiments such as ohmộs law	1	-	2	2	1	-	6
17	Constructing step down transformer	-	-	3	3	5	-	11
18	Constructing simple circuit using semi conductor devices such as diode, transistor, resistor etc.	3	-	3	-	2	1	9
19	Constructing electric bell	4	-	2	-	1	2	9
20	Constructing half wave rectifier	2	1	1	2	2	-	8
21	Constructing full wave rectifier	3	-	1	2	2	-	8
22	Constructing simple analogue ohmmeter	1	-	3	3	3	-	10

TASK NO.	TASK	SIMPSON PSYCHOMOTOR DOMAIN LEVELS						
		PERCEPTION (5-10%)	SET (5-10%)	GUIDED RESPONSE (20-30%)	MECHANISM (20-30%)	COMPLEX OVERT RESPONSE (25-30%)	ADAPTATION (5 -10%)	NO.OF SKILL ITEMS
23	Carrying out forward biasing of a diode	-	-	1	1	4	-	6
24	Carrying out reverse biasing of a diode	-	1	1	1	3	-	6
25	Carrying out wiring of electrical circuit	-	1	2	3	2	-	8
26	Constructing a simple common emitter transistor amplifier	1	-	-	4	3	-	8
C: FAULT TRACING AND REPAIR OPERATION								
27	Dismantling of electrical/electronic circuit or unit	1	2	4	4	1	-	12
28	Identifying bad components/faults in the circuit	1	-	2	1	1	-	5

TASK NO.	**TASK**	**SIMPSON'S PSYCHOMOTOR DOMAIN LEVELS**						
		PERCEPTION (5-10%)	**SET (5-10%)**	**GUIDED RESPONSE (20-30%)**	**MECHANISM (20-30%)**	**COMPLEX OVERT RESPONSE (25-30%)**	**ADAPTATION (5-10%)**	**NO. OF SKILL ITEMS**
29	Removing bad components from the circuit	-	1	2	1	3	1	8
30	Fixing in good electronic components in the circuit	-	-	-	3	4	2	9
31	Coupling the maintained circuit/unit	-	-	2	3	2	-	7
32	Testing the unit or equipment for functionality	-	-	-	3	1	-	4
	TOTAL ITEMS	21	20	60	57	69	18	245
	% OF TOTAL ITEMS	8.57	8.16	24.5	23.26	28.16	7.34	100

Appendix C

DRAFT COPY OF THE BASIC ELECTRONICS PROCESS SKILLS ASSESSMENT INSTRUMENT (BEPSAI) FOR SENIOR SECONDARY SCHOOLS

DIRECTION

Please rate the performance of the student on each of the following process skills

Name of Student --

S/N	OPERATIONS/TASKS	Very Poor	Poor	Average	Good	Very Good
A: MEASURING AND TESTING OPERATION						
	Task 1: Measuring current using ammeter					
	Procedural steps/skill items					
1	Determining the type of ammeter to use					
2	Considering the capacity or current rating					
3	Adjusting the pointer of the meter to zero if using analogue ammeter					
4	Setting the selector knob to a higher scale first					
5	Setting the selector knob down to the applicable current range i.e. milliampere or microampere					
6	Connecting ammeter in series with the circuit					
7	Connecting the positive lead (RED) of the ammeter to the positive terminal of the voltage supply					
8	Connecting the negative lead (BLACK) of the ammeter to the negative terminal of the voltage supply.					
9	Switching on the power supply					
10	Making sure that the meter is placed perfectly on a horizontal surface.					
11	Viewing the pointer from directly above such that the pointer coincides with the calibrating point. (to avoid parallax error)					
12	Taking and recording the ammeter reading.					

	Task 2: Measuring voltage with voltmeter	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/skill items					
1	Selecting and using appropriate voltmeter					
2	Considering the value of voltage to be measured					
3	Setting the pointer of voltmeter to zero position					
4	Setting the range selector to the highest range scale first					
5	Reducing the range selector as needed to the lower ranges					
6	Connecting the positive lead (+, red) of the voltmeter to the positive terminal of the battery					
7	Connecting the negative lead (-, black) of the meter to the negative terminal of the battery or source					
8	Connecting the voltmeter across or in parallel with the component voltage to be measured					
9	Ensuring that the meter is placed perfectly on a horizontal surface to avoid parallax error.					
10	Viewing the pointer from directly above such that the pointer coincides with the calibrated point (to avoid parallax error)					
11	Taking and recording the voltmeter reading.					

	Task 3: Measuring resistance with ohmmeter	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/skill items					
1	Identifying appropriate ohmmeter					
2	Placing the meter horizontally					
3	Inserting the two lead or probes correctly					
4	De-energizing the live circuit					
5	Removing the resistor or material to be measured					
6	Short-circuiting the two leads of the meter					
7	Setting the pointer of the ammeter to zero.					
8	Avoiding to touch the bare metal parts of the probes or resistor leads. (To avoid error due to body resistance)					
9	Placing red lead on the positive side of the circuit					
10	Placing black lead on the negative side of the circuit					
11	Reading off the resistance indicated by the scale					
12	Multiplying by 1, 10, 100, 1000, or more as applicable					

	Task 4: Measuring power using single phase wattmeter	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/skill items					
1	Selecting appropriate wattmeter					
2	Connecting wattmeter across the appropriate location in the circuit					
3	Adjusting the pointer of the meter to zero.					
4	Placing the leads on supply terminals					
5	Taking the readings and recording it					

	Task 5: Measuring power using three phase wattmeter	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/skill items					
1	Selecting appropriate wattmeter					
2	Connecting wattmeter to appropriate location in the circuit					
3	Adjusting the pointer of the meter to zero					
4	Placing the leads on supply terminals					
5	Taking the reading and record it					

	Task 6: Using multimeter to measure DC Voltage (DC,V)	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/skill items					
1	Setting the range selector to DC,V range					
2	Connecting the red lead to the positive terminal					
3	Connecting the black lead on the negative terminal					
4	Reading the value on the scale and recording it					

	Task 7: Using multimeter to measure AC Voltage (AC,V)	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/skill items					
1	Setting the range selector to AC,V					
2	Connecting the test leads to the circuit under test regardless of the polarities					
3	Reading the measured value on the scale and recording it					

	Task 8: Using multimeter to measure DC Current (DC, A)	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/skill items					
1	Setting the range selector to DC, A range position					
2	Connecting the red test lead to the positive polarity					
3	Connecting the black test lead to the negative polarity					
4	Reading and recording the value on the scale					

	Task 9: Using multimeter to measure AC Current (AC,A)	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/skill items					
1	Setting the range selector to AC,A range position					
2	Connecting the red test lead to the circuit regardless of the polarities					
3	Reading and recording the value on the scale					

	Task 10: Measuring resistance using multimeter	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/skill items					
1	Setting the range selector to a prescribed range position (n x 1kn x 10 or n x 1)					
2	Short circuiting the test leads					
3	Turning ohm adjustment to set the pointer to zero ohm position					
4	Removing the resistor from the motherboard before testing					
5	Connecting the test leads to the resistor under test					
6	Reading the value on the ohm scale and recording the same					

	Task 11: Using multimeter to measure voltage of a battery	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/skill items					
1	Setting the range selector to DC or BATT position					
2	Connecting the positive test lead to the positive terminal of the battery					
3	Connecting the negative test lead to the negative terminal of the battery					
4	Reading the value on the DC or BATT scale and recording the same					

	Task 12: Using multimeter for continuity test	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
1	Setting the range selector to the OHM position					
2	Connecting the test leads to the circuit under test					
3	Confirming the continuity of the circuit.					

NOTE: A digital multimeter reads value when there is no open circuit, otherwise the reading would be zero.

An analog multimeter makes a buzzing sound when the circuit is continuous, and makes no sound when the circuit is open.

	Task 13: Using oscilloscope to measure electrical quantities e.g. amplitude, frequency, period.	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/skill items					
1	Ensuring that the intensity control is not set at a high level for a long time (it can burn the phosphor on the screen)					
2	Placing the oscilloscope where there is no strong local magnetic field (to avoid unwanted deflection of electron beam)					
3	Placing the oscilloscope on horizontal platform /table					
4	Connecting the oscilloscope to power supply					
5	Connecting the leads to the circuit to be measured					
6	Ensuring that a bright spot does not stay on the display for a long time (this may burn the phosphor on the screen)					
7	Allowing the signals to be steady before calibration					
8	Adjusting the overall gain of the Y-amplifier using the VOLTS/DIV control					
9	Using the trigger circuit to delay the time base waveform					
10	Changing the scales of the X-axis and Y-axis to allow many different signals to be displayed					
11	Adjusting the Y-POS to allow the zero level on the Y-axis to be changed					
12	Dividing the oscilloscope screen into squares to allow the horizontal scale to be expressed in seconds, milliseconds or microseconds per division (s/DIV, ms/DIV, µs/DIV).					
13	Using the TIME/DIV control to change the scale of the X-axis as appropriate.					
	IF USING DIGITAL OSCILLOSCOPE ASSESS ON ITEMS 14A AND 15A					
14A	Pressing Quick Measure to display the readings for various electrical quantities					

15A	Reading and recording the readings for amplitude, frequency, period, etc					
	IF USING ANALOGUE OSCILLOSCOPE ASSESS ON ITEMS 14B, 15B AND 16B					
14B	Noting the scales on the X and Y axes					
15B	Noting the parameter of the waveform that corresponds to the electrical quantity to be measured					
16B	Converting accordingly using the scale applicable to the particular axis					

	Task 14: Determining waveform shapes of electronic components using oscilloscope	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/skill items					
1	Connecting the leads to the circuit to be analyzed					
2	Adjusting the overall gain of the Y-amplifier using the VOLTS/DIV control					
3	Using the trigger circuit to delay the time base waveform					
4	Changing the scales of the X-axis and Y-axis to allow many different signals to be displayed					
5	Adjusting the Y-POS to allow the zero level on the Y-axis to be changed					
6	Dividing both sides of the screen into equal number of parts. Drawing both horizontal and vertical line through the divisions to make small squares on the screen					
7	Expressing the horizontal scale in seconds, milliseconds or microseconds per division (s/DIV, ms/DIV, µs/DIV)					
8	Using the TIME/DIV control to change the scale of the X-axis.					
9	Powering up the circuit to be analyzed					

10	Pressing the button for the channel on which to view the waveform					
11	Recording the displayed waveform					

	Task 15: Maintaining electronic measuring instrument	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/skill items					
1	Opening the instrument					
2	Checking the internal battery or cell					
3	Replacing the battery (if necessary)					
4	Checking the fuse					
5	Replacing the fuse (if necessary)					
6	Checking the leads for open circuit					
7	Inserting the probes into proper socket					
8	Checking that the dial circuit is correct					
9	Adjusting zero adjustment knob					
10	Cleaning the inner parts of the instrument					
11	Reassembling/closing the instrument					
12	Sending for repairs (if necessary)					

	Task 16: Performing simple experiments such as ohm's law	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/skill items					
1	Selecting the right materials and tools for the experiment including measuring instruments					
2	Using low current for measurement (To minimize heating effect of currents)					
3	Using a smoothed DC voltage supply (To avoid complications)					
4	Connecting components on the board as required					
5	Soldering the components correctly					
6	Determining the readings on the scale of the instrument and recording the same					

B: CONSTRUCTING ELECTRIC CIRCUIT OPERATION						
	Task 17: Constructing step down transformer	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/skill items					
1	Determining the grade (SWG) of the coil for the construction and the primary/secondary turns needed.					
2	Cutting the iron core of the transformer to specification					
3	Laminating the iron core					
4	Making the correct number of turns of coil on primary side					
5	Making appropriate number of turns of coil on secondary side of the transformer					
6	Coupling the transformer with laminated iron core					
7	Terminating the construction with appropriate diameter of flexible cable					
8	Carrying out continuity test on selected coils					
9	Applying a known value of AC voltage to the primary side of the transformer.					
10	Reading the output voltage from the secondary side.					
11	Comparing/contrasting the input and the output.					

	Task 18: Constructing simple circuits using semi conductor devices such as diode, transistor, resistor etc.	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/skill items					
1	Selecting appropriate materials and tools for the construction					
2	Selecting adequate semi conductors such as transistors, diodes, integrated circuit, etc.					
3	Testing each semi conductor device before use					

4	Inserting the leads of each semi conductor device unto the Vero board					
5	Connecting the components as needed in the circuit diagram					
6	Soldering the joints correctly and avoiding dry joints					
7.	Ensuring that the soldering iron does not stay too long on the devices (to avoid burning them)					
8	Terminating the circuit					
9	Testing the constructed circuit using appropriate methods and instruments					

	Task 19: Constructing electric bell	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/skill items					
1	Selecting gong or bell of appropriate size					
2	Selecting a strip of metal striker					
3	Selecting a coated wire of appropriate gauge					
4	Selecting two iron core					
5	Carrying out winding on the iron core appropriate number of items, connecting one turn to the other serially					
6	Fastening the coils to the insulated board parallel to each other					
7	Fixing the metal striker close to the end of two coils					
8	Terminating the leads of the two coils					
9	Checking for continuity of coils					

	Task 20: Constructing half wave rectifier	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/skill items					
1	Selecting appropriate diodes for half wave rectifier					
2	Selecting appropriate transformer					
3	Identifying primary and secondary sides of the transformer correctly using multimeter or by observing the					

	leads					
4	Selecting appropriate capacitor and resistor					
5	Making the configuration of rectifier on the mother board					
6	Soldering the components to specification					
7	Avoiding dry joints and overheating of components during soldering					
8	Terminating the construction correctly					

	Task 21: Constructing full wave rectifier	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/skill items					
1	Selecting appropriate diodes for the full wave rectifier					
2	Selecting appropriate transformer					
3	Identifying primary and secondary sides of the transformer correctly using multimeter or by observing the leads					
4	Selecting appropriate capacitor and resistor					
5	Making the configuration of rectifier on the vero board					
6	Soldering the components					
7	Avoiding dry joints and overheating of components during soldering					
8	Terminating the construction correctly					

	Task 22: Constructing Simple Analogue Ohmmeter	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps / Process skill items					
1	Determining tools for the construction					
2	Selecting appropriate components for the construction					
3	Interpreting the circuit components for the construction					
4	Cutting vero board to correct size					

	Task 23: Carrying out forward biasing of a diode	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/skill items					
1	Determining components to be used for the biasing					
2	Identifying the different terminals of the diode.					
3	Connecting diode and battery in forward bias					
4	Measuring current in forward bias circuit					
5	Measuring resistance in forward bias					
6	Confirming whether resistance is high or low.					

	Task 24: Carrying out reverse biasing of a diode	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/skill items					
1	Determining components to be used for the biasing					
2	Identifying the terminals of the diode.					
3	Connecting diode and battery in reverse bias					
4	Measuring and record current in reverse bias.					
5	Measuring and record resistance in reversed bias					
6	Confirming whether the resistance is high or low					

	Task 25: Carrying out wiring of electrical circuit	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/skill items					
1	Identifying materials for wiring					
2	Laying out the cables on the wiring board					
3	Connecting all the electrical components correctly					
4	Terminating all joints appropriately					
5	Taping all the naked joints with insulation tape					
6	Covering the joint boxes					
7	Connecting the switch to the circuit					
8	Test- running the wiring circuit					

S/N	**Task 26: Constructing A Simple Common emitter Transistor Amplifier**	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/skill items					
1.	Selecting the components needed for the amplifier circuit (Transistor, resistor , capacitor etc)					
2.	Identifying the collector pin, the base pin and the emitter pin of the transistor					
3.	Laying out on the vero board, all the components needed for the circuit					
4.	Soldering each component in turn.					
5.	Ensuring that the components are not exposed to excessive heat from the soldering iron or using a low wattage soldering iron (To avoid burning the components).					
6.	Cutting the excess lengths of pins after soldering					
7.	Applying from a signal generator, a small input signal (in the millivolts, or milliampere range) at the input of the circuit.					
8.	Confirming using an oscilloscope that there is a gain at the output					

C: FAULTS TRACING OPERATION						
	Task 27: Dismantling of electrical/electronic circuit or unit	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/skill items					
1	Selecting appropriate tools for the task					
2	Ensuring that the device is not connected to a power source					
3	Placing the unit horizontally					
4	Handling components with care to avoid damage					
5	Turning the unit upside down					
6	Unscrewing the unit or circuit					
7	Inserting appropriate screw driver into screw slot					
8	Turning the screw driver in anticlockwise direction (to loosen the screws)					
9	Removing all the screws					
10	Keeping the screws safely(for later use)					
11	Opening the unit or equipment					
12	Disconnecting all wiring					

	Task 28: Identifying bad components/faults in the circuit	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/skill items					
1	Selecting functional electronic tester or meter for the task					
2	Connecting the tester to each suspected component in turn					
3	Taking the reading of the component(s)					
4	Detecting open or short circuit in the component or equipment					
5	Observing any physical damage in the unit or equipment					

	Task 29: Removing bad components from the cirucuit	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/skill items					
1	Turning selector of multimeter to ohm range					
2	Turning the circuit board upside down					
3	Locating the tags of the components					
4	Placing the bit of the hot soldering iron on it for a few seconds to melt the solder					
5	Avoiding prolonged soldering iron contact with the component (to avoid burning of the components)					
6	Removing the components from the board gently					
7	Placing the leads of the meter on tips of the component					
8	Testing or reading for functionality					

	Task 30: Fixing in good electronic components in the circuit	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/skill items					
1	Identifying the bad component					
2	Placing the bit of the hot soldering iron for a few seconds to melt and remove the solder from the hole where the bad component is fixed					
3	Identifying appropriate replacement					
4	Inserting the good component through the hole					
5	Turning the vero board upside down					
6	Soldering the tags of the component for two seconds					
7	Cutting out excess tags					
8	Removing excess solder with lead sucker					
9	Avoiding prolonged soldering iron contact with the component (to avoid burning of the component)					

	Task 31: Coupling the maintained circuit/unit	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/skill items					
1	Packing all the flexible wires in the equipment together with rubber clips					
2	Screwing the mother board firmly with the container					
3	Coupling the equipment					
4	Aligning the container					
5	Inserting the screws correctly					
6	Inserting appropriate screw driver					
7	Turning the screw driver in a clockwise direction to tighten the screws					

	Task 32: Testing the unit or equipment for functionality	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/skill items					
1	Switching off the socket outlet					
2	Plugging the equipment to the socket outlet					
3	Switching on the socket outlet to power the equipment					
4	Observing the equipment for functionality					

Appendix D

LIST OF SCHOOLS IN LAGOS STATE THAT OFFERED BASIC ELECTRONICS UP TO SENIOR SECONDARY LEVEL IN THE 2014/2015 SCHOOL YEAR

S/N	NAME OF SCHOOL	NUMBER OF BASIC ELECTRONICS STUDENTS IN SS3
1	Fortune Private College, Ikotun	3
2	Nigerian Navy Secondary School, Navy Town, Ojo	9
3	Dr. Soyemi Memorial Secondary School, Festic Town, Lagos	1
4	Nowa Secondary School, Navy Town, Ojo	1
5	Sacred Heart College, Apapa	16
6	Ifaco International Secondary, Ifako-Ijaiye	5
7	Solomon Grace Secondary School, Abule-Egba	11
8	New-Tech College, Fagba Iju ï Lagos	1
9	Babinton Macaulay Junior Seminary, Ikorodu	3
10	Lighthouse International Secondary School, Ikorodu	9
11	The Primelight High School, Ikorodu	8
12	Totland Secondary School, Agric ï Ikorodu	1
13	Queenôs College, Yaba	1
14	Western College, Yaba	4
15	International School, University of Lagos	4
16	Federal Science and Technical College, Yaba	25
17	Royal Star Comprehensive College, Ijeshatedo	4
18	Abrahamôs Seeds College, Onipanu ï Mushin	1
19	S-Triumph International School, Ojo	25
20	Command Day Secondary School, Nafrc, Oshodi	5
21	Binta International High School, Ejigbo	1
22	Al-Faruq College, Ejigbo	9
23	Grace High School, Gbagada	8
24	Towab High School, Ijegun ï Ikotun	1
25	Misam International College, Ajasa	2
	TOTAL	158

SOURCE: Lagos State Ministry of Education

Appendix E

LETTER TO VALIDATES

Department of Vocational Teacher Education
Faculty of Education,
University of Nigeria,
Nsukka.

24th October, 2014

____
____
____

Dear Sir/ Madam,

REQUEST FOR VALIDATION OF INSTRUMENT

I am a post-graduate student of the above-named department and I am carrying out a study on THE DEVELOPMENT AND VALIDATION OF A BASIC ELECTRONICS PROCESS SKILLS ASSESSMENT INSTRUMENT FOR SENIOR SECONDARY SCHOOLS**.** I would be grateful if you could provide necessary assistance by validating the instrument that will be used for the study.

In validating the instrument you should, among other things,

1) confirm that all the 28 tasks are within the basic electronics curriculum;
2) identify other operations and/or tasks that are within the curriculum but are not covered by the assessment instrument;
3) confirm that all the procedural steps for carrying out each task are as listed in the instrument and that no practical steps are omitted;
4) vet the language used in the instrument to ensure that it is easily understood, unambiguous and straight to the point.

Please find attached for your necessary action: the purpose of the study, the research questions, the hypotheses, and the instrument to be validated ï the draft Basic Electronics Process Skills Assessment Instrument (BEPSAI) for senior secondary schools. Also attached are the draft table of specifications based on Simpsonôs taxonomy of the psychomotor domain, and the basic electronics curriculum for senior secondary schools.

Thank you.

Yours faithfully,
UMANAH, RAPHAEL ANYIEKAN
PG/PhD/08/49043
Tel: 08060616048
E-mail: raphael.umanah@yahoo.com

Appendix F

SUMMARY OF VALIDATES' COMMENTS

1. The identified procedural steps/skills items are not clearly stated. Make them clearer.
2. Write out in full abbreviations used in describing each task
3. Identify and include each precautionary measure to be carried out by the student
4. Check out your grammar on some of the skills items
5. Break up óconstructions of full wave and half wave rectifiersô into two separate tasks
6. Break up carrying out forward and reverse biasing of diodes into two separate tasks
7. The procedural steps for construction of electric bell should be adjusted to truly reflect construction of an electric bell and not a bell circuit
8. What constitutes these indications: very low, low, moderate, high and very high?
9. There are many process skills; which ones are you interested in?
10. Group the items according to the process skills irrespective of the components of the circuit
11. Change the indicators from: very low, low, moderate, high and very high to very poor, poor, average, good and very good
12. There is little or no difference between the task: applying oscilloscope to measure electrical quantities and the task: determining waveform shapes of electronic components using oscilloscope

NAMES AND ADDRESS OF THE VALIDATES

1. DR. MOSES I. ODO ï Lecturer I, Department of Science and Technical Education, University of Lagos
2. MR. A.A. GHANDI ï Head, Electrical Department, Government Technical College, Farfaru, Sokoto
3. DR. N.A. UDOFIA ï Senior Lecturer, Department of Educational Foundation, University of Uyo, Uyo.
4. DR. B.C. MADU ï Department of Science Education, University of Nigeria Nsukka, Enugu
5. DR. A.U. IGWE ï Chief Lecturer/Dean, School of Technical Education, Federal College of Education (Technical), Akoka, Yaba, Lagos.

Appendix G_1

RESULT OF FACTOR ANALYSIS USING SPSS

Research Question 1: Tasks suitable for inclusion in the assessment instrument

Component Matrix[a]

	Component		
	1	2	3
TASK1	.841	-.031	-.460
TASK2	.810	-.188	.033
TASK3	.913	.123	.001
TASK4	.910	-.018	.075
TASK5	.824	.012	-.025
TASK6	.844	-.120	.388
TASK7	.888	-.030	.273
TASK8	.913	.123	.001
TASK9	.900	-.018	.075
TASK10	.824	.012	-.025
TASK11	.854	-.120	.388
TASK12	.888	-.030	.273
TASK13	-.117	.863	.274
TASK14	-.215	.836	.082
TASK15	.904	-.073	-.167
TASK16	.901	.290	.115
TASK17	.765	.451	-.228
TASK18	.782	.267	-.316
TASK19	.608	-.101	-.475
TASK20	.778	-.143	-.136
TASK21	.795	.048	-.079
TASK22	.639	.124	-.318
TASK23	.741	-.031	-.460
TASK24	.810	-.188	.033
TASK25	.913	.123	.001
TASK26	.700	-.018	.075

TASK27	.824	.012	-.025
TASK28	.842	-.120	.388
TASK29	.808	-.030	.273
TASK30	.332	.652	.147
TASK31	.904	-.073	-.167
TASK32	.901	.290	.115

Research Question 2: Basic electronics practical process skill items for senior secondary III students

Component Matrix[a]

	Component		
	1	2	3
ITEM1	.626	.116	-.071
ITEM2	**.302**	**-.017**	**-.019**
ITEM3	.894	-.144	-.041
ITEM4	.903	.020	-.023
ITEM5	.254	.865	.091
ITEM6	.214	.867	.004
ITEM7	**.052**	**.206**	**.037**
ITEM8	.086	.862	.156
ITEM9	.173	.766	.022
ITEM10	.140	.771	.143
ITEM11	.254	.865	.091
ITEM12	.214	.867	.004
ITEM13	.052	.826	.037
ITEM14	.086	.862	.156
ITEM15	.173	.766	.022
ITEM16	.140	.771	.143
ITEM17	.216	.780	-.006
ITEM18	-.011	.655	.602
ITEM19	-.009	.796	.004
ITEM20	.253	.719	.017
ITEM21	.149	.838	.161
ITEM22	.810	-.038	.269

ITEM23	.719	-.229	.121
ITEM24	.779	-.128	-.284
ITEM25	.816	.065	-.042
ITEM26	.668	-.167	.281
ITEM27	.768	-.049	.307
ITEM28	.800	-.013	-.277
ITEM29	.912	-.040	-.008
ITEM30	.877	-.119	-.063
ITEM31	.810	-.074	-.027
ITEM32	**.213**	**-.049**	**-.176**
ITEM33	.878	.025	-.227
ITEM34	.903	.020	-.023
ITEM35	.779	-.100	.329
ITEM36	.810	-.038	.269
ITEM37	.719	-.229	.121
ITEM38	.779	-.128	-.284
ITEM39	.816	.065	-.042
ITEM40	.668	-.167	.281
ITEM41	.768	-.049	.307
ITEM42	.800	-.013	-.277
ITEM43	.912	-.040	-.008
ITEM44	.877	-.119	-.063
ITEM45	.810	-.074	-.027
ITEM46	.823	-.049	-.176
ITEM47	.878	.025	-.227
ITEM48	.254	.865	.091
ITEM49	.214	.867	.004
ITEM50	.052	.826	.037
ITEM51	.086	.862	.156
ITEM52	.173	.766	.022
ITEM53	.140	.771	.143
ITEM54	.216	.780	-.006
ITEM55	-.011	.655	.602

ITEM56	-.009	.796	.004
ITEM57	.253	.719	.017
ITEM58	.149	.838	.161
ITEM59	-.041	-.288	.807
ITEM60	.054	-.134	.840
ITEM61	.221	-.268	.827
ITEM62	.135	-.303	.680
ITEM63	-.002	-.462	.642
ITEM64	**.147**	**-.149**	**.046**
ITEM65	.174	-.348	.710
ITEM66	.135	-.268	.778
ITEM67	-.140	-.393	.552
ITEM68	.036	-.163	.741
ITEM69	-.007	-.123	.688
ITEM70	.175	-.317	.745
ITEM71	.668	-.167	.281
ITEM72	.768	-.049	.307
ITEM73	.800	-.013	-.277
ITEM74	.912	-.040	-.008
ITEM75	.877	-.119	-.063
ITEM76	.810	-.074	-.027
ITEM77	.823	-.049	-.176
ITEM78	.878	.025	-.227
ITEM79	.912	-.040	-.008
ITEM80	.877	-.119	-.063
ITEM81	.810	-.074	-.027
ITEM82	.823	-.049	-.176
ITEM83	.878	.025	-.227
ITEM84	.850	.219	.194
ITEM85	-.170	.279	.872
ITEM86	.894	-.144	-.041
ITEM87	.903	.020	-.023
ITEM88	.779	-.100	.329

ITEM89	.810	-.038	.269
ITEM90	.719	-.229	.121
ITEM91	.779	-.128	-.284
ITEM92	.816	.065	-.042
ITEM93	.668	-.167	.281
ITEM94	.768	-.049	.307
ITEM95	.800	-.013	-.277
ITEM96	.912	-.040	-.008
ITEM97	.877	-.119	-.063
ITEM98	.810	-.074	-.027
ITEM99	.823	-.049	-.176
ITEM100	.878	.025	-.227
ITEM101	.803	-.036	-.065
ITEM102	.894	-.144	-.041

Component Matrix[a]

	Component		
	1	2	3
ITEM103	.905	.057	-.280
ITEM104	.802	-.395	-.341
ITEM105	.836	-.408	-.098
ITEM106	.758	-.135	.442
ITEM107	.802	.080	.146
ITEM108	.824	.156	.298
ITEM109	.688	-.449	.094
ITEM110	.779	-.202	.418
ITEM111	.792	.341	.190
ITEM112	.902	.017	-.141
ITEM113	.867	.130	-.291
ITEM114	.792	.066	-.244
ITEM115	.795	.409	-.067
ITEM116	.860	.307	-.078
ITEM117	.176	.033	-.041
ITEM118	.123	-.016	.880

ITEM119	.909	.020	.005
ITEM120	.905	.057	-.280
ITEM121	.802	-.395	-.341
ITEM122	.836	-.408	-.098
ITEM123	.758	-.135	.442
ITEM124	.802	.080	.146
ITEM125	.824	.156	.298
ITEM126	.688	-.449	.094
ITEM127	.779	-.202	.418
ITEM128	.792	.341	.190
ITEM129	.902	.017	-.141
ITEM130	.909	.020	.005
ITEM131	**.205**	**.057**	**-.280**
ITEM132	.802	-.395	-.341
ITEM133	.836	-.408	-.098
ITEM134	.758	-.135	.442
ITEM135	.802	.080	.146
ITEM136	.824	.156	.298
ITEM137	.688	-.449	.094
ITEM138	.779	-.202	.418
ITEM139	.792	.341	.190
ITEM140	.902	.017	-.141
ITEM141	.867	.130	-.291
ITEM142	.792	.066	-.244
ITEM143	.795	.409	-.067
ITEM144	.860	.307	-.078
ITEM145	.860	.307	-.078
ITEM146	.023	.229	.881
ITEM147	-.215	. .945	-.009
ITEM148	.909	.020	.005
ITEM149	.905	.057	-.280
ITEM150	.802	-.395	-.341
ITEM151	.836	-.408	-.098

ITEM152	.758	-.135	.442
ITEM153	.802	.080	.146
ITEM154	.824	.156	.298
ITEM155	.688	-.449	.094
ITEM156	**.079**	**-.202**	**.418**
ITEM157	.792	.341	.190
ITEM158	.902	.017	-.141
ITEM159	.867	.130	-.291
ITEM160	.792	.066	-.244
ITEM161	.795	.409	-.067
ITEM162	.860	.307	-.078
ITEM163	.909	.020	.005
ITEM164	.905	.057	-.280
ITEM165	.802	-.395	-.341
ITEM166	.836	-.408	-.098
ITEM167	.758	-.135	.442
ITEM168	.802	.080	.146
ITEM169	.824	.156	.298
ITEM170	.688	-.449	.094
ITEM171	.779	-.202	.418
ITEM172	.792	.341	.190
ITEM173	.902	.017	-.141
ITEM174	.867	.130	-.291
ITEM175	.792	.066	-.244
ITEM176	.795	.409	-.067
ITEM177	.860	.307	-.078
ITEM178	-.133	.836	-.325
ITEM179	.909	.020	.005
ITEM180	.905	.057	-.280
ITEM181	.802	-.395	-.341
ITEM182	.836	-.408	-.098
ITEM183	.758	-.135	.442
ITEM184	.802	.080	.146

ITEM185	.824	.156	.298
ITEM186	.688	-.449	.094
ITEM187	.779	-.202	.418
ITEM188	.792	.341	.190
ITEM189	.902	.017	-.141
ITEM190	.867	.130	-.291
ITEM191	.792	.066	-.244
ITEM192	.795	.409	-.067
ITEM193	.860	.307	-.078
ITEM194	-.085	.515	.207
ITEM195	.909	.020	.005
ITEM196	.905	.057	-.280
ITEM197	.802	-.395	-.341
ITEM198	.836	-.408	-.098
ITEM199	.758	-.135	.442
ITEM200	.802	.080	.146
ITEM201	.824	.156	.298
ITEM202	.688	-.449	.094
ITEM203	.779	-.202	.418
ITEM204	.792	.341	.190
ITEM205	.902	.017	-.141
ITEM206	.867	.130	-.291
ITEM207	.792	.066	-.244
ITEM208	.795	.409	-.067
ITEM209	.860	.307	-.078
ITEM210	.792	.341	.190
ITEM211	.902	.017	-.141
ITEM212	.867	.130	-.291
ITEM213	.792	.066	-.244
ITEM214	.795	.409	-.067
ITEM215	.860	.307	-.078
ITEM216	.940	-.201	.037
ITEM217	.909	.020	.005

ITEM218	.905	.057	-.280
ITEM219	.802	-.395	-.341
ITEM220	.836	-.408	-.098
ITEM221	.758	-.135	.442
ITEM222	.802	.080	.146
ITEM223	.824	.156	.298
ITEM224	.688	-.449	.094
ITEM225	.779	-.202	.418
ITEM226	.792	.341	.190
ITEM227	.902	.017	-.141
ITEM228	.867	.130	-.291
ITEM229	.792	.066	-.244
ITEM230	.795	.409	-.067
ITEM231	.860	.307	-.078
ITEM232	.909	.020	.005
ITEM233	.905	.057	-.280
ITEM234	.802	-.395	-.341
ITEM235	.836	-.408	-.098
ITEM236	.758	-.135	.442
ITEM237	.802	.080	.146
ITEM238	.824	.156	.298
ITEM239	.688	-.449	.094
ITEM240	.779	-.202	.418
ITEM241	-.085	.505	.207
ITEM242	.709	.020	.005
ITEM243	.805	.057	-.280
ITEM244	.812	-.395	-.341
ITEM245	.836	-.408	-.098
ITEM246	.781	-.135	.442
ITEM247	.811	.080	.146

Appendix G_2

PROCESS SKILL ITEMS DISCARDED AFTER FACTOR ANALYSIS

S/N	PROCESS SKILL ITEM	FORMER LOCATION
1.	Connecting the positive lead (RED) of the ammeter to the positive terminal of the voltage supply	Task One
2.	Considering the capacity or current rating	Task One
3.	Setting the pointer of the ammeter to zero	Task Three
4.	Turning ohm adjustment to set the pointer to zero ohm position	Task Ten
5.	Reading the output voltage from the secondary side.	Task Seventeen
6.	Soldering the components to specification	Task Twenty

Appendix H

FINAL COPY OF THE BASIC ELECTRONICS PROCESS SKILLS ASSESSMENT INSTRUMENT (BEPSAI) FOR SENIOR SECONDARY SCHOOLS

DIRECTION

Please rate the performance of the student on each of the following process skills

Name of Student --

S/N	OPERATIONS/TASKS	Very Poor	Poor	Average	Good	Very Good
A: MEASURING AND TESTING OPERATION (TASKS 1 – 16)						
	Task 1: Measuring current using ammeter					
	Procedural steps/Process skill items					
1	Determining the type of ammeter to use					
2	Adjusting the pointer of the meter to zero if using analogue ammeter					
3	Setting the selector knob to a higher scale first					
4	Setting the selector knob down to the applicable current range i.e. milliampere or microampere					
5	Connecting ammeter in series with the circuit					
6	Connecting the negative lead (BLACK) of the ammeter to the negative terminal of the voltage supply.					
7	Switching on the power supply					
8	Making sure that the meter is placed perfectly on a horizontal surface.					
9	Viewing the pointer from directly above such that the pointer coincides with the calibrating point. (to avoid parallax error)					
10	Taking and recording the ammeter reading.					

	Task 2: Measuring voltage with voltmeter	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/Process skill items					
1	Selecting and using appropriate voltmeter					
2	Considering the value of voltage to be measured					
3	Setting the pointer of voltmeter to zero position					
4	Setting the range selector to the highest range scale first					
5	Reducing the range selector as needed to the lower ranges					
6	Connecting the positive lead (+, red) of the voltmeter to the positive terminal of the battery					
7	Connecting the negative lead (-, black) of the meter to the negative terminal of the battery or source					
8	Connecting the voltmeter across or in parallel with the component voltage to be measured					
9	Ensuring that the meter is placed perfectly on a horizontal surface to avoid parallax error.					
10	Viewing the pointer from directly above such that the pointer coincides with the calibrated point (to avoid parallax error)					
11	Taking and recording the voltmeter reading.					

	Task 3: Measuring resistance with ohmmeter	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/Process skill items					
1	Identifying appropriate ohmmeter					
2	Placing the meter horizontally					
3	Inserting the two lead or probes correctly					

4	De-energizing the live circuit					
5	Removing the resistor or material to be measured					
6	Short-circuiting the two leads of the meter					
7	Avoiding to touch the bare metal parts of the probes or resistor leads. (To avoid error due to body resistance)					
8	Placing red lead on the positive side of the circuit					
9	Placing black lead on the negative side of the circuit					
10	Reading off the resistance indicated by the scale					
11	Multiplying by 1, 10, 100, 1000, or more as applicable					

	Task 4: Measuring power using single phase wattmeter	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/Process skill items					
1	Selecting appropriate wattmeter					
2	Connecting wattmeter across the appropriate location in the circuit					
3	Adjusting the pointer of the meter to zero.					
4	Placing the leads on supply terminals					
5	Taking the readings and recording it					

	Task 5: Measuring power using three phase wattmeter	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/Process skill items					
1	Selecting appropriate wattmeter					
2	Connecting wattmeter to appropriate location in the circuit					
3	Adjusting the pointer of the meter to zero					
4	Placing the leads on supply terminals					
5	Taking the reading and record it					

	Task 6: Using multimeter to measure DC Voltage (DC,V)	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/Process skill items					
1	Setting the range selector to DC,V range					
2	Connecting the red lead to the positive terminal					
3	Connecting the black lead on the negative terminal					
4	Reading the value on the scale and recording it					

	Task 7: Using multimeter to measure AC Voltage (AC,V)	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/Process skill items					
1	Setting the range selector to AC,V					
2	Connecting the test leads to the circuit under test regardless of the polarities					
3	Reading the measured value on the scale and recording it					

	Task 8: Using multimeter to measure DC Current (DC, A)	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/Process skill items					
1	Setting the range selector to DC, A range position					
2	Connecting the red test lead to the positive polarity					
3	Connecting the black test lead to the negative polarity					
4	Reading and recording the value on the scale					

	Task 9: Using multimeter to measure AC Current (AC,A)	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/Process skill items					
1	Setting the range selector to AC,A range position					
2	Connecting the red test lead to the circuit regardless of the polarities					

3	Reading and recording the value on the scale					

	Task 10: Measuring resistance using multimeter	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/Process skill items					
1	Setting the range selector to a prescribed range position (n x 1kn x 10 or n x 1)					
2	Short circuiting the test leads					
3	Removing the resistor from the motherboard before testing					
4	Connecting the test leads to the resistor under test					
5	Reading the value on the ohm scale and recording the same					

	Task 11: Using multimeter to measure voltage of a battery	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/Process skill items					
1	Setting the range selector to DC or BATT position					
2	Connecting the positive test lead to the positive terminal of the battery					
3	Connecting the negative test lead to the negative terminal of the battery					
4	Reading the value on the DC or BATT scale and recording the same					

	Task 12: Using multimeter for continuity test	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
1	Setting the range selector to the OHM position					
2	Connecting the test leads to the circuit under test					
3	Confirming the continuity of the circuit.					

NOTE: A digital multimeter reads value when there is no open circuit, otherwise the reading would be zero.

An analog multimeter makes a buzzing sould when the circuit is continuous, and makes no sound when the circuit is open.

	Task 13: using oscilloscope to measure electrical quantities e.g. amplitude, frequency, period.	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps / Process skill items					
1	Ensuring that the intensity control is not set at a high level for a long time (it can burn the phosphor on the screen)					
2	Placing the oscilloscope where there is no strong local magnetic field (to avoid unwanted deflection of electron beam)					
3	Placing the oscilloscope on horizontal platform/table					
4	Connecting the oscilloscope to power supply					
5	Connecting the leads to the circuit to be measured					
6	Ensuring that a bright spot does not stay on the display for a long time (this may burn the phosphor on the screen)					
7	Allowing the signals to be steady before calibration					
8	Adjusting the overall gain of the Y-amplifier using the VOLTS/DIV control					
9	Using the trigger circuit to delay the time base waveform					
10	Changing the scales of the X-axis and Y-axis to allow many different signals to be displayed					
11	Adjusting the Y-POS to allow the zero level on the Y-axis to be changed					
12	Dividing the oscilloscope screen into squares to allow the horizontal scale to be expressed in seconds, milliseconds or microseconds per division (s/DIV, ms/DIV, µs/DIV)					

13	Using the TIME/DIV control to change the scale of the X-axis as appropriate					
	IF USING DIGITAL OSCILLOSCOPE ASSESS ON ITEMS 14A AND 15A					
14A	Pressing Quick Measure to display the reading for various electrical quantities					
15A	Reading and recording the readings for amplitude, frequency, period etc					
	IF USING ANALOGUE OSCILLOSCOPE ASSESS ON ITEMS 14B, 15B AND 16B					
14B	Noting the scales on the X and Y axes					
15B	Noting the parameter of the waveform that corresponds to the electrical quantity to be measured					
16B	Converting accordingly using the scale applicable to the particular axis					

	Task 14: Determining waveform shapes of electronic components using oscilloscope	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/Process skill items					
1	Connecting the leads to the circuit to be analyzed					
2	Adjusting the overall gain of the Y-amplifier using the VOLTS/DIV control					
3	Using the trigger circuit to delay the time base waveform					
4	Changing the scales of the X-axis and Y-axis to allow many different signals to be displayed					
5	Adjusting the Y-POS to allow the zero level on the Y-axis to be changed					
6	Dividing both sides of the screen into equal number of parts. Drawing both horizontal and vertical line through the divisions to make small squares on the screen					
7	Expressing the horizontal scale in seconds, milliseconds or microseconds per division (s/DIV, ms/DIV, µs/DIV)					
8	Using the TIME/DIV control to change the scale of the X-axis.					
9	Powering up the circuit to be analyzed					
10	Pressing the button for the channel on which to view the waveform					
11	Recording the displayed waveform					

	Task 15: Maintaining electronic measuring instrument	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/Process skill items					
1	Opening the instrument					
2	Checking the internal battery or cell					
3	Replacing the battery (if necessary)					
4	Checking the fuse					
5	Replacing the fuse (if necessary)					
6	Checking the leads for open circuit					
7	Inserting the probes into proper socket					
8	Checking that the dial circuit is correct					
9	Adjusting zero adjustment knob					
10	Cleaning the inner parts of the instrument					
11	Reassembling/closing the instrument					
12	Sending for repairs (if necessary)					

	Task 16: Performing simple experiments such as ohm's law	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/Process skill items					
1	Selecting the right materials and tools for the experiment including measuring instruments					
2	Using low current for measurement (To minimize heating effect of currents)					
3	Using a smoothed DC voltage supply (To avoid complications)					
4	Connecting components on the board as required					
5	Soldering the components correctly					
6	Determining the readings on the scale of the instrument and recording the same					

B: CONSTRUCTING ELECTRIC CIRCUIT OPERATION (TASKS 17 – 26)						
	Task 17: Constructing step down transformer	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/Process skill items					
1	Determining the grade (SWG) of the coil for the construction and the primary/secondary turns needed.					
2	Cutting the iron core of the transformer to specification					
3	Laminating the iron core					
4	Making the correct number of turns of coil on primary side					
5	Making appropriate number of turns of coil on secondary side of the transformer					
6	Coupling the transformer with laminated iron core					
7	Terminating the construction with appropriate diameter of flexible cable					
8	Carrying out continuity test on selected coils					
9	Applying a known value of AC voltage to the primary side of the transformer.					
10	Comparing/contrasting the input and the output.					

	Task 18: Constructing simple circuits using semi conductor devices such as diode, transistor, resistor etc.	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/Process skill items					
1	Selecting appropriate materials and tools for the construction					
2	Selecting adequate semi conductors such as transistors, diodes, integrated circuit, etc.					
3	Testing each semi conductor device before use					
4	Inserting the leads of each semi conductor device unto the vero board					
5	Connecting the components as needed in the circuit diagram					

6	Soldering the joints correctly and avoiding dry joints					
7.	Ensuring that the soldering iron does not stay too long on the devices (to avoid burning them)					
8	Terminating the circuit					
9	Testing the constructed circuit using appropriate methods and instruments					

	Task 19: Constructing electric bell	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/Process skill items					
1	Selecting gong or bell of appropriate size					
2	Selecting a strip of metal striker					
3	Selecting a coated wire of appropriate gauge					
4	Selecting two iron core					
5	Carrying out winding on the iron core appropriate number of items, connecting one turn to the other serially					
6	Fastening the coils to the insulated board parallel to each other					
7	Fixing the metal striker close to the end of two coils					
8	Terminating the leads of the two coils					
9	Checking for continuity of coils					

	Task 20: Constructing half wave rectifier	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/Process skill items					
1	Selecting appropriate diodes for half wave rectifier					
2	Selecting appropriate transformer					
3	Identifying primary and secondary sides of the transformer correctly using multimeter or by observing the leads					
4	Selecting appropriate capacitor and resistor					

5	Making the configuration of rectifier on the mother board					
6	Avoiding dry joints and overheating of components during soldering					
7	Terminating the construction correctly					

	Task 21: Constructing full wave rectifier	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/Process skill items					
1	Selecting appropriate diodes for the full wave rectifier					
2	Selecting appropriate transformer					
3	Identifying primary and secondary sides of the transformer correctly using multimeter or by observing the leads					
4	Selecting appropriate capacitor and resistor					
5	Making the configuration of rectifier on the vero board					
6	Soldering the components					
7	Avoiding dry joints and overheating of components during soldering					
8	Terminating the construction correctly					

	Task 22: Constructing Simple Analogue Ohmmeter	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps / Process skill items					
1	Determining tools for the construction					
2	Selecting appropriate components for the construction					
3	Interpreting the circuit components for the construction					
4	Cutting vero board to correct size					

	Task 23: Carrying out forward biasing of a diode	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/Process skill items					
1	Determining components to be used for the biasing					
2	Identifying the different terminals of the diode.					
3	Connecting diode and battery in forward bias					
4	Measuring current in forward bias circuit					
5	Measuring resistance in forward bias					
6	Confirming whether resistance is high or low.					

	Task 24: Carrying out reverse biasing of a diode	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/skill items					
1	Determining components to be used for the biasing					
2	Identifying the terminals of the diode.					
3	Connecting diode and battery in reverse bias					
4	Measuring and record current in reverse bias.					
5	Measuring and record resistance in reversed bias					
6	Confirming whether the resistance is high or low					

	Task 25: Carrying out wiring of electrical circuit	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/skill items					
1	Identifying materials for wiring					
2	Laying out the cables on the wiring board					
3	Connecting all the electrical components correctly					

4	Terminating all joints appropriately					
5	Taping all the naked joints with insulation tape					
6	Covering the joint boxes					
7	Connecting the switch to the circuit					
8	Test-running the wiring circuit					

	Task 26: Constructing a simple common emitter transistor amplifier	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/skill items					
1	Selecting the components needed for the amplifier circuit (transistor, resistor, capacitor etc)					
2	Identifying the collector pin, the base pin and the emitter pin of the transistor					
3	Laying out on the vero board, all the components needed for the circuit					
4	Soldering each component in turn					
5	Ensuring that the components are not exposed to excessive heat from the soldering iron or using a low wattage soldering iron (to avoid burning the components).					
6	Cutting the excess lengths of pins after soldering					
7	Applying from a signal generator, a small input signal (in the millivolts, or milliampere range) at the input of the circuit					
8	Confirming using an oscilloscope that there is a gain at the output					

C: FAULTS TRACING OPERATION						
	Task 27: Dismantling of electrical/electronic circuit or unit	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/skill items					
1	Selecting appropriate tools for the task					
2	Ensuring that the device is not connected					

	to a power source					
3	Placing the unit horizontally					
4	Handling components with care to avoid damage					
5	Turning the unit upside down					
6	Unscrewing the unit or circuit					
7	Inserting appropriate screw driver into screw slot					
8	Turning the screw driver in anticlockwise direction (to loosen thr screws)					
9	Removing all the screws					
10	Keeping the screws safely (for later use)					
11	Opening the unit or equipment					
12	Disconnecting all wiring					

	Task 28: Identifying bad components/fault in the circuit	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/skill items					
1	Selecting functional electronic tester or meter for the task					
2	Connecting the tester to each suspected component in turn					
3	Taking the reading of the component (s)					
4	Detecting open or short circuit in the component or equipment					
5	Observing any physical damage in the unit or equipment					

	Task 29: Removing bad components from the circuit	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/skill items					
1	Turning selector of multimeter to ohm range					
2	Turning the circuit board upside down					
3	Locating the tags of the components					

4	Placing the bit of the hot soldering iron on it for a few seconds to melt the solder					
5	Avoiding prolonged soldering iron contact with the component (to avoid burning of the components)					
6	Removing the components from the board gently					
7	Placing the leads of the meter on tips of the component					
8	Testing or reading for functionality					

	Task 30: Fixing in good electronic components in the circuit	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/skill items					
1	Identifying the bad component					
2	Placing the bit of the hot soldering iron for a few seconds to melt and remove the solder from the hole where the bad component is fixed					
3	Identifying appropriate replacement					
4	Inserting the good component through the hole					
5	Turning the vero board upside down					
6	Soldering the tags of the component for two seconds					
7	Cutting out excess tags					
8	Removing excess solder with lead sucker					
9	Avoiding prolonged soldering iron contact with the component (to avoid burning of the component)					

	Task 31: Coupling the maintained circuit/unit	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/skill items					
1	Packing all the flexible wires in the equipment together with rubber clips					
2	Screwing the mother board firmly with the container					
3	Coupling the equipment					

4	Aligning the container					
5	Inserting the screws correctly					
6	Inserting appropriate screw driver					
7	Turing the screw driver in a clockwise direction to tighten the screws					

	Task 32: Testing the unit or equipment for functionality	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/skill items					
1	Switching off the socket outlet					
2	Plugging the equipment to the socket outlet					
3	Switching on the socket outlet to power the equipment					
4	Observing the equipment for functionality					

Appendix I
RESULT OF THE RELIABILITY TEST

TASK 1

Case Processing Summary

		N	%
Cases	Valid	25	100.0
	Excluded[a]	0	.0
	Total	25	100.0

Reliability Statistics

Cronbach's Alpha	N of Items
.833	12

TASK 2

Case Processing Summary

		N	%
Cases	Valid	25	100.0
	Excluded[a]	0	.0
	Total	25	100.0

Reliability Statistics

Cronbach's Alpha	N of Items
.811	11

TASK 3

Case Processing Summary

		N	%
Cases	Valid	25	100.0
	Excluded[a]	0	.0
	Total	25	100.0

Reliability Statistics

Cronbach's Alpha	N of Items
.889	11

TASK 4

Case Processing Summary

		N	%
Cases	Valid	25	100.0
	Excluded[a]	0	.0

	Total	25	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.781	6

TASK 5

Case Processing Summary

		N	%
Cases	Valid	25	100.0
	Excluded[a]	0	.0
	Total	25	100.0

Reliability Statistics

Cronbach's Alpha	N of Items
.770	5

TASK 6

Case Processing Summary

		N	%
Cases	Valid	25	100.0
	Excluded[a]	0	.0
	Total	25	100.0

Reliability Statistics

Cronbach's Alpha	N of Items
.721	4

TASK 7

Case Processing Summary

		N	%
Cases	Valid	25	100.0
	Excluded[a]	0	.0
	Total	25	100.0

Reliability Statistics

Cronbach's Alpha	N of Items
.763	3

TASK 8

Case Processing Summary

		N	%
Cases	Valid	25	100.0
	Excluded[a]	0	.0
	Total	25	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.672	4

TASK 9

Case Processing Summary

		N	%
Cases	Valid	25	100.0
	Excluded[a]	0	.0
	Total	25	100.0

Reliability Statistics

Cronbach's Alpha	N of Items
.681	3

TASK 10

Case Processing Summary

		N	%
Cases	Valid	25	100.0
	Excluded[a]	0	.0
	Total	25	100.0

Reliability Statistics

Cronbach's Alpha	N of Items
.882	5

TASK 11

Case Processing Summary

		N	%
Cases	Valid	25	100.0
	Excluded[a]	0	.0
	Total	25	100.0

Reliability Statistics

Cronbach's Alpha	N of Items
.781	4

TASK 12

Case Processing Summary

		N	%
Cases	Valid	25	100.0
	Excluded[a]	0	.0
	Total	25	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.732	3

TASK 13

Case Processing Summary

		N	%
Cases	Valid	25	100.0
	Excluded[a]	0	.0
	Total	25	100.0

Reliability Statistics

Cronbach's Alpha	N of Items
.893	18

TASK 14

Case Processing Summary

		N	%
Cases	Valid	25	100.0

		N	%
	Excluded[a]	0	.0
	Total	25	100.0

Reliability Statistics

Cronbach's Alpha	N of Items
.692	12

TASK 15

Case Processing Summary

		N	%
Cases	Valid	25	100.0
	Excluded[a]	0	.0
	Total	25	100.0

Reliability Statistics

Cronbach's Alpha	N of Items
.812	12

TASK 16

Case Processing Summary

		N	%
Cases	Valid	25	100.0
	Excluded[a]	0	.0
	Total	25	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.721	6

TASK 17

Case Processing Summary

		N	%
Cases	Valid	25	100.0
	Excluded[a]	0	.0
	Total	25	100.0

Reliability Statistics

Cronbach's Alpha	N of Items

Reliability Statistics

Cronbach's Alpha	N of Items
.813	10

TASK 18

Case Processing Summary

		N	%
Cases	Valid	25	100.0
	Excluded[a]	0	.0
	Total	25	100.0

Reliability Statistics

Cronbach's Alpha	N of Items
.683	9

TASK 19

Case Processing Summary

		N	%
Cases	Valid	25	100.0
	Excluded[a]	0	.0
	Total	25	100.0

Reliability Statistics

Cronbach's Alpha	N of Items
.791	9

TASK 20

Case Processing Summary

		N	%
Cases	Valid	25	100.0
	Excluded[a]	0	.0
	Total	25	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.821	7

TASK 21

Case Processing Summary

		N	%
Cases	Valid	25	100.0
	Excluded[a]	0	.0
	Total	25	100.0

Reliability Statistics

Cronbach's Alpha	N of Items
.743	4

TASK 22

Case Processing Summary

		N	%
Cases	Valid	25	100.0
	Excluded[a]	0	.0
	Total	25	100.0

Reliability Statistics

Cronbach's Alpha	N of Items
.792	14

TASK 23

Case Processing Summary

		N	%
Cases	Valid	25	100.0
	Excluded[a]	0	.0
	Total	25	100.0

Reliability Statistics

Cronbach's Alpha	N of Items
.812	6

TASK 24

Case Processing Summary

		N	%
Cases	Valid	25	100.0
	Excluded[a]	0	.0
	Total	25	100.0

Case Processing Summary

		N	%
Cases	Valid	25	100.0
	Excluded[a]	0	.0
	Total	25	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.684	6

TASK 25

Case Processing Summary

		N	%
Cases	Valid	25	100.0
	Excluded[a]	0	.0
	Total	25	100.0

Reliability Statistics

Cronbach's Alpha	N of Items
.882	8

TASK 26

Case Processing Summary

		N	%
Cases	Valid	25	100.0
	Excluded[a]	0	.0
	Total	25	100.0

Reliability Statistics

Cronbach's Alpha	N of Items
.791	8

TASK 27

Case Processing Summary

		N	%
Cases	Valid	25	100.0
	Excluded[a]	0	.0
	Total	25	100.0

Reliability Statistics

Cronbach's Alpha	N of Items
.832	12

TASK 28

Case Processing Summary

		N	%
Cases	Valid	25	100.0
	Excluded[a]	0	.0
	Total	25	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.843	5

TASK 29

Case Processing Summary

		N	%
Cases	Valid	25	100.0
	Excluded[a]	0	.0
	Total	25	100.0

Reliability Statistics

Cronbach's Alpha	N of Items
.812	8

TASK 30

Case Processing Summary

		N	%
Cases	Valid	25	100.0
	Excluded[a]	0	.0
	Total	25	100.0

Reliability Statistics

Cronbach's Alpha	N of Items
.743	9

TASK 31

Case Processing Summary

		N	%
Cases	Valid	25	100.0
	Excluded[a]	0	.0
	Total	25	100.0

Reliability Statistics

Cronbach's Alpha	N of Items
.771	7

TASK 32

Case Processing Summary

		N	%
Cases	Valid	25	100.0
	Excluded[a]	0	.0
	Total	25	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.641	4

ENTIRE TASK

Case Processing Summary

		N	%
Cases	Valid	25	100.0
	Excluded[a]	0	.0
	Total	25	100.0

Reliability Statistics

Cronbach's Alpha	N of Items
.772	242

Appendix J
THE 3 TASKS WITH 25 PROCESS SKILL ITEMS UTILIZED TO DETERMINE ABILITY GROUPS OF STUDENTS

S/N	OPERATIONS/TASKS	Very Poor	Poor	Average	Good	Very Good
	Task 1: Measuring current using ammeter					
	Procedural steps/skill items					
1	Determining the type of ammeter to use					
2	Considering the capacity or current rating					
3	Adjusting the pointer of the meter to zero if using analogue ammeter					
4	Setting the selector knob to a higher scale first					
5	Setting the selector knob down to the applicable current range i.e. miliampere or microampere					
6	Connecting ammeter in series with the circuit					
7	Connecting the positive lead (RED) of the ammeter to the positive terminal of the voltage supply					
8	Connecting the negative lead (BLACK) of the ammeter to the negative terminal of the voltage supply.					
9	Switching on the power supply					
10	Making sure that the meter is placed perfectly on a horizontal surface.					
11	Viewing the pointer from directly above such that the pointer coincides with the calibrating point. (to avoid parallax error)					
12	Taking and recording the ammeter reading.					

	Task 20: Constructing half wave rectifier	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/skill items					
13	Selecting appropriate diodes for half wave rectifier					
14	Selecting appropriate transformer					
15	Identifying primary and secondary sides of the transformer correctly using multimeter or by observing the leads					
16	Selecting appropriate capacitor and resistor					
17	Making the configuration of rectifier on the mother board					
18	Soldering the components to specification					
19	Avoiding dry joints and overheating of components during soldering					
20	Terminating the construction correctly					

	Task 28: Identifying bad components/faults in the circuit	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
	Procedural steps/skill items					
21	Selecting functional electronic tester or meter for the task					
22	Connecting the tester to each suspected component in turn					
23	Taking the reading of the component(s)					
24	Detecting open or short circuit in the component or equipment					
25	Observing any physical damage in the unit or equipment					

Appendix K

H01 Results of Analysis of Variance (ANOVA)

ANOVA

		Sum of Squares	Df	Mean Square	F	Sig.
ITEM1	Between Groups	5.100	2	2.550	2.343	.120
	Within Groups	23.940	22	1.088		
	Total	29.040	24			
ITEM2	Between Groups	.296	2	.148	.242	.787
	Within Groups	13.464	22	.612		
	Total	13.760	24			
ITEM3	Between Groups	2.540	2	1.270	1.510	.243
	Within Groups	18.500	22	.841		
	Total	21.040	24			
ITEM4	Between Groups	2.450	2	1.225	1.481	.249
	Within Groups	18.190	22	.827		
	Total	20.640	24			
ITEM5	Between Groups	3.236	2	1.618	2.154	.140
	Within Groups	16.524	22	.751		
	Total	19.760	24			
ITEM6	Between Groups	2.253	2	1.126	1.449	.256
	Within Groups	17.107	22	.778		
	Total	19.360	24			
ITEM7	Between Groups	2.353	2	1.176	1.052	.366
	Within Groups	24.607	22	1.119		
	Total	26.960	24			
ITEM8	Between Groups	3.560	2	1.780	1.916	.171
	Within Groups	20.440	22	.929		
	Total	24.000	24			
ITEM9	Between Groups	1.820	2	.910	1.004	.383
	Within Groups	19.940	22	.906		
	Total	21.760	24			

ITEM10	Between Groups	.003	2	.001	.002	.998
	Within Groups	15.357	22	.698		
	Total	15.360	24			
ITEM11	Between Groups	3.236	2	1.618	2.154	.140
	Within Groups	16.524	22	.751		
	Total	19.760	24			
ITEM12	Between Groups	2.253	2	1.126	1.449	.256
	Within Groups	17.107	22	.778		
	Total	19.360	24			
ITEM13	Between Groups	2.353	2	1.176	1.052	.366
	Within Groups	24.607	22	1.119		
	Total	26.960	24			
ITEM14	Between Groups	3.560	2	1.780	1.916	.171
	Within Groups	20.440	22	.929		
	Total	24.000	24			
ITEM15	Between Groups	1.820	2	.910	1.004	.383
	Within Groups	19.940	22	.906		
	Total	21.760	24			
ITEM16	Between Groups	.003	2	.001	.002	.998
	Within Groups	15.357	22	.698		
	Total	15.360	24			
ITEM17	Between Groups	1.483	2	.741	.889	.425
	Within Groups	18.357	22	.834		
	Total	19.840	24			
ITEM18	Between Groups	.196	2	.098	.077	.926
	Within Groups	27.964	22	1.271		
	Total	28.160	24			
ITEM19	Between Groups	3.176	2	1.588	2.000	.159
	Within Groups	17.464	22	.794		
	Total	20.640	24			
ITEM20	Between Groups	6.828	2	3.414	3.951	.034
	Within Groups	19.012	22	.864		

	Total	25.840	24			
ITEM21	Between Groups	2.792	2	1.396	1.613	.222
	Within Groups	19.048	22	.866		
	Total	21.840	24			
ITEM22	Between Groups	1.103	2	.551	.509	.608
	Within Groups	23.857	22	1.084		
	Total	24.960	24			
ITEM23	Between Groups	.873	2	.437	.433	.654
	Within Groups	22.167	22	1.008		
	Total	23.040	24			
ITEM24	Between Groups	.390	2	.195	.264	.770
	Within Groups	16.250	22	.739		
	Total	16.640	24			
ITEM25	Between Groups	1.686	2	.843	.962	.398
	Within Groups	19.274	22	.876		
	Total	20.960	24			
ITEM26	Between Groups	.526	2	.263	.209	.813
	Within Groups	27.714	22	1.260		
	Total	28.240	24			
ITEM27	Between Groups	1.896	2	.948	1.071	.360
	Within Groups	19.464	22	.885		
	Total	21.360	24			
ITEM28	Between Groups	7.781	2	3.891	4.463	.024
	Within Groups	19.179	22	.872		
	Total	26.960	24			
ITEM29	Between Groups	2.676	2	1.338	1.474	.251
	Within Groups	19.964	22	.907		
	Total	22.640	24			
ITEM30	Between Groups	2.357	2	1.178	1.230	.312
	Within Groups	21.083	22	.958		
	Total	23.440	24			
ITEM31	Between Groups	4.036	2	2.018	1.852	.180

	Within Groups	23.964	22	1.089		
	Total	28.000	24			
ITEM32	Between Groups	3.912	2	1.956	2.259	.128
	Within Groups	19.048	22	.866		
	Total	22.960	24			
ITEM33	Between Groups	5.176	2	2.588	2.426	.112
	Within Groups	23.464	22	1.067		
	Total	28.640	24			
ITEM34	Between Groups	2.450	2	1.225	1.481	.249
	Within Groups	18.190	22	.827		
	Total	20.640	24			
ITEM35	Between Groups	.483	2	.241	.194	.825
	Within Groups	27.357	22	1.244		
	Total	27.840	24			
ITEM36	Between Groups	1.103	2	.551	.509	.608
	Within Groups	23.857	22	1.084		
	Total	24.960	24			
ITEM37	Between Groups	.873	2	.437	.433	.654
	Within Groups	22.167	22	1.008		
	Total	23.040	24			
ITEM38	Between Groups	.390	2	.195	.264	.770
	Within Groups	16.250	22	.739		
	Total	16.640	24			
ITEM39	Between Groups	1.686	2	.843	.962	.398
	Within Groups	19.274	22	.876		
	Total	20.960	24			
ITEM40	Between Groups	.526	2	.263	.209	.813
	Within Groups	27.714	22	1.260		
	Total	28.240	24			
ITEM41	Between Groups	1.896	2	.948	1.071	.360
	Within Groups	19.464	22	.885		
	Total	21.360	24			

ITEM42	Between Groups	7.781	2	3.891	4.463	.024
	Within Groups	19.179	22	.872		
	Total	26.960	24			
ITEM43	Between Groups	2.676	2	1.338	1.474	.251
	Within Groups	19.964	22	.907		
	Total	22.640	24			
ITEM44	Between Groups	2.357	2	1.178	1.230	.312
	Within Groups	21.083	22	.958		
	Total	23.440	24			
ITEM45	Between Groups	4.036	2	2.018	1.852	.180
	Within Groups	23.964	22	1.089		
	Total	28.000	24			
ITEM46	Between Groups	3.912	2	1.956	2.259	.128
	Within Groups	19.048	22	.866		
	Total	22.960	24			
ITEM47	Between Groups	5.176	2	2.588	2.426	.112
	Within Groups	23.464	22	1.067		
	Total	28.640	24			
ITEM48	Between Groups	3.236	2	1.618	2.154	.140
	Within Groups	16.524	22	.751		
	Total	19.760	24			
ITEM49	Between Groups	2.253	2	1.126	1.449	.256
	Within Groups	17.107	22	.778		
	Total	19.360	24			
ITEM50	Between Groups	2.353	2	1.176	1.052	.366
	Within Groups	24.607	22	1.119		
	Total	26.960	24			
ITEM51	Between Groups	3.560	2	1.780	1.916	.171
	Within Groups	20.440	22	.929		
	Total	24.000	24			
ITEM52	Between Groups	1.820	2	.910	1.004	.383
	Within Groups	19.940	22	.906		

	Total	21.760	24			
ITEM53	Between Groups	.003	2	.001	.002	.998
	Within Groups	15.357	22	.698		
	Total	15.360	24			
ITEM54	Between Groups	1.483	2	.741	.889	.425
	Within Groups	18.357	22	.834		
	Total	19.840	24			
ITEM55	Between Groups	.196	2	.098	.077	.926
	Within Groups	27.964	22	1.271		
	Total	28.160	24			
ITEM56	Between Groups	3.176	2	1.588	2.000	.159
	Within Groups	17.464	22	.794		
	Total	20.640	24			
ITEM57	Between Groups	6.828	2	3.414	3.951	.034
	Within Groups	19.012	22	.864		
	Total	25.840	24			
ITEM58	Between Groups	2.792	2	1.396	1.613	.222
	Within Groups	19.048	22	.866		
	Total	21.840	24			
ITEM59	Between Groups	.478	2	.239	.242	.787
	Within Groups	21.762	22	.989		
	Total	22.240	24			
ITEM60	Between Groups	3.209	2	1.605	1.895	.174
	Within Groups	18.631	22	.847		
	Total	21.840	24			
ITEM61	Between Groups	2.036	2	1.018	1.247	.307
	Within Groups	17.964	22	.817		
	Total	20.000	24			
ITEM62	Between Groups	4.166	2	2.083	1.813	.187
	Within Groups	25.274	22	1.149		
	Total	29.440	24			
ITEM63	Between Groups	2.596	2	1.298	1.300	.293

	Within Groups	21.964	22	.998		
	Total	24.560	24			
ITEM64	Between Groups	2.167	2	1.083	1.092	.353
	Within Groups	21.833	22	.992		
	Total	24.000	24			
ITEM65	Between Groups	2.103	2	1.051	1.557	.233
	Within Groups	14.857	22	.675		
	Total	16.960	24			
ITEM66	Between Groups	2.162	2	1.081	1.265	.302
	Within Groups	18.798	22	.854		
	Total	20.960	24			
ITEM67	Between Groups	5.526	2	2.763	2.676	.091
	Within Groups	22.714	22	1.032		
	Total	28.240	24			
ITEM68	Between Groups	2.321	2	1.161	1.444	.257
	Within Groups	17.679	22	.804		
	Total	20.000	24			
ITEM69	Between Groups	1.579	2	.790	.743	.487
	Within Groups	23.381	22	1.063		
	Total	24.960	24			
ITEM70	Between Groups	1.452	2	.726	.709	.503
	Within Groups	22.548	22	1.025		
	Total	24.000	24			
ITEM71	Between Groups	.526	2	.263	.209	.813
	Within Groups	27.714	22	1.260		
	Total	28.240	24			
ITEM72	Between Groups	1.896	2	.948	1.071	.360
	Within Groups	19.464	22	.885		
	Total	21.360	24			
ITEM73	Between Groups	7.781	2	3.891	4.463	.024
	Within Groups	19.179	22	.872		
	Total	26.960	24			

ITEM74	Between Groups	2.676	2	1.338	1.474	.251
	Within Groups	19.964	22	.907		
	Total	22.640	24			
ITEM75	Between Groups	2.357	2	1.178	1.230	.312
	Within Groups	21.083	22	.958		
	Total	23.440	24			
ITEM76	Between Groups	4.036	2	2.018	1.852	.180
	Within Groups	23.964	22	1.089		
	Total	28.000	24			
ITEM77	Between Groups	3.912	2	1.956	2.259	.128
	Within Groups	19.048	22	.866		
	Total	22.960	24			
ITEM78	Between Groups	5.176	2	2.588	2.426	.112
	Within Groups	23.464	22	1.067		
	Total	28.640	24			
ITEM79	Between Groups	2.676	2	1.338	1.474	.251
	Within Groups	19.964	22	.907		
	Total	22.640	24			
ITEM80	Between Groups	2.357	2	1.178	1.230	.312
	Within Groups	21.083	22	.958		
	Total	23.440	24			
ITEM81	Between Groups	4.036	2	2.018	1.852	.180
	Within Groups	23.964	22	1.089		
	Total	28.000	24			
ITEM82	Between Groups	3.912	2	1.956	2.259	.128
	Within Groups	19.048	22	.866		
	Total	22.960	24			
ITEM83	Between Groups	5.176	2	2.588	2.426	.112
	Within Groups	23.464	22	1.067		
	Total	28.640	24			
ITEM84	Between Groups	.286	2	.143	.200	.820
	Within Groups	15.714	22	.714		

	Total	16.000	24			
ITEM85	Between Groups	.905	2	.452	.367	.697
	Within Groups	27.095	22	1.232		
	Total	28.000	24			
ITEM86	Between Groups	2.540	2	1.270	1.510	.243
	Within Groups	18.500	22	.841		
	Total	21.040	24			
ITEM87	Between Groups	2.450	2	1.225	1.481	.249
	Within Groups	18.190	22	.827		
	Total	20.640	24			
ITEM88	Between Groups	.483	2	.241	.194	.825
	Within Groups	27.357	22	1.244		
	Total	27.840	24			
ITEM89	Between Groups	1.103	2	.551	.509	.608
	Within Groups	23.857	22	1.084		
	Total	24.960	24			
ITEM90	Between Groups	.873	2	.437	.433	.654
	Within Groups	22.167	22	1.008		
	Total	23.040	24			
ITEM91	Between Groups	.390	2	.195	.264	.770
	Within Groups	16.250	22	.739		
	Total	16.640	24			
ITEM92	Between Groups	1.686	2	.843	.962	.398
	Within Groups	19.274	22	.876		
	Total	20.960	24			
ITEM93	Between Groups	.526	2	.263	.209	.813
	Within Groups	27.714	22	1.260		
	Total	28.240	24			
ITEM94	Between Groups	1.896	2	.948	1.071	.360
	Within Groups	19.464	22	.885		
	Total	21.360	24			
ITEM95	Between Groups	7.781	2	3.891	4.463	.024

	Within Groups	19.179	22	.872		
	Total	26.960	24			
ITEM96	Between Groups	2.676	2	1.338	1.474	.251
	Within Groups	19.964	22	.907		
	Total	22.640	24			
ITEM97	Between Groups	2.357	2	1.178	1.230	.312
	Within Groups	21.083	22	.958		
	Total	23.440	24			
ITEM98	Between Groups	4.036	2	2.018	1.852	.180
	Within Groups	23.964	22	1.089		
	Total	28.000	24			
ITEM99	Between Groups	3.912	2	1.956	2.259	.128
	Within Groups	19.048	22	.866		
	Total	22.960	24			
ITEM100	Between Groups	5.176	2	2.588	2.426	.112
	Within Groups	23.464	22	1.067		
	Total	28.640	24			

ANOVA

		Sum of Squares	Df	Mean Square	F	Sig.
ITEM101	Between Groups	1.292	2	.646	.859	.437
	Within Groups	16.548	22	.752		
	Total	17.840	24			
ITEM102	Between Groups	2.540	2	1.270	1.510	.243
	Within Groups	18.500	22	.841		
	Total	21.040	24			
ITEM103	Between Groups	2.450	2	1.225	1.481	.249
	Within Groups	18.190	22	.827		
	Total	20.640	24			
ITEM104	Between Groups	.483	2	.241	.194	.825
	Within Groups	27.357	22	1.244		

	Total	27.840	24			
ITEM105	Between Groups	1.103	2	.551	.509	.608
	Within Groups	23.857	22	1.084		
	Total	24.960	24			
ITEM106	Between Groups	.873	2	.437	.433	.654
	Within Groups	22.167	22	1.008		
	Total	23.040	24			
ITEM107	Between Groups	.390	2	.195	.264	.770
	Within Groups	16.250	22	.739		
	Total	16.640	24			
ITEM108	Between Groups	1.686	2	.843	.962	.398
	Within Groups	19.274	22	.876		
	Total	20.960	24			
ITEM109	Between Groups	.526	2	.263	.209	.813
	Within Groups	27.714	22	1.260		
	Total	28.240	24			
ITEM110	Between Groups	1.896	2	.948	1.071	.360
	Within Groups	19.464	22	.885		
	Total	21.360	24			
ITEM111	Between Groups	7.781	2	3.891	4.463	.024
	Within Groups	19.179	22	.872		
	Total	26.960	24			
ITEM112	Between Groups	2.676	2	1.338	1.474	.251
	Within Groups	19.964	22	.907		
	Total	22.640	24			
ITEM113	Between Groups	2.357	2	1.178	1.230	.312
	Within Groups	21.083	22	.958		
	Total	23.440	24			
ITEM114	Between Groups	4.036	2	2.018	1.852	.180
	Within Groups	23.964	22	1.089		
	Total	28.000	24			
ITEM115	Between Groups	3.912	2	1.956	2.259	.128

	Within Groups	19.048	22	.866		
	Total	22.960	24			
ITEM116	Between Groups	5.176	2	2.588	2.426	.112
	Within Groups	23.464	22	1.067		
	Total	28.640	24			
ITEM117	Between Groups	.155	2	.077	.086	.918
	Within Groups	19.845	22	.902		
	Total	20.000	24			
ITEM118	Between Groups	.029	2	.015	.018	.983
	Within Groups	18.131	22	.824		
	Total	18.160	24			
ITEM119	Between Groups	2.540	2	1.270	1.510	.243
	Within Groups	18.500	22	.841		
	Total	21.040	24			

H02

ANOVA

		Sum of Squares	Df	Mean Square	F	Sig.
ITEM120	Between Groups	2.450	2	1.225	1.481	.249
	Within Groups	18.190	22	.827		
	Total	20.640	24			
ITEM121	Between Groups	.483	2	.241	.194	.825
	Within Groups	27.357	22	1.244		
	Total	27.840	24			
ITEM122	Between Groups	1.103	2	.551	.509	.608
	Within Groups	23.857	22	1.084		
	Total	24.960	24			
ITEM123	Between Groups	.873	2	.437	.433	.654
	Within Groups	22.167	22	1.008		
	Total	23.040	24			
ITEM124	Between Groups	.390	2	.195	.264	.770

	Within Groups	16.250	22	.739		
	Total	16.640	24			
ITEM125	Between Groups	1.686	2	.843	.962	.398
	Within Groups	19.274	22	.876		
	Total	20.960	24			
ITEM126	Between Groups	.526	2	.263	.209	.813
	Within Groups	27.714	22	1.260		
	Total	28.240	24			
ITEM127	Between Groups	1.896	2	.948	1.071	.360
	Within Groups	19.464	22	.885		
	Total	21.360	24			
ITEM128	Between Groups	7.781	2	3.891	4.463	.024
	Within Groups	19.179	22	.872		
	Total	26.960	24			
ITEM129	Between Groups	2.676	2	1.338	1.474	.251
	Within Groups	19.964	22	.907		
	Total	22.640	24			
ITEM130	Between Groups	2.540	2	1.270	1.510	.243
	Within Groups	18.500	22	.841		
	Total	21.040	24			
ITEM131	Between Groups	2.450	2	1.225	1.481	.249
	Within Groups	18.190	22	.827		
	Total	20.640	24			
ITEM132	Between Groups	.483	2	.241	.194	.825
	Within Groups	27.357	22	1.244		
	Total	27.840	24			
ITEM133	Between Groups	1.103	2	.551	.509	.608
	Within Groups	23.857	22	1.084		
	Total	24.960	24			
ITEM134	Between Groups	.873	2	.437	.433	.654
	Within Groups	22.167	22	1.008		
	Total	23.040	24			

ITEM135	Between Groups	.390	2	.195	.264	.770
	Within Groups	16.250	22	.739		
	Total	16.640	24			
ITEM136	Between Groups	1.686	2	.843	.962	.398
	Within Groups	19.274	22	.876		
	Total	20.960	24			
ITEM137	Between Groups	.526	2	.263	.209	.813
	Within Groups	27.714	22	1.260		
	Total	28.240	24			
ITEM138	Between Groups	1.896	2	.948	1.071	.360
	Within Groups	19.464	22	.885		
	Total	21.360	24			
ITEM139	Between Groups	7.781	2	3.891	4.463	.024
	Within Groups	19.179	22	.872		
	Total	26.960	24			
ITEM140	Between Groups	2.676	2	1.338	1.474	.251
	Within Groups	19.964	22	.907		
	Total	22.640	24			
ITEM141	Between Groups	2.357	2	1.178	1.230	.312
	Within Groups	21.083	22	.958		
	Total	23.440	24			
ITEM142	Between Groups	4.036	2	2.018	1.852	.180
	Within Groups	23.964	22	1.089		
	Total	28.000	24			
ITEM143	Between Groups	3.912	2	1.956	2.259	.128
	Within Groups	19.048	22	.866		
	Total	22.960	24			
ITEM144	Between Groups	5.176	2	2.588	2.426	.112
	Within Groups	23.464	22	1.067		
	Total	28.640	24			
ITEM145	Between Groups	5.176	2	2.588	2.426	.112
	Within Groups	23.464	22	1.067		

	Total	28.640	24			
ITEM146	Between Groups	.450	2	.225	.305	.740
	Within Groups	16.190	22	.736		
	Total	16.640	24			
ITEM147	Between Groups	2.253	2	1.126	.914	.416
	Within Groups	27.107	22	1.232		
	Total	29.360	24			
ITEM148	Between Groups	2.540	2	1.270	1.510	.243
	Within Groups	18.500	22	.841		
	Total	21.040	24			
ITEM149	Between Groups	2.450	2	1.225	1.481	.249
	Within Groups	18.190	22	.827		
	Total	20.640	24			
ITEM150	Between Groups	.483	2	.241	.194	.825
	Within Groups	27.357	22	1.244		
	Total	27.840	24			
ITEM151	Between Groups	1.103	2	.551	.509	.608
	Within Groups	23.857	22	1.084		
	Total	24.960	24			
ITEM152	Between Groups	.873	2	.437	.433	.654
	Within Groups	22.167	22	1.008		
	Total	23.040	24			
ITEM153	Between Groups	.390	2	.195	.264	.770
	Within Groups	16.250	22	.739		
	Total	16.640	24			
ITEM154	Between Groups	1.686	2	.843	.962	.398
	Within Groups	19.274	22	.876		
	Total	20.960	24			
ITEM155	Between Groups	.526	2	.263	.209	.813
	Within Groups	27.714	22	1.260		
	Total	28.240	24			
ITEM156	Between Groups	1.896	2	.948	1.071	.360

	Within Groups	19.464	22	.885		
	Total	21.360	24			
ITEM157	Between Groups	7.781	2	3.891	4.463	.024
	Within Groups	19.179	22	.872		
	Total	26.960	24			
ITEM158	Between Groups	2.676	2	1.338	1.474	.251
	Within Groups	19.964	22	.907		
	Total	22.640	24			
ITEM159	Between Groups	2.357	2	1.178	1.230	.312
	Within Groups	21.083	22	.958		
	Total	23.440	24			
ITEM160	Between Groups	4.036	2	2.018	1.852	.180
	Within Groups	23.964	22	1.089		
	Total	28.000	24			
ITEM161	Between Groups	3.912	2	1.956	2.259	.128
	Within Groups	19.048	22	.866		
	Total	22.960	24			
ITEM162	Between Groups	5.176	2	2.588	2.426	.112
	Within Groups	23.464	22	1.067		
	Total	28.640	24			
ITEM163	Between Groups	2.540	2	1.270	1.510	.243
	Within Groups	18.500	22	.841		
	Total	21.040	24			
ITEM164	Between Groups	2.450	2	1.225	1.481	.249
	Within Groups	18.190	22	.827		
	Total	20.640	24			
ITEM165	Between Groups	.483	2	.241	.194	.825
	Within Groups	27.357	22	1.244		
	Total	27.840	24			
ITEM166	Between Groups	1.103	2	.551	.509	.608
	Within Groups	23.857	22	1.084		
	Total	24.960	24			

ITEM167	Between Groups	.873	2	.437	.433	.654
	Within Groups	22.167	22	1.008		
	Total	23.040	24			
ITEM168	Between Groups	.390	2	.195	.264	.770
	Within Groups	16.250	22	.739		
	Total	16.640	24			
ITEM169	Between Groups	1.686	2	.843	.962	.398
	Within Groups	19.274	22	.876		
	Total	20.960	24			
ITEM170	Between Groups	.526	2	.263	.209	.813
	Within Groups	27.714	22	1.260		
	Total	28.240	24			
ITEM171	Between Groups	1.896	2	.948	1.071	.360
	Within Groups	19.464	22	.885		
	Total	21.360	24			
ITEM172	Between Groups	7.781	2	3.891	4.463	.024
	Within Groups	19.179	22	.872		
	Total	26.960	24			
ITEM173	Between Groups	2.676	2	1.338	1.474	.251
	Within Groups	19.964	22	.907		
	Total	22.640	24			
ITEM174	Between Groups	2.357	2	1.178	1.230	.312
	Within Groups	21.083	22	.958		
	Total	23.440	24			
ITEM175	Between Groups	4.036	2	2.018	1.852	.180
	Within Groups	23.964	22	1.089		
	Total	28.000	24			
ITEM176	Between Groups	3.912	2	1.956	2.259	.128
	Within Groups	19.048	22	.866		
	Total	22.960	24			
ITEM177	Between Groups	5.176	2	2.588	2.426	.112
	Within Groups	23.464	22	1.067		

	Total	28.640	24			
ITEM178	Between Groups	.276	2	.138	.217	.806
	Within Groups	13.964	22	.635		
	Total	14.240	24			
ITEM179	Between Groups	2.540	2	1.270	1.510	.243
	Within Groups	18.500	22	.841		
	Total	21.040	24			
ITEM180	Between Groups	2.450	2	1.225	1.481	.249
	Within Groups	18.190	22	.827		
	Total	20.640	24			
ITEM181	Between Groups	.483	2	.241	.194	.825
	Within Groups	27.357	22	1.244		
	Total	27.840	24			
ITEM182	Between Groups	1.103	2	.551	.509	.608
	Within Groups	23.857	22	1.084		
	Total	24.960	24			
ITEM183	Between Groups	.873	2	.437	.433	.654
	Within Groups	22.167	22	1.008		
	Total	23.040	24			
ITEM184	Between Groups	.390	2	.195	.264	.770
	Within Groups	16.250	22	.739		
	Total	16.640	24			
ITEM185	Between Groups	1.686	2	.843	.962	.398
	Within Groups	19.274	22	.876		
	Total	20.960	24			
ITEM186	Between Groups	.526	2	.263	.209	.813
	Within Groups	27.714	22	1.260		
	Total	28.240	24			
ITEM187	Between Groups	1.896	2	.948	1.071	.360
	Within Groups	19.464	22	.885		
	Total	21.360	24			
ITEM188	Between Groups	7.781	2	3.891	4.463	.024

	Within Groups	19.179	22	.872		
	Total	26.960	24			
ITEM189	Between Groups	2.676	2	1.338	1.474	.251
	Within Groups	19.964	22	.907		
	Total	22.640	24			
ITEM190	Between Groups	2.357	2	1.178	1.230	.312
	Within Groups	21.083	22	.958		
	Total	23.440	24			
ITEM191	Between Groups	4.036	2	2.018	1.852	.180
	Within Groups	23.964	22	1.089		
	Total	28.000	24			
ITEM192	Between Groups	3.912	2	1.956	2.259	.128
	Within Groups	19.048	22	.866		
	Total	22.960	24			
ITEM193	Between Groups	5.176	2	2.588	2.426	.112
	Within Groups	23.464	22	1.067		
	Total	28.640	24			
ITEM194	Between Groups	.498	2	.249	.317	.731
	Within Groups	17.262	22	.785		
	Total	17.760	24			
ITEM195	Between Groups	2.540	2	1.270	1.510	.243
	Within Groups	18.500	22	.841		
	Total	21.040	24			
ITEM196	Between Groups	2.450	2	1.225	1.481	.249
	Within Groups	18.190	22	.827		
	Total	20.640	24			
ITEM197	Between Groups	.483	2	.241	.194	.825
	Within Groups	27.357	22	1.244		
	Total	27.840	24			
ITEM198	Between Groups	1.103	2	.551	.509	.608
	Within Groups	23.857	22	1.084		
	Total	24.960	24			

ITEM199	Between Groups	.873	2	.437	.433	.654
	Within Groups	22.167	22	1.008		
	Total	23.040	24			
ITEM200	Between Groups	.390	2	.195	.264	.770
	Within Groups	16.250	22	.739		
	Total	16.640	24			

H03

ANOVA

		Sum of Squares	Df	Mean Square	F	Sig.
ITEM201	Between Groups	1.686	2	.843	.962	.398
	Within Groups	19.274	22	.876		
	Total	20.960	24			
ITEM202	Between Groups	.526	2	.263	.209	.813
	Within Groups	27.714	22	1.260		
	Total	28.240	24			
ITEM203	Between Groups	1.896	2	.948	1.071	.360
	Within Groups	19.464	22	.885		
	Total	21.360	24			
ITEM204	Between Groups	7.781	2	3.891	4.463	.024
	Within Groups	19.179	22	.872		
	Total	26.960	24			
ITEM205	Between Groups	2.676	2	1.338	1.474	.251
	Within Groups	19.964	22	.907		
	Total	22.640	24			
ITEM206	Between Groups	2.357	2	1.178	1.230	.312
	Within Groups	21.083	22	.958		
	Total	23.440	24			
ITEM207	Between Groups	4.036	2	2.018	1.852	.180

	Within Groups	23.964	22	1.089		
	Total	28.000	24			
ITEM208	Between Groups	3.912	2	1.956	2.259	.128
	Within Groups	19.048	22	.866		
	Total	22.960	24			
ITEM209	Between Groups	5.176	2	2.588	2.426	.112
	Within Groups	23.464	22	1.067		
	Total	28.640	24			
ITEM210	Between Groups	7.781	2	3.891	4.463	.024
	Within Groups	19.179	22	.872		
	Total	26.960	24			
ITEM211	Between Groups	2.676	2	1.338	1.474	.251
	Within Groups	19.964	22	.907		
	Total	22.640	24			
ITEM212	Between Groups	2.357	2	1.178	1.230	.312
	Within Groups	21.083	22	.958		
	Total	23.440	24			
ITEM213	Between Groups	4.036	2	2.018	1.852	.180
	Within Groups	23.964	22	1.089		
	Total	28.000	24			
ITEM214	Between Groups	3.912	2	1.956	2.259	.128
	Within Groups	19.048	22	.866		
	Total	22.960	24			
ITEM215	Between Groups	5.176	2	2.588	2.426	.112
	Within Groups	23.464	22	1.067		
	Total	28.640	24			
ITEM216	Between Groups	.452	2	.226	.659	.527
	Within Groups	7.548	22	.343		
	Total	8.000	24			
ITEM217	Between Groups	2.540	2	1.270	1.510	.243
	Within Groups	18.500	22	.841		
	Total	21.040	24			

ITEM218	Between Groups	2.450	2	1.225	1.481	.249
	Within Groups	18.190	22	.827		
	Total	20.640	24			
ITEM219	Between Groups	.483	2	.241	.194	.825
	Within Groups	27.357	22	1.244		
	Total	27.840	24			
ITEM220	Between Groups	1.103	2	.551	.509	.608
	Within Groups	23.857	22	1.084		
	Total	24.960	24			
ITEM221	Between Groups	.873	2	.437	.433	.654
	Within Groups	22.167	22	1.008		
	Total	23.040	24			
ITEM222	Between Groups	.390	2	.195	.264	.770
	Within Groups	16.250	22	.739		
	Total	16.640	24			
ITEM223	Between Groups	1.686	2	.843	.962	.398
	Within Groups	19.274	22	.876		
	Total	20.960	24			
ITEM224	Between Groups	.526	2	.263	.209	.813
	Within Groups	27.714	22	1.260		
	Total	28.240	24			
ITEM225	Between Groups	1.896	2	.948	1.071	.360
	Within Groups	19.464	22	.885		
	Total	21.360	24			
ITEM226	Between Groups	7.781	2	3.891	4.463	.024
	Within Groups	19.179	22	.872		
	Total	26.960	24			
ITEM227	Between Groups	2.676	2	1.338	1.474	.251
	Within Groups	19.964	22	.907		
	Total	22.640	24			
ITEM228	Between Groups	2.357	2	1.178	1.230	.312
	Within Groups	21.083	22	.958		

	Total	23.440	24			
ITEM229	Between Groups	4.036	2	2.018	1.852	.180
	Within Groups	23.964	22	1.089		
	Total	28.000	24			
ITEM230	Between Groups	3.912	2	1.956	2.259	.128
	Within Groups	19.048	22	.866		
	Total	22.960	24			
ITEM231	Between Groups	5.176	2	2.588	2.426	.112
	Within Groups	23.464	22	1.067		
	Total	28.640	24			
ITEM232	Between Groups	2.540	2	1.270	1.510	.243
	Within Groups	18.500	22	.841		
	Total	21.040	24			
ITEM233	Between Groups	2.450	2	1.225	1.481	.249
	Within Groups	18.190	22	.827		
	Total	20.640	24			
ITEM234	Between Groups	.483	2	.241	.194	.825
	Within Groups	27.357	22	1.244		
	Total	27.840	24			
ITEM235	Between Groups	1.103	2	.551	.509	.608
	Within Groups	23.857	22	1.084		
	Total	24.960	24			
ITEM236	Between Groups	.873	2	.437	.433	.654
	Within Groups	22.167	22	1.008		
	Total	23.040	24			
ITEM237	Between Groups	.390	2	.195	.264	.770
	Within Groups	16.250	22	.739		
	Total	16.640	24			
ITEM238	Between Groups	1.686	2	.843	.962	.398
	Within Groups	19.274	22	.876		
	Total	20.960	24			
ITEM239	Between Groups	.526	2	.263	.209	.813

	Within Groups	27.714	22	1.260		
	Total	28.240	24			
ITEM240	Between Groups	1.896	2	.948	1.071	.360
	Within Groups	19.464	22	.885		
	Total	21.360	24			
ITEM241	Between Groups	.261	2	.131	.167	.847
	Within Groups	17.179	22	.781		
	Total	17.440	24			
ITEM242	Between Groups	.131	2	.066	.100	.905
	Within Groups	14.429	22	.656		
	Total	14.560	24			

Appendix L

OPERATIONAL GUIDELINES FOR USING THE BASIC ELECTRONICS PROCESS SKILLS ASSESSMENT INSTRUMENT (BEPSAI)

Introduction

A basic electronics process skill assessment instrument has been developed, validated and tried out. The result showed that all the items contained therein are valid and reliable for assessing studentsô practical skills in basic electronics at the senior secondary level. As a process assessment instrument, it is to be used only when the students are carrying out practical tasks. It is not an alternative to practical work neither is it a paper and pencil type of performance test. Therefore, it should not be used for any of such purposes. It is a device for assessing step-by-step practical activities or skills involved in carrying out tasks that require the use of tools, equipment and materials.

This manual contains instructions to teachers and any other persons who may wish to use the BEPSAI, either in full or in part, for the purpose of assessing studentsô process skills in basic electronics at the senior secondary level. Although the instrument is developed specifically for use at the senior secondary level, aspects of it could be modified to suit varying students levels or categories depending on the course objectives and the type/level of students to be assessed. In this manual, instructions are provided to teachers on the preparation of the workshop environment, the equipment tools, materials and machines that should be provided before administering this test. Also contained in this manual are guidelines for the assessors who may be involved in the actual assessment of the students. Furthermore, directions on how to score, compute, grade and interprete the scores for each student has been provided. It is therefore recommended that, before this assessment instrument is used, the teachers/assessors should carefully study this manual and follow the instructions stipulated in it.

GUIDELINES FOR PREPARATION OF THE WORKSHOP

1. Before using this instrument to assess students the teachers concerned should ensure that all the preliminary arrangements regarding the workshop environment are put in place. By this, it is expected that, all hand and machine tools, materials and accessories necessary for use in the execution of the task should be adequately provided in perfect working conditions.

2. The workshop arrangement should be such that
   (a) a team of assessors could be comfortably seated where they can clearly see the tasks being performed by the students.

(b) a candidate could carry out a given task while standing, sitting or bending depending on the task to be performed.

3. Enough copies of the instrument should be provided to cover every student being assessed.

GUIDELINES FOR CONDUCTING ASSESSMENT USING BEPPSS

1. Where many students are to be observed and rated at the same time all of them should not carry out the same task at the same time. Different tasks should be assigned to different students.

2. Whenever some students are to be assessed, the rest of the students should be kept away from the work area, so that they do not gain undue advantage of having pre-information on what is to be done.

3. Whenever a number of students are set at a time to carry out a series of tasks, they should always ensure that their time on one task is exhausted before moving to the next task.

4. Each assessor should have a copy of the assessment instrument and be well positioned where they could all clearly see the students as they carry out the tasks.

5. All the assessors should carry out the assessment independently but at the same time.

6. Under no circumstances should any assessor influence the scoring carried out by another assessor.

7. Nobody should be allowed to assist the student(s) or influence their performance once process assessment has commenced.

8. Each assessor should be as objective as possible in rating each student. Assessors should neither be too generous, nor too strict in their scoring.

GUIDELINES FOR RATING, ANALYZING AND INTERPRETING THE SCORES

1. There are a total of 239 process skill items. Each process skill item attracts a maximum of 5 points (for very good performance) and minimum of 1 point (for very poor performance). Consequently, the maximum score obtainable from the

entire instrument is 5 x 239 = 1195 points, while the minimal score obtainable is 1x239 = 239

2. The score of each student should be converted into a percentage thus: studentsô scores on all the tasks divided by 1195 x 100%

3. Scoring of the instrument should not be one sided. Students who attained the specific skill measured on each item by the raters should earn five points (very good performance). The students who performed item skills to very near perfection should earn four points. This scoring procedure should go down progressively to three, two and one point.

4. For interpretation of the results, students who score 80 percent and above should be assigned the grade of A or Excellent. Students who score 70-79 percent should be assigned the grade of B or Good. Students who score 60-69 percent should be assigned the grade of C or Fair. Students who score 50-59 percent should be assigned the grade of D or Pass. Students who score 40-49percent should be assigned the grade of E or Poor, while students who score 20-39 percent should be assigned the grade of F which is Fail.

CHARACTERISTICS OF THE BASIC ELECTRONICS PROCESS SKILLS ASSESSMENT INSTRUMENT

1. It is specific - touching on specific basic electronics tasks.
2. It is comprehensive - covering the 3 main operations in the senior secondary basic electronics curriculum.
3. It is easy to use for rating and grading of process skills.
4. Each process skill is assessed independently.
5. It provides for individualized assessment.
6. It is objective, valid and reliable.
7. It is practicable for use on all the identified 32 tasks.