EFFECT OF CIRCUIT SIMULATION ON ACHIEVEMENT AND INTEREST OF TECHNICAL COLLEGE ELECFTRONICS STUDENTS IN BENUE STATE

By

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THE DEPARTMENT OF VOCATIONAL TEACHER EDUCATION

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TITLE PAGE

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APPROVAL PAGE

This research project has been approved for the Department of Vocational Teacher Education, University of Nigeria, Nsukka

By

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CERTIFICATION

Akor Stephen Terungwa, is a student in the department of Vocational Teacher Education, with registration number PG/M.ED/09/51844 has satisfactorily completed the requirements for the course and research work for the award of the higher degree of Masters of Education in Industrial Technical Education. The work embodied in this thesis is original and has not been submitted in part or in full for any other diploma or degree of this or any university.

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Akor Stephen Terungwa

(Student)

DEDICATION

This research work is highly dedicated to the Holy Trinity, my late grandfather Pa. Abraham AkorIkyowase; my parents Mr. Edward H. Akor, Mrs. Comfort S. Akor and Mrs. Esther M. Akor.

ACKNOWLEDGMENTS

My sincere appreciation goes to my supervisor Dr. T. C. Ogbuanya for her wisdom, encouragement and endurance during this research work. May God Almighty enrich her with more wisdom.

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All glory, honour and power be to God Almighty for crowning my efforts and making all things possible for me.

Akor Stephen Terungwa

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Abstract

This study investigated the effect of circuit simulation on achievement and interest of technical college electronics students in Benue State. The study was a quasi-non-equivalent control group design with a population of 132 students drawn from four technical colleges that offer electronics in the state. The students were divided into control and experimental groups of 66 students each. The experimental group used circuit simulation instructional technique while the control group used the lecture demonstration method. The achievement and the interest of the two groups were determined using an electronic circuit and devices achievement test (ECDAT) and an interest inventory. Mean, standard deviation and the analysis of covariance (ANCOVA) were computed using SPSS. The findings of the study revealed that there was no significant difference between the pre-test mean score of the control and the experimental groups; there was a significant difference between the post-test mean scores of the control and the experimental groups in favour of the later; there was a significant difference between the interest levels of the control and the experimental groups in favour of the later. These results suggested that the treatment had a positive effect on electronics studentsô achievement and interest thus leading to the conclusion that, circuit simulation instructional technique is more effective than the lecture demonstration method. Based on these findings, the researcher suggested that, technical teachers should be encouraged to employ Circuit Simulation instructional strategy in delivering their lessons, since it enhances academic achievement and interest; tertiary institutions that train teachers should include circuit simulation instruction in the technical education courses in order to impart its usage to student teachers; curriculum planners should include the use of circuit simulation in the electronics curriculum considering its benefits in the teaching and learning of electronics; circuit simulation should be used in the laboratories to reduce the waste of materials.

CHAPTER I

INTRODUCTION

Background of the Study

Electronics technology is that aspect of technology that involves the manipulation of voltages and electric currents through the use of various devices for the purpose of performing some useful action. According to Shokin (2010), it is the science that deals with the interaction of electrons and electromagnetic fields and with the methods of developing electronic devices and equipment, in which the interaction is used to convert electromagnetic energy for, primarily, the transmission, processing, and storage of information. Jones (2001) defines electronics as the science and technology based on and concerned with the controlled flow of **electrons** or other carriers of electric charge, especially in semiconductor devices. Similarly, the Institute of Electrical and Electronics Engineers (IEEE) refers to it as the discipline where non-linear and active electrical components such as electron tubes, and semiconductor devices, especially transistors, diodes and integrated circuits, are utilized to design electronic circuits, devices and systems, typically also including passive electrical components and based on printed circuit boards. The term denotes a broad technology field that covers important subfields such as analog electronics, digital electronics, consumer electronics, embedded systems and power electronics. The major disparity between Electrical and Electronics Technology is that, while Electrical Technology deals with study of high voltages, power transmissions, core electrical devices (transformers, motors, alternators and so on), Electronic Technology deals with very low voltages.

Electronics is playing a leading role in the scientific and technical revolution. The introduction of electronic devices in various areas of human activity contributes in large and often decisive measure to the resolution of complex scientific and technical problems, to an increase in the productivity of physical and mental labour, and to the improvement of economic indices of production. The achievements of electronics have formed the basis of an industry that produces electronic equipment used in communications, automation, television, radar, computer technology, instrument-making, and industrial-process control systems, as well as illuminating-engineering, infrared, and X-ray equipment.

At the technical college level, electronics technology is aimed at providing trained manpower in applied science, technology and commerce. It is also geared towards giving training and imparting the necessary skills leading to the production of craftsmen, technicians, and other skilled personnel who will be enterprising and self-reliant (Federal Republic of Nigeria (FRN), 2004).

The attainment of the above aims has been rigidly controlled under the tutelage of poor quality teachers, teaching facilities and methods. These, according to Aina (2000) are responsible for the high failure rates in main trade subjects. He asserted that over the years, records have shown that there is a sharp decline in the level of studentsô performances in the National Technical Certificate Examination (NTC). Aina stressed that a close examination of the factors responsible for this wastage indicate that technical college education is no longer attractive to youths because of poor teaching, poor instructional techniques and scanty infrastructural facilities.

With these mass failures in public examination, unemployment and low technological development, the researcher is prompted to look into the instructional techniques used by teachers in the teaching and learning of electronics and hence experiment on the possibility of adopting one modern instructional technique for effective instruction. This can help teaching objectives to be enhanced from intellectual abilities and cognition to psychomotor and affective learning (Overbough, 2003). It will also help the students to meet up with the rapid development of computer application in the world of work.

The rapid development in the use of computer in every facet of life has also necessitated the need for the inclusion of computer application in teaching of electronics. For instance, the present electronic industry utilizes computer to design, analyze and test circuits before they are built (circuit simulation). This has the advantage of saving cost and reduces the risk of accident since faulty circuits are identified and resolved by the software (IEEE, 2008).

A circuit is the combination of various devices in a closed conducting path to perform various useful actions. According to Theraja and Theraja (2006) is a closed conducting path through which electric current flows or is intended to flow. Gibilisco (2001) defined a circuit as a closed path through which current flows from a generator, through various components, and back to the generator. Gibilisco further stated that an electronic circuit is often a combination of interconnected sub circuits.

Simulation means creating something that is similar to real life or behaving like a real life situation. According to Burmen and Tuma (2009), simulation is the reproduction of the essential features of something, e.g. as an aid to study or training. Gibilisco (2001) defines simulation as imitation of the performance of a process, device, or system; the use of a mathematical model to represent a physical process, device, or system orthe use of a computer, sometimes with virtual reality hardware and software, to mimic a real-life situation.

To simulate then means to create something that is similar to real life or behaves like that of real life situation. According to Belz (2007), to simulate is to reproduce features of something

that is to reproduce features of something as an aid or model. Example of this is a computer model simulating the behaviour of a propagated wave. Similarly, Allen (2011) stated that, to simulate is to reproduce the features of something for a given purpose.

Electronic Circuit Simulation is the use of computer software to design, analyze and test circuits before construction. According to Rozenblart(2003), it is a computer program predicting the behaviour of a real circuit. It replaces real components with idealized electrical models. On the other hand, it allows measurements of internal currents, voltages and power that in many cases are virtually impossible to do any other way. Simulation software allows for modeling of circuit operation and is an invaluable analysis tool. Due to its highly accurate modeling capability, many Colleges and Universities like University of Florida and Marne use this type of software for the teaching of electronics technician and electronics engineering programs (O'Haver, 2008). Electronics simulation software engages the user by integrating them into the learning experience. These kinds of interaction actively engage learners to analyze, synthesize, organize, and evaluate content its results in learners constructing their own knowledge (Robbins & Miller, 2002)

The need for circuit simulation in teaching electronics is very important as observing voltages and currents in a circuit can provide an insight that is not always possible with pencil-and-paper analysis. According to Hart (1993), Simulation may be used in place of laboratory experiment, especially during the student's initial study of electronic circuits, or it can be used as a design tool in preparation for laboratory work. He further stated that, observing voltage and current from Simulation accomplishes some of the same objectives as those of laboratory experience. Correspondingly, Pillage (1996) asserted that, with circuit simulation, voltages and currents can be investigated much more efficiently than in hardware laboratory. To him, problems may arise in a laboratory with components, equipment and wiring, which distracts from the primary objective of understanding the operation of a circuit, and, in some instances, a laboratory experiment is not practical. In teaching power electronics, high-powered equipment may not be available for student use, and suitable instrumentation must be employed for power measurement and analysis.

To analyse a circuit, one could build it on screen by selecting components (resistors, capacitors, transistors, diodes, power sources, etc) from a library of parts which then position and interconnect the desired circuit. One can change component values connections and analysis options instantly with the click of a mouse. Simulating a circuitós behaviour before actually building it can greatly improve design efficiency by making faulty designs known as such, and providing insight into the behaviour of electronics circuit designs. The most well knownanalog simulator is SPICE, an acronym for Simulation Program with Integrated Circuit Emphasis.

Circuit simulation programs can be a very powerful tool for teaching the operation of complex circuits and systems. Obtaining an instant answer to a "what if" question can generate interest and a "feel" for how a thing operates not quickly possible through mathematical analysis. Good simulation programs do have a learning curve. Student must use some time to learn to operate and interact with the simulation program that is often not as intuitive as tutorial programs and drill and practice programs. Simulation programs are generally combined circuit design and training tools. Therefore, the teacher must design into his/her course situations and activities involving the simulation program in a useful instructional fashion. A few programs combine simulation with drill and practice to produce easy to use virtual circuits that can be measured, tested and repaired on the computer screen (Resources for Electronics Training, 2006).

The use of circuit simulation in teaching electronics has the potentials of providing students-centred and interactive classroom as well as active involvement of students in learning. Interaction with circuit simulation program provides diverse activities such as active engagement and frequent feedback to students. It also provide human/computer interface which has a direct relationship to studentsô cognitive ability and has tendency to improve studentsô learning, transfer of learning and construction of knowledge. According to Markov (2009), use of circuit simulation software provides change in teacherös role from that of dispenser of information and adviser to that of facilitator and modeller. This provides technology-rich environment to motivate interest and strengthen achievement of electronic learners.

Interest refers to a feeling of curiosity or concern about something that makes the attention turn towards it. Sholahuddin (2010) refers to interest as the desire for something, the object of the soul in order to achieve something desired. According to him, interest creates the inclination to attend to certain stimuli, to engage in certain activities, and to acquire specific knowledge or skills. This illustrates that a person will not achieve the desired aim if the person does not have an interest or desire of the soul to achieve the goals. In conjunction with learning activities, interest becomes a driving force to achieve the desired goals, without the interest, learning objectives will not be achieved.

Academic achievement denotes knowledge and skills attained by students in school or institution subjects or course designed by a score obtained in an achievement test. According to Olaitan, Eyoh&Sowande(2000), academic achievement is always denoted by a score which represent the amount of learning acquired, knowledge gained or skills and competencies in the subjects. The methods and tools employed by a teacher to impact the lesson could influence studentsô learning interest as well as academic achievement (Lowmen, 2006).

As more demands are put upon the education in todayøs world of rapid technology changes, it may be needful to recognize that there is need for Circuit Simulation techniques to be applied in teaching/learning situation in electronics. With Circuit Simulation, electronic teachers will be able to inculcate both academic and workplace skills to the students. Thus, increase in studentsô flexibility in interest, understanding, problem solving and academic achievement will as well make students adaptive to present changes in the world of work.

Statement of the Problem

As a result of increasing industrialization of modern times and the role of electronics in our society, knowledge and skills in electronics become indispensible. According to OøHaver (2008), electronics is playing a leading role in the scientific and technical revolution. The introduction of electronic devices in various areas of human activity contributes in large and often decisive measure to the resolution of complex scientific and technical problems, to an increase in the productivity of physical and mental labour, and to the improvement of economic indices of production.

Technical colleges are expected to produce craftsmen. However, in the past ten years, they have recorded a failure rate of over sixty percent in the West African Certificate Examination (WAEC) and National Business and Technical Examination Board (NABTEB) National Technical Certificate (NTC) trade component of the examination that should certify them as craftsmen (FME,2010). Similarly, the chief examiners report asserted that Radio-Television and Electronic work candidates general performance in the three components was very poor. Specifically, in the NABTEB NTC certificate examination conducted in Radio-Television and Electronics servicing in May/June 2004, students recorded 30% failure rate in

Radio Communication, 60% failure in Television system and 27% failure in electronic devices and circuits (NABTEB 2004). This gives overall performance of candidates to be below average. At present, technical colleges suffer from gross infrastructural dilapidation, staff shortage and inadequacies in facilities, books and instructional equipment (FME, 2010). The Federal Ministry of Education in the national master plan further stressed that, the poor quality staff employed to teach the trades do not posses the skills they are supposed to teach. Also shortage of tools, equipment, training materials as well as limited time given to trade subjects contribute to the failure of the trade to equip the students with vocational skills for employment or self-employment.

Also worthy of note is the fact that the modern industry emphasizes efficiency and accuracy in order to enhance production as well as save cost. A personal interview with some technical employees of Multinational Telecommunication Network (MTN) and Ericson revealed that most of their jobs like networking and signal testing are done with the computer before putting into practice. As a result of this, these employers prefer fresh recruits with requisite knowledge in computer application in various aspects of the profession.

These poor status of craftsmen (electronics students) are pointers to the fact that traditional methods of teaching electronics rarely produce skilled labour employers are looking for in the present world of work. This study therefore sought to find the teaching technique for acquiring the requisite skill in electronics that can enable electronic students become self-reliant.

Purpose of the Study

The main purpose of this study is to determine the effect of Circuit Simulation on achievement and interest of electronics students of technical colleges in Benue State. Specifically the study will;

1. Compare the pre-test scores of the control and the experimental groups in the achievement test.

2. Compare the pre-test and post test scores of the control group in the achievement test

3. Determine difference between the pre-test and post-test mean scores of experimental groups in the achievement test.

4. Compare the post-test scores of the control and experimental groups in the achievement test.

5. Determine the difference between the interest level of the control and the experimental groups in the interest test

Research Questions

The following are the research questions formulated for this study:

1. What are the pre-test mean scores of the control and the experimental groups in the achievement test?

2. What are the pre-test and post-test mean scores of the control group in the achievement test?

3. What are the pre-test and post-test mean scores of experimental group in the achievement test?

4. What are the post-test scores of the control and experimental groups in the achievement test?

5. What are the mean scores of the control and the experimental groups in the interest test?

Hypotheses

The study will be guided by the following null hypotheses to be tested at 0.05 level of significance.

HO_1. There will be no significant difference between the pre-test mean scores of the control and experimental group in the achievement test.

HO_2 There will be no significant difference between the post-test mean scores of the control and experimental groups in the achievement test.

HO_3 There will be no significant difference between the interest level of the control and experimental groups.

Significance of the Study

The findings of this study, if successful will be of benefit to the electronics student, teachers, parents and school administrators. Also to benefit from this research findings are curriculum planners, employers of labour, the government and the society at large.

Electronic students will benefit from this research because the use circuit simulation removes the difficulties that students encounter in analysing circuit using mathematical equations and determinants. The students will also utilize the knowledge beyond the class room environment due to the technological advancement and the introduction of computer application in the industry. This will add value to the parentsô investment in their childrenös education. For the teachers, the use of circuit simulation will ease their work because of the ability of the software to fault the circuits with errors. The school administrators will also benefit because the introduction of this modern method of instruction will affect the studentsô academic and work performance, thus promoting the image of the school.

The curriculum planners will also benefit from the findings because this will help to inculcate modern teaching methods that can meet the modern industrial standards. For the employers of labour, the use of simulation in the classroom will help for the production of quality manpower that meets the modern world. This will also save the cost of retraining.

These findings will also be of help to the government because it will help in realizing the aims of technical education in Nigeria as a result of studentsô increased interest and achievement in electronics. The society will stand to benefit from the quality services of these graduates.

Delimitation of the Study

This study is delimited to four methods of circuit simulation technique namely: Tool selection (I.e. arrow, wire, text, delete, zoom and rotate tools); device (diodes, transistors, resistors, sources, etc) selection/pasting; circuit wiring/analysis and fault simulation. The study however excludes advanced techniques like creating new devices and digital SimCode because of the studentsô present level. It covers the second year students in four Technical Colleges in Benue State.

CHAPTER II

REVIEW OF RELATED LITERATURE

The review of related literature for the study is organized under the following sub-headings.

1. **Conceptual framework:**

-Technical colleges.

- Electronics Technology.

- Teaching/learning of electronics.

- Circuit Simulation

- Learning Interest and Academic achievement

2. Theoretical framework:

- Gestaltôs cognitive theory

- Piagetôs constructivist learning theory.

3. Related Empirical studies.

4. Summary of Related Literature.

Conceptual Framework

Technical Colleges.

Technical colleges in Nigeria have been training people to become craftsmen and technicians. Training qualifies them for jobs in both public and private sectors of the economy. Both sectors, according to Ndomi (2005), require well-trained and competent technicians who can operate and maintain the available technical equipment. Therefore, there is a need for qualitative technical colleges for education and training to produce graduates that can perform competently in their chosen vocation without a need for pre-employment training. The major goal of Vocational and Technical institutions is to prepare students for successful employment in the labour market (Finch &Crunkilton, 1999). This condition can be met through a curriculum that is relevant and comprehensive and a well-equipped workshop with relevant training facilities. School workshops offer opportunities for practical training of students in skill acquisition in their technical trade areas for future development of the key sectors of the economy in order to meet the basic needs of electricity, roads and machinery, among others. Studentõs practical projects are an important part of the curriculum in technical colleges, but a supportive school environment is a fundamental requirement for the successful implementation of curriculum (Bybee&Loucks-Horsely, 2000; Penney & Fox, 1997). This aspect of the curriculum can only be implemented where facilities in the workshop are adequate and relevant. Availability of appropriate facilities enhances student learning by allowing them to be involved in demonstrations, and practice will continue to build their skills. However most of the technical colleges in Nigeria have been forced to perform below standard due to purported non availability, poor management or utter neglect of the required facilities in the workshops for effective training.

In Benue State, there are a total number of eight technical colleges. These comprise of four Governments, two Missionary and two privately owned technical colleges (Ministry of Science and Technology, 2010). Out of these eight, only four offer radio, television and electronics. These colleges produce graduates in the area of electronic technology. The graduates are equipped with different skills required for construction of different electronic circuits as well as maintenance of different electronic appliances such as radios, televisions, digital video disk (DVD) players, computers, wrist watches, clocks and so on. They posses skills and knowledge required in different areas of electronics. Graduates of these colleges are also provided with experiences that will enable them master job tasks requiring entry level skills in the electronic industry. This requires application of scientific, technical knowledge and skills in solution to different problems in the field of electronics and different mathematical computations. Like other senior secondary schools, the duration of electronics technology in technical college is three years for craft level (NTC) and one year for advanced craft level (ANTC). These certificates are awarded by National Business and Technical Examination Board (NABTEB). Activities of technical colleges are coordinated by National Board for Technical Education (NBTE), while NABTEB conducts the entrance and certificate examinations, (FRN, 2004).

Electronics Technology.

Electronics Technology is that aspect of technical education designed for the exploration and development of ideas in electronics. In addition to developing studentsô technological and creative capabilities in related discipline and understanding, electronic technology also offers wide range of context within which students;

- Learn how to control or modify the environment to meet defined needs.
- Develop skills and judgement in the selection and use of electronic resources including materials, equipment and information technology.
- Acquire a system approach to solving electronic problems and making decisions.
- Develop critical thinking and ability to evaluate the quality and effectiveness of products and develop skills in team work.

The aims of electronics technology as an aspect of technical education could be realized through the design/ evaluation of sequence of processes and development of young peopleǿs technological capabilities. According to Ogwo (2002), curriculum of Vocational Technical Education is considered as the totality of those skills and activities systematically planned to educate the students for gainful employment in any chosen occupation or a cluster of occupations. He further maintained that, the curriculum is made to consist of programmes of instruction, organization and evaluation all structured to enable the students acquire knowledge and skills necessary for securing and advancing in any chosen occupation.

UNESCO and Ilo (2002) asserted that, for an effective and efficient realization of vocational and technical education objectives, the following logical steps in principles and theories must be followed;

- The training environment is a replica of the working environment itself.
- The training jobs are carried on in the same way as in occupation itself.
- The trainee is trained specific\ally in the manipulative habits and thinking habits required in the occupation itself.
- The training helps the trainee to capitalize his/her interest and abilities to the highest possible degree.
- The training is given to those who need it, want it and are able to profit by it.

- Adequate repetitive training experiences from the occupation enables right habits of doing and thinking to the degree necessary for employment.
- Instructor in himself is a master of skills and knowledge he/she teaches.
- Training is carried out to the extent where it gives the trainee a productive ability with which he can secure or hold employment.
- Training is given on actual jobs not on exercise or pseudo jobs.
- The content of the training, which is taught, is obtained from the master of the occupation.
- Training should be oriented to the manpower needs of the community.
- Vocational education at the secondary level is considered with preparation of the individual for initial entry employment.

According to the Federal Republic of Nigeria (FRN) (2004), the general education component in the curriculum is aimed at providing the trainee with complete knowledge in secondary education while technical courses are to enhance the understanding of the machines, tools and materials of their trade and application and as a board concrete foundation for post-secondary (technical education) into the polytechnics, colleges of education (technical) or into university. Okoro (1999) stated that, technical college is regarded as principal vocational institution that offers full vocational training intended to prepare students for entry into various occupations.

The FRN (2004) also stated that, at the completion of technical college, the students shall have three options;

- To secure employment.
- To set up their own business and become self-employed and be able to employ others.
- Pursue further education in advance craft/technical programme in polytechnics, colleges of education (technical) and in university.

The above stated options are in line with the broad objectives of technical education, which is to give training and impart necessary skills. These objectives according to Ogbuanya (1999) are intended to be achieved largely through technical colleges where practical skill training is disseminating for the acquisition of skills for self-reliance among Nigerian youth. Accordingly, Ogwo (2002) noted that, technical teachers should realise the need for a better understanding of what method to use in teaching and learning situations as they constitute a most contribution role in studentsô acquisition of knowledge and skills.

Teaching/learning of electronics

Electronics technology, like any other technology course is conventionally taught with manual tools such as chalkboard, drawing board and instruments, still images and physical mock-ups (National Board for Technical Education (NBTE), 2003). According to Vriten as cited in Ukuma (2009), the following procedures are obtained in the traditional method.

- The teacher writes the topic of the lesson on the chalkboard sometime with or without objectives.
- He discusses and explains the procedures.
- Students are expected to listen to the explained procedures.
- Students may ask questions for clarity.
- The class progresses at the paced of the fastest learner, few several teachers will assist the slow learners.
- Ample opportunities are not given to students to practice in electronics because of the traditional instrument such as chalkboard illustrations.
- Students are given task electronics without a clear understanding of the concepts.

According to Ford and Pollar (2004), the traditional instructional aides make it difficult to solve complex and complicated calculations, drawings, theoretical and practical problems easily. Similarly, Johnson and Machenzie (2002) revealed from their finding that traditional instructional aides lack accuracy and consistency both in appearance and performance. In support of these, Regan and Smith (2003) asserted that the traditional instructional methods lack cognitive strategies to ensure students interest, adaptation and problem solving. This implies that the traditional method of instruction and teaching aids limit extensive and variable practices, waste time, non-feasible and boring as students cannot work at their pace. In summary, Okoro (2002) stated that a teacherös sound level of technical knowledge and skill, adequate rich environment, pedagogical techniques and careful articulation of instructional procedures could ensure a productive outcome in students.

Circuit Simulation

The use of technology in every aspect of life has changed the way of doing things and solving problems. Circuit Simulation as earlier mentioned is the use of computer software (circuit simulator) to design, analyse and test circuits before they are built. The approach differs from the conventional methods of using drawing and writing instruments to draw and use mathematical calculations to analyse circuits. This also changes the role of instructor and learnersô approach to learning. According to Spencer, Stubbs and Huber (2000), the role of instructor changes in a technology-based-learning environment. Instructors are no longer the main emphasis in the classroom as their role is shifted from an imparter of knowledge to a facilitator of finding, assessing and making meaning from variety of information. The technology based education instructor also assumes the role of mentor and encourages students to rely on each other and to pursue their knowledge goals more independently. In the use of circuit simulation as an instructional medium, there is a shift in teaching such as departure from direct teaching approach. Teachers use less effort as they function more as lesson guides for students pursuing their educational goals with little dependence. They often, in collaboration with their students, design higher level learning goals and a learning environment that supports the pursuit of those goals (Ozoagu, 2007).

The use of circuit simulation in teaching electronics has been a practice since 1996 at the Wake Forest University and has proven to be accurate and effective (Mathews, 2008). Mathews further stated that with this development,students must test every design in CircuitMaker (simulation) sinceCircuitMaker has virtual voltmeters, oscilloscopes, function generators that behave much like the ones they use in lab. Building circuits in CircuitMaker (simulation) is much faster than building them in lab, and students make fewer wiring mistakes. The software is safe to use alone, and the components never break. Also students quickly determine whether their circuits behave as they planned, if they do not understand something, they find out immediately. They usually discover their own misunderstandings as they frequently discuss the measurements reported by CircuitMaker (simulation) , and work with each other to determine what is wrong with the circuit and their understanding of its underlying principles. He further stated that, ñoccasionally the students need help from me. We nearly always discuss the student's design in front of CircuitMaker. Rather than telling the student the answer, I can prompt the student to measure voltages at key points, so that the student can often discover the problem on his or her own. The student will have learned not only more about the design of the circuit, but will also have learned more about diagnosing circuit problemsò (Stephan and Wriggers, 2010).

Accordingly, Peterson (2010) confirmed that, the use of circuit simulation makes homework time more like lab time such that students are able to observe, model, predict, and observe again as part of homework. He further stated that the difference in what the students in the class are learning was brought home to him most dramatically by a conversation he had with the teaching assistant during the second electronics lab in spring of 1996, their first semester of using this software. In his observation, the students were all hard at work building and diagnosing circuits. Unlike in the past where he and the training assistant could not keep up with all the questions and need for help, this day, the questions were rare. In his assertion, an hour with CircuitMaker is worth around three hours of lab time. (You can wire with the software much faster than you can breadboard real components.) By second lab, the students had more "virtual" lab experience than most would gain in a semester of "real" electronics labs. With this, he assigned more difficult work in the subsequent class and the students met his expectations.

Conducting a lesson using Circuit Simulation

The main aim of teaching and learning is to ensure that learners attain the set goals, aims and objectives of a given course or programme. In doing this, various methods and strategies are employed or experimented to ascertain the most effective approach in teaching various concepts.

In teaching electronics with the aid of circuit simulation, the following steps are followed.

Step 1: Preparing for the lesson.

- Make a logical lesson plan following the syllabus.
- Select the relevant circuits as specified by the syllabus.
- Using your chosen circuit simulation software, practice the construction of the selected circuits from the simplest to the complex.
- Repeat the process for conversance and competence.
- Simulate the circuits against faults.

Step 2: Before administering the lesson, the teacher should ensure that:

- The students are conversant with the basic keys through drill and practice.
- The students understand the meaning and function of each tool from the simulator's tool bar.
- The students are able to do click and drag with the mouse.

Step 3: During the instructional session, the teacher should;

- Engage the students in the active use of key-board and mouse.
- Teach the students how to select and place devices from the tool bar.
- Teach the students how to wire the devices together to form a circuit.
- Teach the students how to simulate the circuit.

Circuit Simulation and the Modern industries

The dynamic nature of technology, particularly the electronic technology has made it necessary to bridge the existing gap between the training institutions and the industry. This is because of the fast replacement of manual application in the industry with the computer. According to IEE (2006), labour saving ideas involving the computer, particularly for industrial and mechanical purposes, is a never-ending process. Computers in industry are drastically changing the way things are made and profoundly changing the jobs of the people who make them. In 1947 the California Institute of Technology devised a method for using computers to aid in designing aircraft. By 1950, the Massachusetts Institute of Technology (MIT) had developed an automatically controlled milling machine used in cutting metal parts. In 1963, Sketchpad, an early forerunner of the Computer Aided Design (CAD) system, was developed by Lincoln Laboratories. A similar system, DAC-1 from General Motors, was developed at the same time. In 1968 MIT and the U.S. Air Force jointly developed a CAD/CAM (computer aided manufacturing) system to drive lathes and tooling machines used in the aeronautics industry. By the 1970s a number of new methods were developed to remove much of the tedious and manual processes from design and manufacturing work. Now an essential part of industry, CAD/CAM, as it is more commonly called, is the process of using the computer in design and manufacturing functions. Thousands or tens of thousands of highly technical and accurate drawings and charts are required for the many design specifications, blueprints, material lists and other documents used to build complex machines.

If the engineers decide structural components need to be changed, all the plans and drawings must also be changed. Prior to CAD/CAM, human designers and draftspersons had to change them manually, a time consuming and error-prone process.

When a CAD system is used, the computer can automatically evaluate and change all corresponding documents instantly. Using interactive graphics workstations, designers, engineers and architects can create models or drawings, increase or decrease sizes, rotate or change them at will, and see results instantly on screen. CAD use is particularly valuable in space programs, where many unknown design variables are involved. Previously, engineers depended upon trial-and-error testing and modification, a time consuming and possibly life threatening process. However, when aided by computer simulation and testing, a great deal of time, money and possibly lives can be saved. Besides its use in the military, CAD is also used in civil aeronautics, automotive and data processing industries. CAM, commonly utilized in conjunction with CAD, uses the computer to communicate instructions to automated machinery. CAM techniques are especially suited for manufacturing plants, where tasks are repetitive, tedious or dangerous for human workers. While the use of CAD/CAM systems enables the production of better, less expensive products, workers stand to lose their livelihoods due to the increased acceptance of automated systems. Computer Integrated Manufacturing (CIM), a term popularized by Joseph Harrington in 1975, is also known as Autofacturing. CIM is a programmable manufacturing method designed to link CAD, CAM, industrial robotics, and machine manufacturing using unattended processing workstations. CIM offers uninterrupted operation from raw materials to finished product, with the added benefits of quality assurance and automated assembly. Computer Aided Engineering (CAE), which appeared in the late 1970s, combines software, hardware, graphics, automated analysis, simulated operation and physical testing to improve accuracy, effectiveness and productivity.

Learning Interest and Academic achievement

Interest refers to a feeling of curiosity or concern about something that makes the attention turn towards it. Sholahuddin (2010) refers to interest as the desire for something, the object of the soul in order to achieve something desired. According to him, interest creates the inclination to attend to certain stimuli, to engage in certain activities, and to acquire specific knowledge or skills. This illustrates that a person will not achieve the desired inner if the person does not have an interest or desire of the soul to achieve the goals. In conjunction with learning activities, interests became a driving force to achieve the desired goals, without the interest, learning objectives will not be achieved. According to Ainley&Hidi, (2002), within the interest literature, the relationship between interest and learning focuses on three types of interest: individual, situational, and topic. *Individual* interest is considered to be an individualôs predisposition to attend to certain stimuli, events, and objects. *Situational* interest is elicited by certain aspects of the environment. These include content features such as human activity or life themes, and structural features such as the ways in which tasks are organized and presented. *Topic* interest, the level of interest triggered when a specific topic is presented, seems to have both individual and situational aspects.

In their designed framework termed Interest-Driven Learning (IDL), Edelson and Joseph (2001) address two major challenges to the design of interest-driven learning. The first challenge is motivating the broad range of learning objectives that are valued in our educational systems, many of which do not appear to hold any interest to their intended audience. We call this the challenge of coverage. The IDL framework addresses the challenge of coverage through strategies for creating relevance for learning objectives. The second challenge is accommodating the variation in the motivational strength of interests among different individuals and within the same individual at different times. We call this the challenge of strength. The IDL framework addresses the challenge of strength through the use of a variety of types of motivation to supplement interest.

The IDL Framework is designed to take advantage of the unique benefits of interest as a motivator for learning. Prior research has described three benefits of interest in comparison to other sources of motivation: Mastery goal orientation toward learning, increased persistence and effort, and more richly and strongly connected knowledge.

Mastery Goal Orientation.As Schiefele (1991) has observed, interest leads to a mastery goal orientation. When learners are motivated by interest, they are motivated by the intrinsic reward of having knowledge that they recognize will be useful to them. When a learner perceives that certain knowledge or skills are useful to the pursuit of an interest, he or she is drawn to masterthe knowledge or skills, not just to demonstratethem. In other words, a learner motivated by interest possesses a natural mastery orientation toward learning. This contrasts with the performance goal orientation that results from sources of motivation in which the perceived value is achievement or recognition. Researchers have accumulated a considerable body of evidence showing the positive impact of a mastery goal orientation on learning outcomes (Ames, 1992; Dweck, 1986; Lepper, 1988; Meece, 1991).

Persistence and Effort. Research has shown that when a student has interest in a task, he or she is likely to expend more effort and persist longer at that task. Interest has been shown to lead to more persistent motivation and greater effort in a range of learning tasks. (Hannover, 1998). In a review of the research on interest and learning in reading, Hidi (1990) cites a wide range of experiments showing the positive impact of interest on engagement, attention, and learning outcomes.

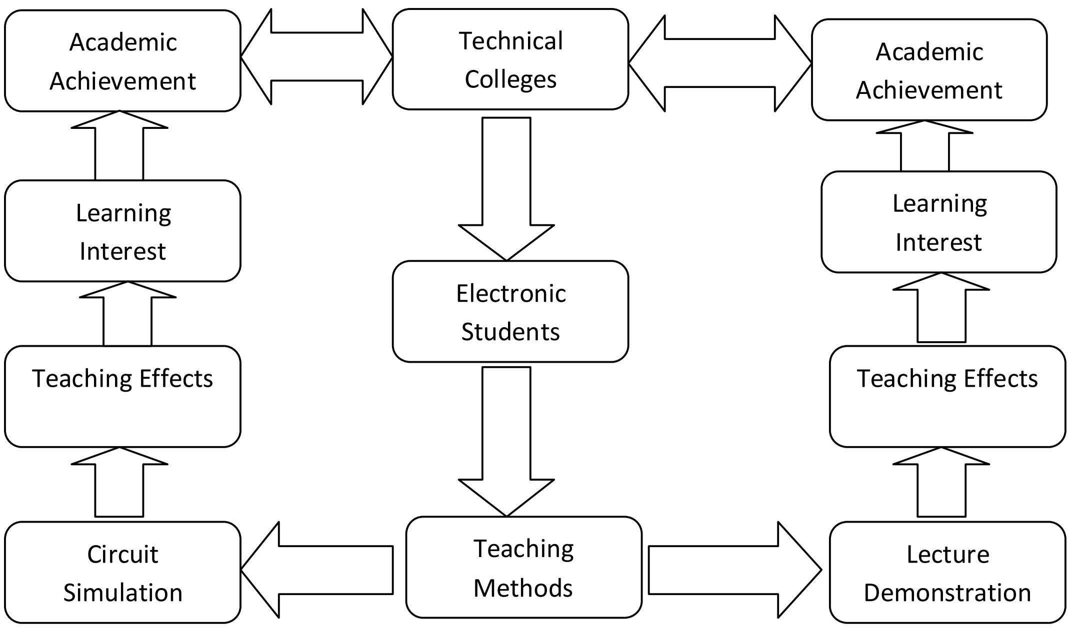
More Richly and Strongly Connected Knowledge. Individual interest, in particular, carries an important cognitive benefit for learning because people have rich knowledge structures to build upon in their areas of interest. Renninger (2000) describes this as the ñstored knowledgeò component These elaborated knowledge structures offer the opportunity for rich connections between new and prior knowledge. Studies by Schiefele (1991) and Alexander *et al*. (1995), have demonstrated the benefits of high interest and high knowledge in text comprehension and retention. The enduring quality of individual interest also implies that new knowledge is likely to be reinforced by frequent use.

Academic achievement

Academic achievement denotes knowledge and skills attained by students in school or institution subjects or course designed by a score obtained in an achievement test. An achievement test is an instrument administered to an individual to elicit certain desired and expected responses, as demanded in the instrument. According to Olaitanetal (2000), academic achievement is always denoted by a score which represent the amount of learning acquired, knowledge gained or skills and competencies in the subjects.

Academic achievement is hinged on seven factors. These include; teaching method, intelligence, background, organization, opportunity, motivation, instructional procedures, teaching aids, learnersô interest and others,(Artherton, 2003). Artherton further stated other factors like learnerôs mental ability, his goals and purposes, his identification with learning, his maturation and methods of guidance, availability of facilities and methods of testing as affecting the learnerôs achievement. Similarly, Rhoades, Bar-yam and Sweeney (2006) confirmed that the effectiveness of teaching and the pertinence of the assessment of learning achievement can be enhanced by teaching adaptation of instructional strategies to students learning style. In conformity, Lowmen (2006) asserted that the methods and tools employed by a teacher to impact the lesson could influence studentsô learning and academic achievement.

The conceptual framework is represented in the schema below.



Two groups of Electronic students from Technical Colleges in Benue State were subjected to two teaching methods (that is, the **lecture demonstration** and **circuit simulation**). These methods of teaching are expected to create various effects on the students. These effects are expected to influence the learning interest of the students which will in turn influence the academic achievement of the students. At the end of the experiment, the mean scores from the interest inventory and the achievement test were compared to determine the most effective method.

Theoretical Framework.

A theory consists of concepts, constructs, principles and propositions that serve as the body of knowledge (Association for Educational Communications and Technology (AECT), 2001). According to Camp (2001), it is a set of interrelated constructs, definitions and propositions that present a rational view of phenomena by explaining or predicting relationship among those elements. Theories of learning are statements of principles formulated out of certain observed phenomena which have been verified have been verified to some degree as having apparent relationships with instructional techniques (Asuquo, 2005). He noted that theories guide practice and lead to application of knowledge to solve real-world problems. To this effect, the theoretical framework of this study is based on cognitive, constructivist and simulation learning theories.

Gestalt's Cognitive Theory

The theory of cognitive learning emerged in the 1950s and the major proponents this theory were Max Wertheimer, Wolfgang Kohler and Kurt Koffka. Cognitive theorists conceive learning as resulting from learnersô cognitive processes such as perceptual, problem solving and thinking abilities. According to Ogwo (2005), the main futures of these theories are their stress on human intelligence and its potentials for helping learners retain process and apply acquired information in future. He further stressed that cognitive theories are compliant in discovery, insightful and inquiry-based learning. The principles are expedient in teaching engineering and graphic designs, mathematical calculations and creative writing.

Also known as Gestalt theorists, the cognitive theorists view learning as connection, hence the theory is commonly known as the theory of connectionism. They see learning also as occurring by association between stimulus and response. The main theme of this theory states that for every stimulus(S) there is a response® and when the response to a stimulus is followed with some positive effect (i.e. reward and satisfaction, that particular stimulus response (S-R) bond would be stamped in, where as others followed by some negative effect (i.e. punishment and annoyance) would stamp it out from the behaviour of the organism. To them, learning was a stamping in of the successful stimulus response(S-R) bonds and forgetting was a stamping out of the unsuccessful stimulus response(S-R) bonds. This basic concept of learning is the main viewpoint in the Cognitive Learning Theory (CLT). The theory has been used to explain mental processes as they are influenced by both intrinsic and extrinsic factors, which eventually bring about learning in an individual.

Cognitive Learning Theory implies that the different processes concerning learning can be explained by analyzing the mental processes first. It posits that with effective cognitive processes, learning is easier and new information can be stored in the memory for a long time. On the other hand, ineffective cognitive processes result to learning difficulties that can be seen anytime during the lifetime of an individual.

According to Uhlig (2008), the person-environment interaction, human beliefs, ideas and cognitive competencies are modified by external factors such as a supportive parent, stressful environment or a hot climate. In the person-behavior interaction, the cognitive processes of a person affect his behavior; likewise, performance of such behavior can modify the way he thinks. Lastly, the environment-behavior interaction, external factors can alter the way you display the behavior. Also, your behavior can affect and modify your environment. This model clearly implies that for effective and positive learning to occur an individual should have positive personal characteristics, exhibit appropriate behavior and stay in a supportive environment. In addition, Social Cognitive Theory states that new experiences are to be evaluated by the learner by means of analyzing his past experiences with the same determinants. Learning, therefore, is a result of a thorough evaluation of the present experience versus the past.

Uhlig (2008) further stated that among the several basic concepts that can manifest not only in adults but also in infants, children and adolescents are Observational Learning and Reproductive Learning. He views Observational Learning as learning from other people by means of observing them to effectively way of gain knowledge and alters behavior. While Reproduction is the process wherein there is an aim to effectively increase the repeating of a behavior by means of putting the individual in a comfortable environment with readily accessible materials to motivate him to retain the new knowledge and behavior learned and practice them.

Piaget's Constructivist Theory

The ñconstructivist stance maintains that learning is a process of constructing meaning; it is how people make sense of their experienceò (Merriam and Caffarella, 1999). This is a combination effect of using a personôs cognitive abilities and insight to understand their environment. This concept is easily translated into a self-directed learning style, where the individual has the ability to take in all the information and the environment of a problem and learn.

Although varying constructivist theories exist, there is agreement between the theories ñthat learning is a process of constructing meaning; it is how people make sense of their experienceò (Merriam &Caffaerall, 1999). Two viewpoints of constructivist theories exist.

They include the individual constructivist view and the social constructivist view. To them, the individualist constructivist view understands learning to be an intrinsically personal process whereby ñmeaning is made by the individual and is dependent upon the individualôs previous and current knowledge structureò and as a result can be considered an ñinternal cognitive activityò. The social constructivist view, however, premises that learning is constructed through social interaction and discourse and is considered, to be a process in which meaning is made dialogically (Merriam &Caffaerall, 1999).

When applying this theory to independent learning, it is essential to understand that we need to consider the cultural environment in which this learning takes place. Isolated learning is an oxymoron. Merriam and Caffarella (1999) suggest that adult learning, while self-directed, must have input from outside influences. That may take the form of investigation, social interaction, or more formal learning environments.

The constructivist learning approach involves educators building school curriculum around the experience of their students. Constructivists believe learner-centric instructional classroom methods will strengthen the commitment and involvement of self-motivated learners because of their high level of interaction. Constructivist theory's main theme is that learning is a process in which the learner is able to build on present and previous information. The student is able to take information, create ideas and make choices by utilizing a thought process. The trainer should encourage the student to develop the skills to find out principles on their own. There should be on-going dialog between the student and the trainer. The trainer is responsible for making sure the information is in a format the student can comprehend. The key is to assure that the course builds on what has already been learned.

Relating cognitive and constructivist theories with circuit simulation, Mathews (1996) asserted that through circuit simulation, students can pull together the concepts they have studied, and they can learn to synthesize these concepts to produce new designs for novel purposes. Students must test every design in Circuit Maker. CircuitMaker has virtual voltmeters, oscilloscopes, function generators that behave much like the ones they use in lab.

Building circuits in CircuitMaker is much faster than building them in lab, and students make fewer wiring mistakes. The software is safe to use alone, and the components never break! Students quickly determine whether their circuits behave as they planned. If they do not understand something, they find out immediately. They usually discover their own misunderstandings and discuss the measurements reported by CircuitMaker, and work with each other to determine what is wrong with the circuit and their understanding of its underlying principles.

Narrating his experience with the learners, Mathews stated that ñoccasionally the students need help from me. We nearly always discuss the student's design in front of CircuitMaker. Rather than telling the student the answer, I can prompt the student to measure voltages at key points, so that the student can often discover the problem on his or her ownò. The student will have learned not only more about the design of the circuit, but will also have learned more about diagnosing circuit problems.

Related Empirical Studies.

Jimoyiannis and Komis (2001) examined the effect of the computer simulations on sixty (60) students in Florida to understand the orbital movements, by using basic concepts related with kinematics, in a study made in physics teaching. Jimoyiannis and Komismade made use of post test only, contrast design in their study. The data collected was analysed using mean and standard deviation. As a result of this study, it was seen that teaching basic concepts of kinematics through simulations has brought about successful results and has contributed highly to learning process. The result suggested that the use of simulation in place of still images has the potentials of enhancing studentsô interest, attention and understanding.

Karamustafaoĵ lu (2005) studied the influence of computer based physics activities on studentsô acquisitions is searched on the subject of Simple Harmonic Motion. A 20 question post-test only was used to determine the influence of computer based physics on 120 students. The results were analysed by comparing the mean scores of the experimental and control groups. It was realized that the teaching realized by the simulation program with an applied dynamic system is more successful than the teaching implemented by traditional methods. Also in this study it is stressed that a well-prepared simulation isnọt very adequate by itself and it is necessary to support the simulations considered to be used in order to be able to obtain good results from instruction with the instructive programs concerning related subjects and concept. The studies show that computer based learning by way of simulation programs makes the concepts and processes more concrete and causes the students to understand more easily the relationship between them and as a result of this, a more permanent learning is achieved

A dissertation completed at Texas A&M University (Van LeJeune, 2002) synthesized the findings from existing research on the effects of computer-simulated experiments on studies in science education. Results from 40 reports were integrated by the process of meta-analysis to examine the effect of computer-simulated experiments and interactive videodisk simulation on student achievement and attitudes. Findings indicated significant positive differences in both low-level and high-level achievement of students who use computer-simulated experiments and interactive videodisc simulation as compared to students who used more traditional learning activities. No significant differences in retention or in student attitudes toward the subject or toward the educational method were found. Based on the findings of the study, computer-simulated experiments and interactive videodisk simulation should be used to enhance student learning in science, especially in cases where the use of traditional laboratory activities is expensive, dangerous or impractical (Van LeJeune, 2002). The study concluded that:

- The use of computer-simulated experiments and interactive videodisk simulation in science classrooms improves studentsô low-level achievement, such as ability to learn facts, comprehend scientific processes and apply that knowledge
- The use of computer-simulated experiments and interactive videodisc simulation in science education classrooms improves student problem solving ability and other higher-order thinking skills as compared to traditional science laboratory activities.
- The use of computer-simulated experiments and interactive videodisc simulation in science education classrooms is as equally effective as traditional science laboratory activities in promoting retention of material for a period of two weeks or more
- The use of computer-simulated experiments and interactive videodisc simulation in science education classrooms promoted positive student attitudes toward the subject matter.
- Research on the effects of simulation on student attitudes is much less prevalent than research on student achievement.

Recently some studies have been performed about whether the computer simulation experiments or traditional laboratory experiments are effective on the studentsô successes about Science subjects. According to Bekir ,Uygar and ķebnem (2007) in the study: ñIs the computer based physics instruction as effective as laboratory intensive physics instruction with regards to academic success on electric circuits 9th grade students?ò For this research on 40 students of experimental quality, the design of pre-test and post-test were applied with an experiment and a control group. Data were collected by ñComputer Laboratory Interest Survey (CLIS)ò, ñPhysics Laboratory Interest Survey (PLIS)ò, and ñElectrical Circuits

Success Test (ECST)ò. For the analyses of the data, the arithmetic mean, the standard deviation, dependent and independent t-tests were used. The mean score of the post test of the experiment group was 20,42 (+/- 6,07), but the mean score of the post test of the control group is 19,35 (+/- 4,74). According to this data, the difference between the mean of post test scores of the control group and the experiment group is not meaningful statistically. It also shows that the results of the post test of the two groups are not different from each other. At the end of the study it was seen that there did not exist a significant difference between the instruction in laboratory and the instruction with computer to influence the success of the students. Thereby, it can be concluded that the computer based learning is as effective as the laboratory based learning on studentsô achievement.

Similarly, in a Comparison of Traditional Physical Laboratory and Computer Simulated Laboratory Experiences in Relation to Engineering Undergraduate Studentsô Conceptual Understandings of a Communication Systems Topic, Javidi (2004) found a significant difference on the conceptual test scores between the two groups, in favour of the simulation group. The study was made of 80 students with the control and experimental groups having 40 students each. The results of the finding indicated that simulation group reported more positive attitude toward the laboratory experience than the physical group. In particular, on specific items such as time spent in the lab and student enjoyment, the mean of the simulation group was higher. It was also found that there was positive correlation between the simulation group attitude and their post-test score

Furthermore, the results showed that there was significant difference between the simulation group and the physical group on their post-test scores and follow-up scores. However, no significant difference was found in the physical groupôs scores between the post-test and the follow-up test. The simulation groupôs scores at the post-test were, however, significantly higher than the follow-up scores. These results clearly support that the physical group retained knowledge between the two tests better than the simulation group although the simulation groupǿs follow-up scores were still significantly higher than those obtained by the physical group as discussed above.

The findings of Javidi (2004) were however inconsistent with the earlier findings by Moslehpour (1993) and Hall (2000) which reported no significant differences in student achievement between those who simulate a laboratory exercise and those who perform the same laboratory exercise in a traditional hardware laboratory. The findings are also inconsistent with the findings of Choi et al. (1987), which showed that there was a significant difference (in favour of physical group) between the two groups in the learning of the volume displacement concepts. Based on these results the researchers concluded that computer simulated experiences were not as effective as hands-on experiences which does not agree with the results obtained from this study.

Summary of Review of Related Literature

This review of related literature has covered such areas as the studies about learning process, with an insight into two major groups of learning theories that have dominated discussion on how learning takes place; cognitive field theory and constructivist learning theory. Instructional theories have proposed theoretical models of the connection between learnerǿs environment and internal events of cognitive and learning. To promote learning, these theorists prescribed the applications of various instructional strategies such as the selection of appropriate delivery medium of instruction.

This study seeks to use circuit simulation as an instructional medium to stimulate and enhance studentsô academic achievement and interest in electronics technology. The review highlighted academic achievement and interest in learning, relevance of electronic technology and its curriculum in technical colleges. Other areas reviewed include prevalent instructional methods in teaching electronics, meaning and benefits of Circuit Simulation to electronic students and how to conduct a lesson using Circuit Simulation.

The empirical studies carried out by Jimoyiannis and Komis, Karamustafaoĵ lu, Van LeJeune, Bekir, Uygar, Sebnem and Javidi, favoured the use of simulation as an instructional medium. The findings of Moslehpour and Hall showed no significant differences in studentsô achievement between simulation and laboratory exercise. The review did not reveal any study on the effects of circuit simulation on academic achievement and interest of technical college electronic students. However, the studies done in other areas have shown that circuit simulation improves studentsô academic achievement, understanding and attitude.

CHAPTER III

METHODOLOGY

This study presents the procedure for conducting the study under the following headings; design of the study, area of the study, population for the study, sample and sampling technique, experimental procedures, instrument for data collection, validation reliability of instrument and method of data analysis.

Design of the Study

This study used quasi-experiment, non-equivalent control group design. When randomization is not possible, Gall, Borg and Gall, (2007) stated that quasi experiment is a suitable alternative. The subjects in this study were not randomly assigned; intact class of the students was randomly assigned to either the experimental group or the control group where both intact groups were given a pretest and post test. Hence, this is suitable for this study since intact class was used.

The experimental design is graphically shown below:

Group 1	Experimental group	$0_1 \times 0_2$
Group 2	Control group	0_3 ï 0_4

For the group 1 (experimental), 0_1 and 0_2 stand for the pre-test and post-test scores while group 2 has 0_3 and 0_4 as the pre-test and post-test scores. This shows that the experimental group was given a treatment ôXô (circuit simulation) while the control group maintained the lecture method. At the end of the experiment, the researcher;

- compared the gain in scores of the two groups (0_2-0_1 and 0_4-0_3) and a difference in gain showed that simulation had an effect on studentsô achievement.
- Compared the pretest scores ($0_1$and 0_3) to see if there is any initial difference between the two groups.
- Compared the two post-test means to determine the effect of the treatment.

Area of the Study

This study was conducted in Benue State. The four technical colleges that offer electronics in the state were involved in the study. These include; Government Science and technical college, Makurdi, Government Science and Technical college, Zaki-Biam, Saint Jude Technical College, Vandeikya, and Federal Science and Technical College Otupko. Benue State was chosen because of the fast growing industries in the state that need competent technical manpower.

The choice of these Technical Colleges was informed by the fact that they all offer Radio and Television trade at the NABTEB level. These colleges also have relevant facilities like functional practical laboratories as well as computer laboratories.

Population for the Study

The population for this study comprised 132 NTC II students of Radio and Television in the selected Technical Colleges. The choice of the NTC II was because the students are expected to have offered basic electronics in their first year and were about to offer electronic circuits and devices in their national and terminal examination. The data on the studentsô figure was obtained from the principals of the colleges for the 2011/2012 session. There was no sampling because of the small population.

Instruments for Data Collection

The instruments that were used in this study are the Electronics Circuit and Devices Achievement Test (ECDAT) of thirty (30) objective questions. The same questions were used as pre-test and post-test items. Also used was the interest inventory of twenty-five (25) questions to evaluate the studentsô interest in the control and the experimental groups. The interest inventories were administered at the end of the entire lesson.

Validation of the Instruments

The achievement test and the interest inventory were subjected to content and face validation by three experts, two from the Department of Vocational Teacher Education and a Computer System Analyst from Institute of African Studies, University of Nigeria, Nsukka. These experts reviewed the instruments appropriately. Their corrections were made and incorporated in this work. The test items were generated in line with the specific learning outcome of NTC II, term 2 contact.

Reliability of the Instruments

The reliability coefficient of the electronic achievement test was established with test-retest method. This method is appropriate for this study as it involves repeated measurement with same instrument (Eze, 2005). The reliability coefficient was determined using Pearsonôs Product Moment correlation statistical tool. The achievement test was administered on twenty (20) NTC II electronics students at Government Science and Technical College, Bukuru, Plateau State. The reliability of the interest inventories was established by trial testing using the same twenty (20) students.

Control of Extraneous Variables

To avoid any bias, the subjects in the two groups were not informed that they were being involved in any research. The same lesson content was taught to both experimental and control groups. Each class was grouped into experimental and control groups to ensure that both groups have the same entry aptitude.

Teacher Variability

To control invalidity that could be caused by this variable and to ensure uniform standard in the conduct of the research, the researcher personally prepare the teaching instruments (the circuit simulation instruction lesson plans) and organized training for participating teachers. The teachers were given detail explanation on the use of circuit simulation software and other research expectations.

Experimental Procedure

This study was conducted during the 2011/2012 academic session. The study embraced two groups;

Group 1 - Exposed to circuit simulation instruction.

Group 2 - Exposed to traditional (lecture) method.

Both groups completed a pre-test before the treatment at the same time and setting. After pre-test, the control group commenced learning the material through traditional classroom instruction. The traditional method of chalkboard was used to assist in the presentation of instructional materials. Circuit simulation instruction was used for the experimental group in each class meeting. Each group received an equal amount of instructional time. The duration of the study was five weeks with one hour of classroom instruction per week.

The students were taught by their regular or permanent teachers under the researcherøs supervision. A post-test was given to those exposed to traditional instruction and circuit simulation instruction at the end of the study.

Experimental treatment was conducted for five weeks so that the pre-test did not affect the post-test scores or to interfere with the experimental treatment. Also the test items were reshuffled before the administration of the post-test.

Methods of Data Collection

The researcher with the aid of regular teachers subjected the two groups to pre-testing exercise with the ECDA test to test their requisite knowledge. Thereafter the experimental group was subjected to the treatment after which the post-test was administered to both groups.

The pre-test and post-test scores of the experimental group were recorded and compared with those of the control group. The results were recorded and compared.

Methods of Data Analysis

The research questions were answered using mean of the test scores and the interest inventory responses, while analysis of covariance (ANCOVA) was used to test the hypotheses at 0.05 level of significance. Each of the questions in the 30 multiple choice questions was treated as a point. This implies that item by item test analysis was adopted.

CHAPTER IV

PRESENTATION AND ANALYSIS OF DATA

This chapter deals with the presentation and analysis of data in line with the research questions and hypothesis formulated to guide the study.

Research Question 1

What are the pre-test mean scores of the control and the experimental groups in the ECDAT?

Data in relation to research question 1 is collated and presented in Table 1

Table 1:Mean and standard deviation for pre-test ECDAT scores for the control and experimental groups

	N	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
CGPRT	66	9.00	19.00	13.8030	.25749	2.09189
EGPRT	66	8.00	21.00	13.5455	.27497	2.23388
Valid N (listwise)	66					

From Table 1, the pre-test mean scores for the control group was 13.80 and standard deviation of 2.09 while the experimental group has 13.55 and the standard deviation of 2.23. The difference is not statistically significant. This shows that the students in the two groups had the same aptitude before the re-test.

Research Question 2

What are the pre-test and post-test mean scores of the control group in the ECDAT?

Data in relation to research question 2 is collated and presented in Table 2

Table 2:Mean and standard deviation for the pre-test and post-test ECDAT scores for the control group

	N	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
CGPRT	66	9.00	19.00	13.8030	.25749	2.09189
CGPOT	66	13.00	24.00	18.3485	.28193	2.29040
Valid N (listwise)	66					

Table 2 shows the studentsô ECDAT pre-test and post-test mean scores for the control group. The pre-test mean score was 13.80 and standard deviation of 2.09 while the post-test mean score was 18.35 and standard deviation of 2.29. This suggests that learning took place even when students were taught with the lecture demonstration method.

Research Question 3

What are the pre-test and post-test mean scores of experimental group in the ECDAT?

Data in relation to research question 3 is collated and presented in Table 3

Table 3: Mean and standard deviation for the pre-test and post-test ECDAT scores of experimental group

	N	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
EGPRT	66	8.00	21.00	13.5455	.27497	2.23388
EGPOT	66	18.00	28.00	22.8636	.32163	2.61291
Valid N (listwise)	66					

From Table 3, the student in the experimental group had pre-test mean score of 13.55 while the post-test mean score was 22.86. This shows that the students achieved meaningfully when they were taught with Circuit Simulation.

Research Question 4

What are the post-test scores of the control and experimental group in the ECDAT?

Data in relation to research question 4 is collated and presented in Table 4

Table 4: Mean and standard deviation for the post-test ECDAT scores of control and exp. groups

	N	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
CGPOT	66	13.00	24.00	18.3485	.28193	2.29040
EGPOT	66	18.00	28.00	22.8636	.32163	2.61291
Valid N (listwise)	66					

Table 4 compares the post-test mean scores for the control and the experimental groups. The post-test mean score for the control group was 18.35 while that of the experimental group was 22.86. This shows that, though learning took place in both groups, those taught with the circuit simulation achieved higher than those taught with the lecture demonstration method.

Research Question 5

What are the mean scores of the control and the experimental groups in the interest test?

Data in relation to research question 5 is collated and presented in Table 5

Table 5: Mean and standard deviation for the control and experimental group interest

	N	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
CGIT	25	2.17	3.03	2.5836	.05153	.25763
EGIT	25	3.53	4.00	3.75744	.02015	.10075
Valid N (listwise)	25					

From Table 5, the mean score for the control group in the interest test was 2.58 while that of the experimental group was 3.77. This indicates that students taught with circuit simulation showed more interest than those taught with the lecture demonstration method.

Hypothesis 1

There were no significant difference between the pre-test scores of the control and experimental groups.

The test of this hypothesis 1 is presented in Table 6

Table 6: ANCOVA Tests of Between the control and experimental groups pre-test scores (Dependent Variable:EGPRT)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	299.948[a]	1	299.948	786.254	.000
Intercept	.577	1	.577	1.513	.223
CGPRT	299.948	1	299.948	786.254	.000
Error	24.415	64	.381		
Total	12434.000	66			
Corrected Total	324.364	65			

From Table 6 shows the Sig. P-value of 0.22 > 0.05. It indicates that there is no significant difference, thus accepting the null hypothesis (H_O). This shows that there is no significant difference between the pre-test mean scores of the control and experimental groups.

Hypothesis 2

There were no significant difference between the post-test scores of the control and experimental groups.

The test of this hypothesis 2 is presented in Table 7

Table 7: ANCOVA Tests of Between the control and experimental groups post-test scores (Dependent Variable:EGPOT)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	423.783[a]	1	423.783	1356.818	.000
Intercept	5.786	1	5.786	18.525	.000
CGPOT	423.783	1	423.783	1356.818	.000
Error	19.990	64	.312		
Total	34945.000	66			
Corrected Total	443.773	65			

From Table 7, the sig. P-value is 0.00 < 0.05. The value indicates that there is a significant difference at 0.05 level of significant, thus accepting the null hypothesis. This shows that there is a significant difference between the post-test scores of the experimental and the control groups.

Hypothesis 3

There will be no significant difference between the interest level of the control and experimental groups

The test of this hypothesis 3 is presented in Table 7

Table 8: ANCOVA Tests of Between the control and experimental groups' interest mean scores (Dependent Variable:EGII)

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	.000[a]	0	.	.	.
Intercept	924.548	1	924.548	35490.996	000
Error	.625	24	.026		
Total	925.173	25			
Corrected Total	.625	24			

Table 8 shows a sig. P-value of 0.00 < 0.05. This indicates that there is a significant difference between the mean interest scores of the control and experimental groups at 0.05 level of significance. The null hypothesis is therefore rejected. This shows that students showed more interest when taught with the circuit simulation than when lecture demonstration was used.

Findings of the study

The findings of the study were:

(a) The reliability of the instruments was high as indicated by the SPSS Pearson's correlation at 0.01 and 0.05 levels of significance.

(b) There was no significant difference observed on the mean pre-test scores between the control and the experimental groups.

(c) There was a significant difference in the pre-test and post-test scores of the control group.

(d) There was a significant difference in the pre-test and post test scores of the experimental group.

(e) The students in the experimental group scored higher than those in the control group on the post-test.

(f) The students in the experimental group scored higher than their control counterparts in the interest test.

(g) The overall result showed that students taught with circuit simulation paid more interest and higher achievement than those taught with the lecture demonstration method.

Discussion of the Findings

The results shown in Table 1 are the descriptive statistics of studentsô pre-test achievement for the experimental and the control groups. The results showed that there was no significant difference on the mean pre-test scores between the experimental group ($\bar{x}$ =13.54) and control group ($\bar{x}$=13.80). After the pre-test, the two groups were subjected various treatments. That is, the control group taught with lecture demonstration while the experimental group was taught using circuit simulation. At the end of the treatment, a pot-test was administered with the experimental group ($\bar{x}$=22.86) and control group ($\bar{x}$=18.35), showing that though learning took place in both groups, the experimental group scored higher as indicated in Table 4. This finding is in line with that of Jimoyiannis and Komis (2001) which confirmed that teaching basic concepts of kinematics through simulations has brought about successful results and has contributed highly to learning process. It also agreed with the findings of Karamustafaoĵlu (2005) whose studies showed that computer based learning by way of simulation programs makes the concepts and processes more concrete and causes the students to understand more easily the relationship between them and as a result of this, a more permanent learning is achieved

The interest level of the students in the two groups was also tested at the end of the treatment. Table 5 shows that, students in the experimental group ($\bar{x}$=3.77) and the control group ($\bar{x}$=2.58). This indicates that students showed more interest when taught with circuit simulation than those taught using the lecture demonstration method. This conforms to the Studies by Schiefele (1991) and Alexander *et al*. (1995), who demonstrated the benefits of high interest and high knowledge in text comprehension and retention.

Comparing the results of Tables 4 and 5, it can be seen that the studentsô interest level has a significant effect on the academic achievement. This complies with the findings of Sholahuddin (2010) that in conjunction with learning activities, interests became a driving force to achieve the desired goals, without the interest, learning objectives will not be achieved. It also agreed with Artherton (2003), Bar-yam and Sweeney (2006) and Lowmen (2006) who that, learnersô interest, the methods and tools employed by a teacher to impact the lesson could influence studentsô learning and academic achievement.

These findings also support the propositions of instructional theories in the application of various instructional strategies such as selection of the appropriate delivery medium of instruction to promote learning. Instructional theories have indicated that the selection of instructional strategies should be based on theoretical models of the connection between the learnersô environment and the internal events of cognitive learning (Merriam and Cafferall, 1999). Since Circuit Simulation Instructional Strategy provides the learners with the ability to somewhat control the visualization of the sequence of instructional materials, engage their various senses, learning interactively at their own pace and from the instructor, it is likely this format of instruction leads to meaningful learning and a higher level of achievement for interest and achievement than the Lecture Demonstration method. As a result, the Circuit Simulation Instructional Strategy format should be considered as a substitute to the Lecture Demonstration Strategy. This is in accordance with Mathews (1996) who asserted that through circuit simulation, students can pull together the concepts they have studied, and they can learn to synthesize these concepts to produce new designs for novel purposes.

CHAPTER V

SUMMARY, CONCLUSION AND RECOMMENDATIONS

This chapter presented a summary of the restatement of the problem, the procedure used in the study drew conclusions based on the findings of the study. It also presented the educational implications of the study and the recommendations for further research.

Restatement of the problem

As a result of increasing industrialization of modern times and the role of electronics in our society, knowledge and skills in electronics become indispensible. According to OøHaver (2008), Electronics is playing a leading role in the scientific and technical revolution. The introduction of electronic devices in various areas of human activity contributes in large and often decisive measure to the resolution of complex scientific and technical problems, to an increase in the productivity of physical and mental labour, and to the improvement of economic indexes of production.

Technical colleges are expected to produce craftsmen. However, in the past ten years, they have recorded a failure rate of over sixty percent in the WAEC and NABTEB NTC trade component of the examination that should certify them as craftsmen, (FME,2010). Similarly, the chief examiners report asserted that Radio-Television and Electronic work candidates general performance in the three components was very poor. Specifically, in the NABTEB NTC certificate examination conducted in Radio-Television and Electronics servicing in May/June 2004, students recorded 30% failure rate in Radio Communication, 60% failure in Television system and 27% failure in electronic devices and circuits (NABTEB 2004). This gives overall performance candidates to be below average. At present, technical candidates suffer from gross infrastructural dilapidation, staff shortage and inadequacies in facilities, books and instructional equipment (FME 2010). The Federal Ministry of Education in the national master plan further stressed that, the poor quality staff employed to teach the trades do not poses the skills they are supposed to teach. Also shortage of tools, equipment, training materials as well as limited time given to trade subjects contribute to the failure of the trade to equip the students with vocational skills for employment or self-employment.

Also worthy of note is the fact that the modern industry emphasises efficiency and accuracy in order to enhance production as well as save cost. A personal interview with some technical employees of Multinational Telecommunication Network (MTN) and Ericson revealed that most of their jobs like networking and signal testing are done with the computer before putting into practice. As a result of this, these employers prefer fresh recruits with requisite knowledge in computer application in various aspects of the profession.

All these negative trends are pointers to the fact that traditional methods of teaching electronics rarely produce skills employers are looking for in the present world of work. The problem of this study therefore is that students are not acquiring the requisite skill in electronics that can enable them to be self-reliant. This is because of the poor quality facilities and teaching methods as manifested in studentsô poor performance in the qualifying examinations.

It is against this background that the study of the effects of Circuit Simulation on Achievement and Interest of Technical college Electronics Students in Benue State with the following objectives;

1. Compare the mean pre-test scores of the control and the experimental group

2. Compare the mean pre-test and post test scores of the control group

3. Determine difference between the mean pre-test and post-test scores of experimental group

4. Compare the mean post-test scores of the control and experimental group

5. Determine the difference between the interest level of the control and the experimental group

Summary of the Procedure Used

The data for the study was gathered by administering an Electronic Circuits and Devices Achievement Test (ECDAT) pre-test prior to the experiment. After the treatment, an ECDAT post-test as well as an interest inventory were administered to determine the studentsô post-treatment achievement and their various interest levels. The tests were developed for 132 part two students. That is, 66 for the control group and 66 for the experimental group. All the students were from the four technical colleges offering electronics in Benue State. The data collected were analyzed using the Statistical Package for Social Sciences (SPSS). Research questions were answered using mean and standard deviation while ANCOVA was used to test the hypotheses at 0.05 level of significance. The results were discussed based on the findings in the items contained in the tables therein.

Major Findings

Based on the analysis of the data collected, the following findings were made:

1. There was no significant difference observed on the mean pre-test scores between the experimental and control groups. This implies that the two groups had same initial academic aptitude.
2. Though students in the two groups scored higher in the pos-test than the pre-test, the post-test showed that students in the experimental group scored higher than their

control counterparts. It is a clear indication that students learn better when taught with the Circuit Simulation than the Lecture Demonstration.

3. A significant difference was observed in the mean scores of students in the interest inventory as students in the experimental group scored higher than those in the control group. This indicates that students showed more interest when taught with the Circuit Simulation than when taught with the Lecture Demonstration Method.

Implication of the Study

The educational implications of the findings of this study are for the students, teacher, ministry of education, curriculum planners, tertiary institutions and research institutes. To the electronic students, the findings of this study provides useful medium of instruction that is not only useful for learning but also the competitive and challenging lab scores labour market. The use of Circuit simulation will not only enhance the studentsô academic achievement but also give them an edge over their counterparts in the world of work. The use of this strategy will also help the teachers achieve learning objective with much ease since the use of Circuit Simulation has proven to enhance the learnersô interest and achievement. For the ministry of education in Nigeria, seminars, workshops or conferences are to be organized for technical teachers on how to use Circuit Simulation and direct curriculum planners to adopt it for the purpose of promoting increased interest and achievement among students. Tertiary institutions should include Circuit Simulation instruction in technical and industrial education courses for the training of technical teachers since circuit simulation strategy is effective in teaching electronics. The research institutes are to carry out more work on circuit simulation because the strategy which is proven to be more effective than the lecture demonstration is yet to be introduced in technical classroom.

The findings of the research institute would be published, so that Nigerian Educationist and Professional Associations can make useful findings.

Conclusion

Regarding the instructional tecnique employed and the treatment (circuit simulation technique and the lecture demonstration method), there exist a significant difference in the post-test achievement and interest mean scores of the students in the control and the experimental groups. Results of the statistical analysis showed a significant difference in favour of the students taught with the circuit simulation.

In conclusion, Circuit Simulation Instructional technique had a significant positive effect on studentsô achievement and interest in electronics. Thus Circuit Simulation Instructional technique is more effective in helping students to learn in electronics than the lecture demonstration method.

Recommendations

The following recommendations were made at the end of the study.

1. Technical teachers should be encouraged to employ Circuit Simulation instructional technique in delivering their lessons, since it enhances academic achievement and interest.
2. The tertiary institutions that train teachers should include circuit simulation instruction in the technical education courses in order to impart its usage to student teachers.
3. Curriculum planners should include the use of circuit simulation in the electronics curriculum considering its benefits in the teaching and learning of electronics.
4. The use of circuit simulation in the laboratories to reduce the waste of materials.

Suggestions for Further Research

The following areas are suggested for further research.

1. Effects of animated simulation on the understanding and achievement of electronics beginners.
2. Competency improvement need for the teachers of electronics in the use for circuit simulation instructional strategy.
3. Bridging the gap between the class room and the industry through multimedia PowerPoint.

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APPENDICE

APPENDIX 1

TABLE OF SPECIFICATIONS

Subject: Electronic Circuits and Devices

Class: SSSII

Table 9: Table of Specifications

Competencies: Demonstrate understanding, comprehension, analysis and application

Topics	**Competencies**				**Number of Questions**
	Understanding	**Comprehension**	**Analysis**	**Application**	
DC Power supply unit	1	4			5
Rectifiers	3	4	7		14
Filters		2			2
Voltage Regulators		3	6		9
	Total Number of Questions				**30**

APPENDIX 2

ELECTRONIC STUDENTS' ANSWER SHEET

INSTRUCTION:

1. Write only your assigned number on top of the answer sheet.
2. Shade the letter that corresponds with your answer.
3. Erase neatly if you have change your mind
4. Use HB pencil only.

ANSWER SHEET

1.	[A]	[B]	[C]	[D]	16.	[A]	[B]	[C]	[D]
2.	[A]	[B]	[C]	[D]	17.	[A]	[B]	[C]	[D]
3.	[A]	[B]	[C]	[D]	18.	[A]	[B]	[C]	[D]
4.	[A]	[B]	[C]	[D]	19.	[A]	[B]	[C]	[D]
5.	[A]	[B]	[C]	[D]	20.	[A]	[B]	[C]	[D]
6.	[A]	[B]	[C]	[D]	21.	[A]	[B]	[C]	[D]
7.	[A]	[B]	[C]	[D]	22.	[A]	[B]	[C]	[D]
8.	[A]	[B]	[C]	[D]	23.	[A]	[B]	[C]	[D]
9.	[A]	[B]	[C]	[D]	24.	[A]	[B]	[C]	[D]
10.	[A]	[B]	[C]	[D]	25.	[A]	[B]	[C]	[D]
11.	[A]	[B]	[C]	[D]	26.	[A]	[B]	[C]	[D]
12.	[A]	[B]	[C]	[D]	27.	[A]	[B]	[C]	[D]
13.	[A]	[B]	[C]	[D]	28.	[A]	[B]	[C]	[D]
14.	[A]	[B]	[C]	[D]	29.	[A]	[B]	[C]	[D]
15.	[A]	[B]	[C]	[D]	30.	[A]	[B]	[C]	[D]

APPENDIX 3

ACHIEVEMENT PRE-TEST FOR SSSII ELECTRONICS

STUDENTS OF TECHNICAL COLLEGES IN BENUE STATE

Electronic circuits and devices

Marks: 30

Time: 30 minutes

GENERAL INSTRUCTION

Do not open this paper until you are told to do so.

This paper consists of 30 objective questions. For the objective question, choose any letter (A-D) that corresponds with the correct option. All questions carry equal marks.

1. Which of the following is **correct** about a DC power supply unit? It.....
   (a) amplifies the input voltage.
   (b) controls AC input and converts it into smoothened DC output.
   (c) controls DC input and converts it into smoothened AC output.
   (d) modulates the audio frequency of the radio.
2. Arrange the components of a DC power supply from the **input** to **output**.
   (a) Rectifier, transformer, filter and regulator.
   (b) Filter transformer, regulator and rectifier.
   (c) Transformer, rectifier filter and regulator.
   (d) Transformer, rectifier, regulator and filter.
3. The function of a transformer in a DC power supply unit is to.........
   (a) Step up or step down the input AC.
   (b) Convert the AC to DC.

(c) Step up or step down the input DC.

(d) Convert impedance into resistance.

4. The function of ....in a power supply unit is to smoothen the DC output.

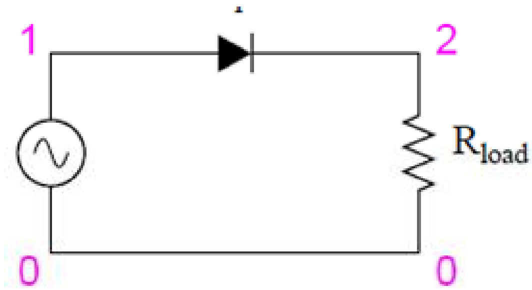
(a) Transformer

(b) Regulator

(c) Rectifier

(d) Filter

5. The figure below represents a schematic of a..........



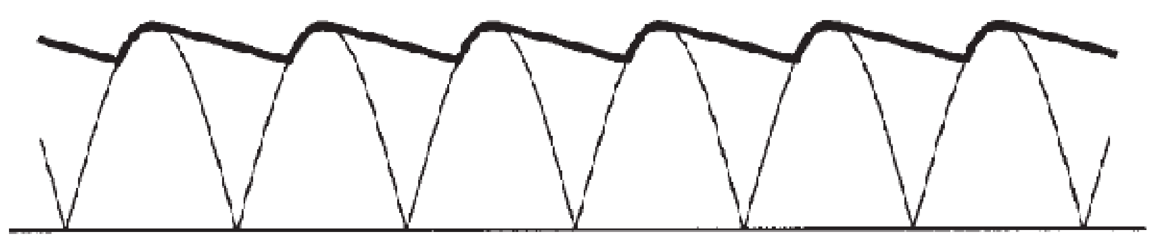
(a) Full-wave rectifier

(b) Filter

(c) Regulator

(d) Half-wave rectifier

6. The wave-form below is a.............



(a) Half-wave, filtered DC output

(b) Half-wave, unfiltered DC output

(c) Full-wave, unfiltered DC output

(d) Full-wave, filtered DC output

7. The applied input AC power to a half-wave rectifier is 100 watts. The DC output power obtained is 40 watts. What is the rectification efficiency?

   (a) 40%

   (b) 30%

   (c) 60%

   (d) 75%

8. A half-wave rectifier is used to supply 50V DC to a resistive load of 800Ý. The diode has a resistance of 25Ý. Calculate AC voltage required.

   (a) 120V

   (b) 80V

   (c) 162V

   (d) 78V

9. Which of the following statement is **true** about regulated DC output and that of the battery?

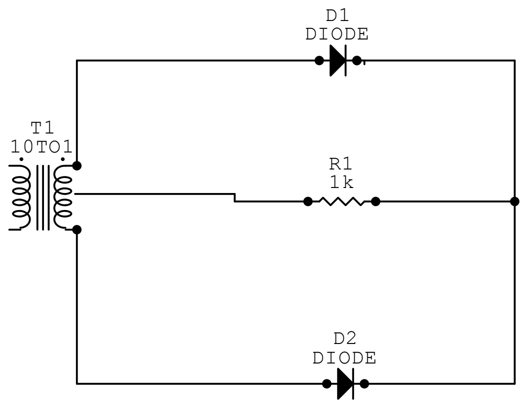
   (a) Regulated DC output is smoother than that of the battery

   (b) Regulated DC output is of the same smoothness with that of the battery

   (c) DC output of the battery is smoother than regulated output

   (d) None of the above

10. The diagram below is a............



(a) Full-wave bridge rectifier

(b) Centre-tap full wave rectifier

(c) Half-wave rectifier

(d) Half-wave bridge rectifier.

11. Main AC power is converted into DC power for........

(a) Light purposes

(b) Heaters

(c) Use in electronic equipment

(d) None of the above

12. The disadvantage of a half-wave rectifier is that the........

(a) Components are expensive

(b) Diodes must have a higher power rating

(c) Output is to filter

(d) None of the above

13. If the ac input of a half-wave rectifier has an r.m.s. of $400/\sqrt{2}$ volts, then diode PIV is......

(a) $400/\sqrt{2}$V

(b) 400V

(c) $400 \times \sqrt{2V}$

(d) None of the above

14. The ripple factor of a half-wave rectifier is.....

(a) 2

(b) 1.21

(c) 2.4

(d) 0.48

15. There is a need of transformer for.....

(a) Half-wave rectifier

(b) Centre-tap full-wave rectifier

(c) Bridge full-wave rectifier

(d) None of the above

16. The PIV rating of each diode in a bridge rectifier is.....that of the equivalent centre-tap rectifier.

(a) One-half

(b) The same as

(c) Twice

(d) Four times

17. For the same secondary voltage, the output voltage from a centre-tap rectifier is..... than that of bridge rectifier.

(a) Twice

(b) Thrice

(c) Four times

(d) One-half

18. If the PIV of a diode is exceeded,.....

(a) The diode conducts poorly

(b) The diode is destroyed

(c) The behaves as zener diode

(d) None of the above

19. A 10V power supply would use..... as filter capacitor

(a) Paper capacitor

(b) Mica capacitor

(c) Electrolytic capacitor

(d) Air capacitor

20. A 1000V power supply would use......as a filter capacitor.

(a) Paper capacitor

(b) Air capacitor

(c) Mica capacitor

(d) Electrolytic capacitor

21. The load voltage is approximately constant when a zener diode is......

(a) Forward biased

(b) Unbiased

(c) Reverse biased

(d) Operating in the breakdown region

22. In a loaded zener regulator, which is the largest zener current?

(a) Series current

(b) Zener current

(c) Load current

(d) None of the above

23. If the load resistance decreases in a zener regulator, then zener current......

(a) Decreases

(b) Stays the same

(c) Increases

(d) None of the above

24. If the ac voltage to unregulated or ordinary power supply increases by 5%, what will be the approximate change in dc output voltage?

(a) 10%

(b) 20%

(c) 15%

(d) 5%

25. If the load current drawn by unregulated power supply increases, the dc output voltage.....

(a) Increases

(b) Decreases

(c) Stays the same

(d) None of the above

26. If a power supply has no-load and full-load voltages of 30V and 25V respectively, then the percentage voltage regulation is.......

(a) 10%

(b) 20%

(c) 15%

(d) 5%

27. A power supply has a voltage of regulation of 1%. If the no-load and full-load voltage is 20V, what is the regulated output voltage?

(a) 20.8

(b) 15.7

(c) 18.6

(d) 17.2

28. Two similar 15V zener diodes are connected in series. What is the output voltage?

(a) 15V

(b) 7.5V

(c) 30V

(d) 45V

29. A power supply can deliver a maximum rated current of 0.5 A after full-loaded output voltage of 20V. What is the minimum load resistance that you can connect across the supply?

(a) 10Ý

(b) 20 Ý

(c) 15 Ý

(d) 40 Ý

30. When load current is zero, the zener current will be.....

(a) Zero

(b) Minimum

(c) Maximum

(d) All of the above.

APPENDIX 4

Marking scheme for electronics achievement pre-test

1. B
2. C
3. A
4. D
5. D
6. D
7. A
8. C
9. C
10. B
11. C
12. C
13. B
14. D
15. B

16. A
17. D
18. B
19. C
10. A
21. D
22. A
23. A
24. D
25. B
26. B
27. A
28. C
29. D
30. C

APPENDIX 5

ACHIEVEMENT POST-TEST FOR SSSII ELECTRONICS STUDENTS OF TECHNICAL COLLEGES IN BENUE STATE

Electronic circuits and devices

Marks: 30

Time: 30 minutes

GENERAL INSTRUCTION

Do not open this paper until you are told to do so.

This paper consists of 30 objective questions. For the objective question, choose any letter (A-D) that corresponds with the correct option. All questions carry equal marks

1. The PIV rating of each diode in a bridge rectifier is.....that of the equivalent centre-tap rectifier.
   (a) One-half
   (b) The same as
   (c) Twice
   (d) Four times
2. For the same secondary voltage, the output voltage from a centre-tap rectifier is..... than that of bridge rectifier.
   (a) Twice

(b) Thrice

(c) Four times

(d) One-half

3. If the PIV of a diode is exceeded,.....

    (a) The diode conducts poorly

    (b) The diode is destroyed

    (c) The behaves as zener diode

    (d) None of the above

4. A 10V power supply would use..... as filter capacitor

    (a) Paper capacitor

    (b) Mica capacitor

    (c) Electrolytic capacitor

    (d) Air capacitor

5. A 1000V power supply would use......as a filter capacitor.

    (a) Paper capacitor

    (b) Air capacitor

    (c) Mica capacitor

    (d) Electrolytic capacitor

6. The load voltage is approximately constant when a zener diode is......

    (a) Forward biased

    (b) Unbiased

    (c) Reverse biased

    (d) Operating in the breakdown region

7. In a loaded zener regulator, which is the largest zener current?

    (a) Series current

(b) Zener current

(c) Load current

(d) None of the above

8. If the load resistance decreases in a zener regulator, then zener current......

(a) Decreases

(b) Stays the same

(c) Increases

(d) None of the above

9. If the ac voltage to unregulated or ordinary power supply increases by 5%, what will be the approximate change in dc output voltage?

(a) 10%

(b) 20%

(c) 15%

(d) 5%

10. If the load current drawn by unregulated power supply increases, the dc output voltage.....

(a) Increases

(b) Decreases

(c) Stays the same

(d) None of the above

11. If a power supply has no-load and full-load voltages of 30V and 25V respectively, then the percentage voltage regulation is.......

(a) 10%

(b) 20%

(c) 15%

(d) 5%

12. A power supply has a voltage of regulation of 1%. If the no-load and full-load voltage is 20V, what is the regulated output voltage?

(a) 20.8

(b) 15.7

(c) 18.6

(d) 17.2

13. Two similar 15V zener diodes are connected in series. What is the output voltage?

(a) 15V

(b) 7.5V

(c) 30V

(d) 45V

14. A power supply can deliver a maximum rated current of 0.5 A after full-loaded output voltage of 20V. What is the minimum load resistance that you can connect across the supply?

(a). 10Ý

(b) 20 Ý

(c) 15 Ý

(d) 40 Ý

15. When load current is zero, the zener current will be.....

(a) Zero

(b) Minimum

(c) Maximum

(d) All of the above.

16. Which of the following is **correct** about a DC power supply unit? It.....

(a) amplifies the input voltage.

(b) controls AC input and converts it into smoothened DC output.

(c) controls DC input and converts it into smoothened AC output.

(d) modulates the audio frequency of the radio.

17. Arrange the components of a DC power supply from the **input** to **output**.

(a) Rectifier, transformer, filter and regulator.

(b) Filter transformer, regulator and rectifier.

(c) Transformer, rectifier filter and regulator.

(d) Transformer, rectifier, regulator and filter.

18. The function of a transformer in a DC power supply unit is to.........

(a) Step up or step down the input AC.

(b) Convert the AC to DC.

(c) Step up or step down the input DC.

(d) Convert impedance into resistance.

19. The function of ....in a power supply unit is to smoothen the DC output.

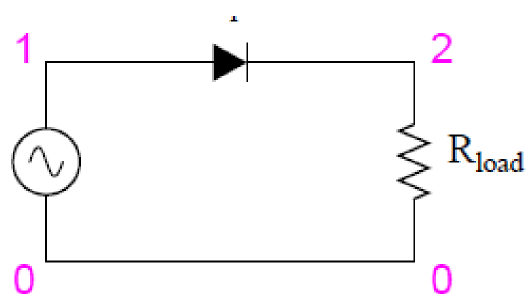
(a) Transformer

(b) Regulator

(c) Rectifier

(d) Filter

20. The figure below represents a schematic of a..........



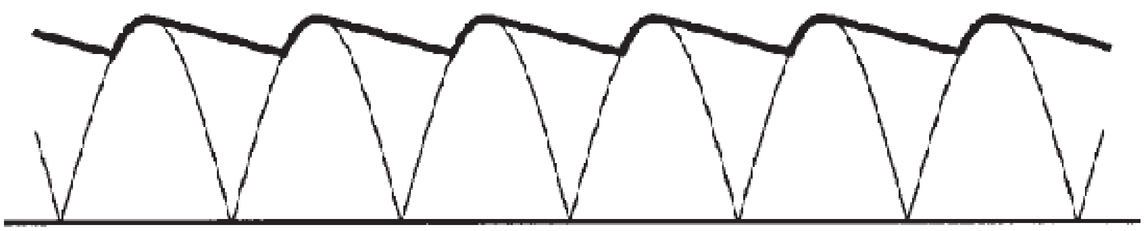
(a) Full-wave rectifier

(b) Filter

(c) Regulator

(d) Half-wave rectifier

21. The wave-form below is a.............



(a) Half-wave, filtered DC output

(b) Half-wave, unfiltered DC output

(c) Full-wave, unfiltered DC output

(d) Full-wave, filtered DC output

22. The applied input AC power to a half-wave rectifier is 100 watts. The DC output power obtained is 40 watts. What is the rectification efficiency?

(a) 40%

(b) 30%

(c) 60%

(d) 75%

23. A half-wave rectifier is used to supply 50V DC to a resistive load of 800Ý. The diode has a resistance of 25Ý. Calculate AC voltage required.

(a) 120V

(b) 80V

(c) 162V

(d) 78V

24. Which of the following statement is **true** about regulated DC output and that of the battery?

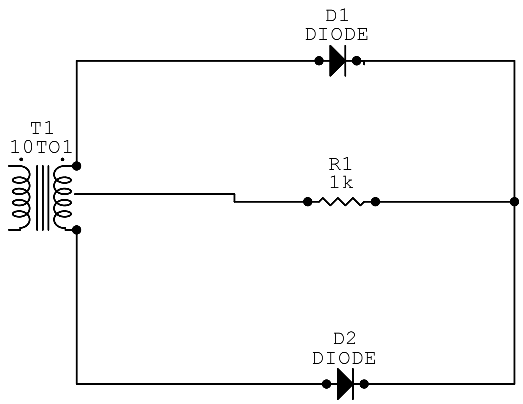
(a) Regulated DC output is smoother than that of the battery

(b) Regulated DC output is of the same smoothness with that of the battery

(c) DC output of the battery is smoother than regulated output

(d) None of the above

25. The diagram below is a............



(a) Full-wave bridge rectifier

(b) Centre-tap full wave rectifier

(c) Half-wave rectifier

(d) Half-wave bridge rectifier.

26. Main AC power is converted into DC power for........

(a) Light purposes

(b) Heaters

(c) Use in electronic equipment

(d) None of the above

27. The disadvantage of a half-wave rectifier is that the........

(a) Components are expensive

(b) Diodes must have a higher power rating

(c) Output is to filter

(d) None of the above

28. If the ac input of a half-wave rectifier has an r.m.s. of $400/\sqrt{2}$ volts, then diode PIV is......

(a) $400/\sqrt{2}$V

(b) 400V

(c) $400 \times \sqrt{2}V$

(d) None of the above

29. The ripple factor of a half-wave rectifier is.....

(a) 2

(b) 1.21

(c) 2.4

(d) 0.48

30. There is a need of transformer for.....

(a) Half-wave rectifier

(b) Centre-tap full-wave rectifier

(c) Bridge full-wave rectifier

(d) None of the above

APPENDIX 6

Marking scheme for electronics achievement post-test

1. A
2. D
3. B
4. C
5. A
6. D
7. A.
8. A
9. D
10. B
11. B
12. A
13. C
14. D
15. C
16. B
17. C
18. A
19. D
20. D
21. D
22. A
23. C
24. C
25. B
26. C
27. C
28. B
29. D
30. B

APPENDIX 7

INTEREST INVENTORY

KEY

SA - Strongly Agree; A - Agree ; N - No opinion;

D - Disagree; SA - Strongly Disagree

Instruction: Check (√) any of the five response options according to your agreement or disagreement to the following statements.

S/N	CIRCUIT DESIGN	SA	A	N	D	SD
1	This method of teaching circuit designing increases the level of attention.					
2	makes learning more enjoyable					
3	increases the level assimilation					
4	increases the level of concentration					
5	is more interactive					
6	encourages collaborative learning					
7	encourages self learning					
8	makes it easier to check errors					
9	reduces the chances of error					
10	can replace the teacher to an extent					
11	makes the process more interesting					
12	There is no need for an alternative method of designing circuits					
S/N	**CIRCUIT ANALYSIS**	**SA**	**A**	**N**	**D**	**SD**
13	This method of teaching circuit analysis increases the level of attention.					
14	makes learning more enjoyable					
15	increases the level assimilation					
16	increases the level of concentration					

17	is more interactive					
18	encourages collaborative learning					
19	encourages self learning					
20	makes it easier to check errors					
21	reduces the chances of error					
22	is more precise					
23	is more retentive					
24	can replace the teacher to an extent					
25	There is no need for an alternative method of teaching this subject.					

APPENDIX 8

CONVENTIONAL LESSON PLAN 1

Subject: Electronic Circuits and Devices

Class: SSSII

Time: 60 minutes

Topic: DC Power supply unit

Specific objectives: By the end of the lesson, the students should be able to:

1. Describe the principle of operation of a power supply unit.
2. Identify the basic components of a power supply unit.
3. Express the function of each component in a power supply unit.

Entry Behaviour: Students are expected to have studied Basic Electronics in their SSSI

Instructional Materials: Model power supply unit, sketches and lesson plan.

Instructional method: Lecture, demonstration, discussion

Instructional procedure:

Time	**Content/Task**	Teacherôs activity	Studentsô activity	Performance Assessment
	Step I			
15 min.	Review of previous knowledge. Statement /explanation of lesson objectives	Write out the instructional objectives. Introduce the students to power supply unit	Listen attentively	Questions
	Step II			
15 min.	Function and operational principle of a power supply unit.	Explain the function of a power supply unit in electronic circuits. Describe the principle	Listen, ask and answer questions.	Evaluative questions.

		of operation of a power supply unit.		
	Step III			
30 min		Outline the main components of a power supply unit. (i.e. transformer, rectifier, filter and regulator). Describe the function of each of the components of a power supply unit.	Listen, ask questions and practice sketches	The teacher gives homework to the students to make a schematic of a power supply unit and explain the function of each component.

CONVENTIONAL LESSON PLAN 2

Subject: Electronic Circuits and Devices

Class: SSSII

Time: 60 minutes

Topic: Rectifiers

Specific objectives: By the end of the lesson, the students should be able to:

1. Discus the function of a rectifier in a power supply unit.
2. Describe the operational principles of a rectifier.
3. Differentiate between a half-wave and full-wave rectifier.
4. Describe the wave-forms of half-wave and full-wave rectifiers.

Entry Behaviour: Students are expected to have studied the main components of a power supply unit in the previous lesson.

Instructional Materials: model rectifier, sketches and lesson plan.

Instructional method: lecture, demonstration, discussion

Instructional procedure:

Time	**Content/Task**	Teacherôs activity	Studentsô activity	Performance Assessment
	Step I			
10 min.	Review of previous knowledge. Statement /explanation of lesson objectives	Test the studentsô previous knowledge. Write out the instructional objectives. Introduce the students to rectifiers	Listen attentively	questions
	Step II			
20 min.	Function and operation principle of a rectifier	Explain the function of a rectifier in a power supply unit. State the two types of rectifiers (half-wave and full-wave rectifiers) Describe the principle of operation of a half-wave rectifier. Describe the wave-form of a half-wave rectifier.	Listen, ask and answer questions.	Evaluative questions.
	Step III			
30 min		Describe the operation of a full-wave centre-tape and full-wave bridge rectifier. Describe the wave-form of a full-wave rectifier.	Listen, ask questions and practice sketches	The teacher gives homework to the students to make a schematic of half-wave and full-wave rectifiers with their wave-

				forms.

CONVENTIONAL LESSON PLAN 3

Subject: Electronic Circuits and Devices

Class: SSSII

Time: 80 minutes

Topic: Filter circuits

Specific objectives: by the end of the lesson, the students should be able to:

1. Discus the function and types of filter circuits.
2. Describe the principle of operation various types of filter circuits.
3. Design and construct various types of filters.
4. Express the function of each component in a filter.

Entry Behaviour: Students are expected to have studied the function filters in power supply unit.

Instructional Materials: model filter circuit, sketches and lesson plan.

Instructional method: lecture, demonstration, discussion

Instructional procedure:

Time	**Content/Task**	**Teacher's activity**	**Students' activity**	**Performance Assessment**
	Step I			
15 min.	Review of previous knowledge. Statement /explanation of lesson objectives	Write out the instructional objectives. Introduce the students to filter circuits	Listen attentively	questions

	Step II			
15 min.	Function and operation principle of a filter.	Explain the function of filters in power supply units. State and describe various types of filter.	Listen, ask and answer questions.	Evaluative questions.
	Step III			
30 min		With the aid of sketches describe the operational principles of various types of filter circuit. Explain and describe the function and behaviour of each component in a filter circuit.	Listen, ask questions and practice sketches	The teacher gives homework to the students to make schematics of various types of filters and describe their operational principle.

CONVENTIONAL LESSON PLAN 4

Subject: Electronic Circuits and Devices

Class: SSSII

Time: 60 minutes

Topic: Voltage Regulators

Specific objectives: by the end of the lesson, the students should be able to:

1. Explain the function of a voltage regulator.

2. State and describe various types of voltage regulators.
3. State the conditions for proper operation of a voltage regulator.
4. Make schematics of various voltage regulators and describe their operational principles.

Entry Behaviour: Students are expected to have studied the function of a voltage regulator in a power supply unit

Instructional Materials: model voltage regulator, sketches and lesson plan.

Instructional method: lecture, demonstration, discussion

Instructional procedure:

Time	**Content/Task**	**Teacher's activity**	**Students' activity**	**Performance Assessment**
	Step I			
15 min.	Review of previous knowledge. Statement /explanation of lesson objectives	Write out the instructional objectives. Introduce the students to voltage regulation and regulators.	Listen attentively	questions
	Step II			
15 min.	Function and operational principle of voltage regulators.	Explain the function of voltage regulators in power supply units. State and describe various types of voltage regulators	Listen, ask and answer questions.	Evaluative questions.
	Step III			
30 min		With the aid of sketches describe the operational principles of various types of voltage regulators and their operational principles. Explain and describe	Listen, ask questions and practice sketches	The teacher gives homework to the students to make schematics of various types of voltage regulators and

		the function and behaviour of each component in a voltage regulator.		describe their operational principles.

APPENDIX 9

ELECTRONIC CIRCUIT SIMULATION LESSON PLAN 1

Subject: Electronic Circuits and Devices

Class: SSSII

Time: 60 minutes

Topic: DC Power supply unit

Specific objectives: By the end of the lesson, the students should be able to:

1. Describe the principle of operation of a power supply unit.
2. Identify the basic components of a power supply unit.
3. Express the function of each component in a power supply unit.
4. Use circuit simulation software to design and analyse power supply unit.

Entry Behaviour: students are expected to have studied Basic Electronics in their SSSI

Instructional Materials: Model power supply unit, computer systems, a projector and lesson plan.

Instructional method: Simulation, demonstration and discussion

Instructional procedure:

Time	**Content/Task**	Teacherôs activity	Studentsô activity	Performance Assessment
	Step I			
15 min.	Review of previous knowledge. Statement /explanation of lesson objectives	Write out the instructional objectives. Introduce the students to power supply unit	Listen attentively	Questions
	Step II			
15 min.	Function and operational principle of a power supply unit.	Explain the function of a power supply unit in electronic circuits. Make a schematic of a simple power supply unit using simulation software. Describe the principle of operation of a power supply unit.	Practice the use of circuit simulation software in making schematic of power supply unit.	Evaluative questions.
	Step III			
30 min		Outline the main components of a power supply unit. (i.e. transformer, rectifier, filter and regulator). Describe the function of each of the components of a power supply unit. Make analysis of the power supply circuit using the simulation software.	Listen, ask questions and practice sketches	The teacher gives homework to the students to make a schematic of a power supply unit using the simulation software and analyse the entire circuit.

ELECTRONIC CIRCUIT SIMULATION LESSON PLAN 2

Subject: Electronic Circuits and Devices

Class: SSSII

Time: 60 minutes

Topic: Rectifiers

Specific objectives: By the end of the lesson, the students should be able to:

1. Discus the function of a rectifier in a power supply unit.
2. Describe the operational principles of a rectifier.
3. Differentiate between a half-wave and full-wave rectifier.
4. Describe the wave-forms of half-wave and full-wave rectifiers.
5. Use circuit simulator to make schematics of various rectifier circuits and analyse same.

Entry Behaviour: Students are expected to have studied the main components of a power supply unit as well as the application of circuit simulator.

Instructional Materials: Model rectifier, computer systems, projector and lesson plan.

Instructional method: Simulation, demonstration, discussion

Instructional procedure:

Time	**Content/Task**	Teacherôs activity	Studentsô activity	Performance Assessment
	Step I			

10 min.	Review of previous knowledge. Statement /explanation of lesson objectives	Test the studentsô previous knowledge. Write out the instructional objectives. Introduce the students to rectifiers	Listen attentively	questions
	Step II			
20 min.	Function and operation principle of a rectifier	Explain the function of a rectifier in a power supply unit. State the two types of rectifiers (half-wave and full-wave rectifiers) Describe the principle of operation of a half-wave rectifier. Describe the wave-form of a half-wave rectifier.	Listen, ask and answer questions.	Evaluative questions.
	Step III			
30 min		Describe the operation of a full-wave centre-tape and full-wave bridge rectifier. Describe the wave-form of a full-wave rectifier. Guide students in making schematics of various rectifier circuits and make analysis.	Practice the design and analysis of the rectifier as guided the teacher.	The teacher gives homework to the students to make a schematic of half-wave and full-wave rectifiers using the simulation software.

ELECTRONIC CIRCUIT SIMULATION LESSON PLAN 3

Subject: Electronic Circuits and Devices

Class: SSSII

Time: 60 minutes

Topic: Filter circuits

Specific objectives: by the end of the lesson, the students should be able to:

1. Discus the function and types of filter circuits.
2. Describe the principle of operation various types of filter circuits.
3. Use circuit simulator to design and construct various types of filters.
4. Express the function of each component in a filter.

Entry Behaviour: Students are expected to have studied the function filters in power supply unit and are conversant with the use of circuit simulator.

Instructional Materials: Model filter circuit, computer systems, projector and lesson plan.

Instructional method: Simulation, demonstration, discussion

Instructional procedure:

Time	Content/Task	Teacher's activity	Students' activity	Performance Assessment
	Step I			
15 min.	Review of previous knowledge. Statement /explanation of lesson objectives	Write out the instructional objectives. Introduce the students to filter circuits	Listen attentively	questions
	Step II			
15 min.	Function and operation principle of a filter.	Explain the function of filters in power supply units. State and describe various types of filter.	Listen, ask and answer questions.	Evaluative questions.
	Step III			
30 min		With the aid of a simulator, sketch and describe the operational principles of various types of filter circuit. Explain and describe the function and behaviour of each component in a filter circuit.	Listen, ask questions and practice sketches	The teacher gives homework to the students to use circuit simulator in making schematics of various types of filters and describe their operational principle.

ELECTRONIC CIRCUIT SIMULATION LESSON PLAN 4

Subject: Electronic Circuits and Devices

Class: SSSII

Time: **60** minutes

Topic: **Voltage Regulators**

Specific objectives: by the end of the lesson, the students should be able to:

1. Explain the function of a voltage regulator.
2. State and describe various types of voltage regulators.
3. State the conditions for proper operation of a voltage regulator.
4. Use simulator to make schematics of various voltage regulators and describe their operational principles.

Entry Behaviour: Students are expected to have studied the function of a voltage regulator in a power supply unit are conversant with the use of simulator.

Instructional Materials: Model voltage regulator, computer systems, projector and lesson plan.

Instructional method: Simulation, demonstration, discussion

Instructional procedure:

Time	Content/Task	Teacher's activity	Students' activity	Performance Assessment
	Step I			
15 min.	Review of previous knowledge.	Write out the instructional objectives.	Listen attentively	questions

	Statement /explanation of lesson objectives	Introduce the students to voltage regulation and regulators.		
	Step II			
15 min.	Function and operational principle of voltage regulators.	Explain the function of voltage regulators in power supply units. State and describe various types of voltage regulators	Listen, ask and answer questions.	Evaluative questions.
	Step III			
30 min		With the aid of simulation sketches describe the operational principles of various types of voltage regulators and their operational principles. Use simulator to analyse and describe the function and behaviour of each component in a voltage regulator.	Listen, ask questions and practice sketches	The teacher gives homework to the students to use simulator in making schematics of various types of voltage regulators and describe their operational principles and analyse same.

APPENDIX 10

Table 10:Table of students' distribution.

S/NO	**NAME OF COLLEGE**	**NUMER OF STUDENTS**
1	Government Science and Technical College, Makurdi	34
2	Government Science and Technical College, Zaki-Biam	32
3	Federal Science and Technical College, Otukpo	38
4	Saint Judeôs Science and Technical College, Vandeikya	28
	TOTAL	**132**

APPENDIX 11

PILOT STUDY

The pilot try out of Electronics Circuit and Devices Achievement Test (ECDAT) was conducted at Government Science and Technical College Bukuru in Plateau State. The aim of the pilot test was to:

1. Have a feedback on studentsô reaction on the different items.
2. Determine the testing time for ECDAT.
3. Estimate the reliability of the instrument.

(A)

ACHIEVEMENT TEST SCORES

Control Group PRE-TEST (CGPRT)	**Control Group POS-TEST (CGPOT)**	**Experimental Group PRE-TEST (EGPRT)**	**Experimental Group POST-TEST (CGPOT)**
13	14	17	18
12	13	12	13
14	13	14	13
9	11	9	11
13	12	13	12
15	16	15	16
14	14	17	14
17	18	12	18
10	12	14	12
13	14	9	14

CORRELATIONS /VARIABLES=**CGPRT CGPOT EGPRT EGPOT** /PRINT=TWOTAIL NOSIG /MISSING=PAIRWISE.

[DataSet0]

(B)
SPSS Analysis of Pearson's Correlations

Correlations

		CGPRT	CGPOT	EGPRT	EGPOT
CGPRT	Pearson Correlation	1	.889**	.324	.740*
	Sig. (2-tailed)		.001	.361	.014
	N	10	10	10	10
CGPOT	Pearson Correlation	.889**	1	.203	.859**
	Sig. (2-tailed)	.001		.574	.001
	N	10	10	10	10
EGPRT	Pearson Correlation	.324	.203	1	.412
	Sig. (2-tailed)	.361	.574		.237
	N	10	10	10	10
EGPOT	Pearson Correlation	.740*	.859**	.412	1
	Sig. (2-tailed)	.014	.001	.237	
	N	10	10	10	10

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

(C)

INTEREST INVENTORY

(CONTROL GROUP)

S/N	CIRCUIT DESIGN	CONTROL GROUP		CONTROL GROUP	

		PRE-INVENTORY(CGPRI)						**POST-INVENTORY(CGPOI)**					
		SA 5	**A 4**	**N 3**	**D 2**	**SD 1**		**SA 5**	**A 4**	**N 3**	**D 2**	**SD 1**	
1	This method of teaching circuit designing increases the level of attention.	2	1	2	3	2		1	1	2	4	2	
2	makes learning more enjoyable	1	1	2	2	4		2	1	1	3	3	
3	increases the level assimilation	2	1	1	3	3		1	2	1	2	4	
4	increases the level of concentration	1	2	0	3	4		2	1	0	2	3	
5	is more interactive	1	2	1	3	3		2	0	1	4	2	
6	encourages collaborative learning	2	0	1	4	3		1	2	2	3	2	
7	encourages self learning	3	1	0	3	3		1	1	2	4	2	
8	makes it easier to check errors	2	1	1	2	4		2	0	1	4	1	
9	reduces the chances of error	2	1	0	4	3		2	1	1	3	3	
10	can replace the teacher to an extent	1	1	1	3	4		1	2	2	3	2	
11	makes the process more interesting	2	1	1	3	3		1	2	1	3	2	
12	There is no need for an alternative method of designing circuits	2	2	0	2	4		2	0	2	4	1	
S/N	**CIRCUIT ANALYSIS**	**SA**	**A**	**N**	**D**	**SD**		**SA**	A	**N**	**D**	**SD**	
13	This method of teaching circuit analysis increases the level of attention.	2	1	0	3	4		2	1	1	3	3	
14	makes learning more enjoyable	1	2	1	3	3		1	2	2	2	3	
15	increases the level assimilation	2	1	1	4	2		2	1	2	3	2	
16	increases the level of concentration	3	1	0	3	3		1	2	1	3	3	

17	is more interactive	2	2	1	2	3		2	1	2	2	3	
18	encourages collaborative learning	3	0	0	3	4		2	1	1	3	3	
19	encourages self learning	2	1	1	2	4		2	1	2	4	1	
20	makes it easier to check errors	3	1	1	3	2		2	2	1	3	1	
21	reduces the chances of error	1	2	0	4	3		1	2	2	3	2	
22	is more precise	2	1	1	3	3		0	2	2	4	2	
23	is more retentive	2	0	0	2	4		1	2	2	3	2	
24	can replace the teacher to an extent	2	1	0	3	3		2	1	0	2	3	
25	There is no need for an alternative method of teaching this subject.	1	2	1	3	2		2	1	0	4	3	

(D)

SPSS Analysis of Pearson's Correlations

Correlations

		SA	A	N	D	SD	SA1	A1	N1	D1	SD1
SA	Pearson Correlation	1	-.553**	-.295	-.023	-.124	-.047	.078	.097	.117	-.159
	Sig. (2-tailed)		.004	.152	.911	.555	.823	.713	.646	.577	.447
	N	25	25	25	25	25	25	25	25	25	25
A	Pearson Correlation	-.553**	1	.030	-.071	-.170	.219	-.307	-.137	-.044	.060
	Sig. (2-tailed)	.004		.888	.736	.417	.294	.136	.513	.834	.776
	N	25	25	25	25	25	25	25	25	25	25

N	Pearson Correlation	-.295	.030	1	-.170	-.319	-.095	.024	.178	.179	-.119
	Sig. (2-tailed)	.152	.888		.416	.120	.651	.911	.393	.391	.570
	N	25	25	25	25	25	25	25	25	25	25
D	Pearson Correlation	-.023	-.071	-.170	1	-.515**	-.218	.342	-.026	-.158	.214
	Sig. (2-tailed)	.911	.736	.416		.008	.296	.095	.902	.451	.304
	N	25	25	25	25	25	25	25	25	25	25
SD	Pearson Correlation	-.124	-.170	-.319	-.515**	1	.141	-.209	.017	-.049	-.044
	Sig. (2-tailed)	.555	.417	.120	.008		.502	.317	.936	.817	.834
	N	25	25	25	25	25	25	25	25	25	25
SA_1	Pearson Correlation	-.047	.219	-.095	-.218	.141	1	-.696**	-.475*	-.055	-.014
	Sig. (2-tailed)	.823	.294	.651	.296	.502		.000	.016	.794	.946
	N	25	25	25	25	25	25	25	25	25	25
A1	Pearson Correlation	.078	-.307	.024	.342	-.209	-.696**	1	.218	-.410*	.211
	Sig. (2-tailed)	.713	.136	.911	.095	.317	.000		.296	.042	.310
	N	25	25	25	25	25	25	25	25	25	25
N1	Pearson Correlation	.097	-.137	.178	-.026	.017	-.475*	.218	1	.240	-.436*
	Sig. (2-tailed)	.646	.513	.393	.902	.936	.016	.296		.249	.029
	N	25	25	25	25	25	25	25	25	25	25
D1	Pearson Correlation	.117	-.044	.179	-.158	-.049	-.055	-.410*	.240	1	-.641**
	Sig. (2-tailed)	.577	.834	.391	.451	.817	.794	.042	.249		.001
	N	25	25	25	25	25	25	25	25	25	25
SD1	Pearson Correlation	-.159	.060	-.119	.214	-.044	-.014	.211	-.436*	-.641**	1
	Sig. (2-tailed)	.447	.776	.570	.304	.834	.946	.310	.029	.001	
	N	25	25	25	25	25	25	25	25	25	25

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

(E)

(EXPERIMENTAL GROUP)

S/N	CIRCUIT DESIGN	EXPERIMENTAL GROUP PRE-INVENTORY(EGPRI)					EXPERIMENTAL GROUP POST-INVENTORY(EGPOI)				
		SA 5	A 4	N 3	D 2	SD 1	SA 5	A 4	N 3	D 2	SD 1

1	This method of teaching circuit designing increases the level of attention.	4	2	1	2	1	3	2	2	2	1
2	makes learning more enjoyable	3	3	2	1	1	4	2	1	2	1
3	increases the level assimilation	4	3	0	2	1	3	3	2	1	1
4	increases the level of concentration	3	2	1	2	1	4	2	2	1	0
5	is more interactive	3	3	0	1	2	3	4	1	2	0
6	encourages collaborative learning	4	3	2	1	1	3	2	2	2	1
7	encourages self learning	3	2	1	0	2	4	2	2	1	1
8	makes it easier to check errors	5	2	2	0	1	3	3	2	1	1
9	reduces the chances of error	3	4	1	1	1	3	3	1	2	1
10	can replace the teacher to an extent	3	5	1	0	1	4	2	2	0	1
11	makes the process more interesting	4	2	2	1	0	4	3	1	1	1
12	There is no need for an alternative method of designing circuits	3	4	2	0	1	3	4	1	2	0
S/N	**CIRCUIT ANALYSIS**	**SA**	**A**	**N**	**D**	**SD**	**SA**	**A**	**N**	**D**	**SD**
13	This method of teaching circuit analysis increases the level of attention.	3	3	1	1	2	5	2	1	0	2
14	makes learning more enjoyable	2	4	2	0	2	4	2	2	1	1
15	increases the level assimilation	3	2	1	2	1	3	3	1	2	1
16	increases the level of concentration	4	2	2	1	0	4	2	2	0	1
17	is more interactive	4	2	1	0	1	3	3	2	2	0
18	encourages collaborative learning	4	3	0	1	2	3	4	2	0	1
19	encourages self learning	3	3	2	1	0	4	2	2	1	1
20	makes it easier to check errors	2	4	1	0	1	3	3	1	2	1

21	reduces the chances of error	4	3	0	2	1	3	5	1	0	1
22	is more precise	3	4	1	2	0	3	2	1	2	2
23	is more retentive	4	2	0	1	2	3	3	2	1	2
24	can replace the teacher to an extent	3	3	2	0	1	4	2	2	0	2
25	There is no need for an alternative method of teaching this subject.	4	3	2	1	1	4	2	3	0	1

(F)

SPSS Analysis of Pearson's Correlations

Correlations

		SA	A	N	D	SD	SA1	A1	N1	D1	SD1
SA	Pearson Correlation	1	-.560**	-.077	.217	-.166	-.282	.221	.373	-.226	.000
	Sig. (2-tailed)		.004	.714	.297	.429	.173	.288	.066	.276	1.000
	N	25	25	25	25	25	25	25	25	25	25
A	Pearson Correlation	-.560**	1	.025	-.265	.012	-.003	.020	-.231	.014	.084
	Sig. (2-tailed)	.004		.904	.201	.954	.988	.923	.266	.947	.691
	N	25	25	25	25	25	25	25	25	25	25
N	Pearson Correlation	-.077	.025	1	-.402*	-.460*	.428*	-.538**	.173	.026	.000

	Sig. (2-tailed)	.714	.904		.046	.021	.033	.006	.409	.901	1.000
	N	25	25	25	25	25	25	25	25	25	25
D	Pearson Correlation	.217	-.265	-.402*	1	-.243	-.191	.088	-.166	.082	.095
	Sig. (2-tailed)	.297	.201	.046		.241	.360	.677	.428	.698	.651
	N	25	25	25	25	25	25	25	25	25	25
SD	Pearson Correlation	-.166	.012	-.460*	-.243	1	.004	.202	.082	-.097	.000
	Sig. (2-tailed)	.429	.954	.021	.241		.983	.334	.695	.645	1.000
	N	25	25	25	25	25	25	25	25	25	25
SA1	Pearson Correlation	-.282	-.003	.428*	-.191	.004	1	-.597**	.165	-.550**	.246
	Sig. (2-tailed)	.173	.988	.033	.360	.983		.002	.430	.004	.235
	N	25	25	25	25	25	25	25	25	25	25
A1	Pearson Correlation	.221	.020	-.538**	.088	.202	-.597**	1	-.419*	.056	-.339
	Sig. (2-tailed)	.288	.923	.006	.677	.334	.002		.037	.789	.098
	N	25	25	25	25	25	25	25	25	25	25
N1	Pearson Correlation	.373	-.231	.173	-.166	.082	.165	-.419*	1	-.433*	.000
	Sig. (2-tailed)	.066	.266	.409	.428	.695	.430	.037		.031	1.000
	N	25	25	25	25	25	25	25	25	25	25
D1	Pearson Correlation	-.226	.014	.026	.082	-.097	-.550**	.056	-.433*	1	-.347
	Sig. (2-tailed)	.276	.947	.901	.698	.645	.004	.789	.031		.090
	N	25	25	25	25	25	25	25	25	25	25
SD1	Pearson Correlation	.000	.084	.000	.095	.000	.246	-.339	.000	-.347	1
	Sig. (2-tailed)	1.000	.691	1.000	.651	1.000	.235	.098	1.000	.090	
	N	25	25	25	25	25	25	25	25	25	25

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

APPENDIX12

(A)

ACHIEVEMENT TEST SCORES

S.NO	CONTROL GROUP PRE-TEST (CGPRT)	CONTROL GROUP POST-TEST (CGPOT)	EXPERIMENTAL GROUP PRE-TEST (EGPRT)	EXPERIMENTAL GROUP POST-TEST (EGPOT)
1.	12	19	14	18
2.	15	18	13	19
3.	13	15	13	21
4.	11	17	16	24
5.	14	21	12	23
6.	16	19	12	19
7.	11	13	16	22
8.	13	18	14	24
9.	14	15	13	23
10.	16	18	13	24
11.	16	19	17	25
12.	13	16	14	21
13.	13	16	14	19
14.	12	15	12	19
15.	17	15	15	24
16.	17	20	14	26
17.	16	19	14	23
18.	11	14	13	18
19.	11	15	12	20
20.	13	16	11	23
21.	13	17	15	22
22.	14	19	15	25
23.	15	19	13	24
24.	12	15	11	19
25.	17	20	11	25

26.	13	19	13	24
27.	13	19	12	19
28.	9	18	14	25
29.	12	20	11	22
30.	14	21	11	23
31.	14	16	13	21
32.	16	18	16	24
33.	16	19	17	26
34.	13	20	18	27
35.	11	21	8	24
36.	14	19	12	23
37.	14	16	15	18
38.	14	15	14	21
39.	13	19	12	23
40.	15	21	12	26
41.	11	19	15	22
42.	11	18	12	25
43.	13	16	13	19
44.	12	17	11	21
45.	17	19	17	25
46.	19	20	16	25
47.	18	18	14	26
48.	16	19	12	23
49.	17	21	12	28
50.	13	22	13	24
51.	14	20	11	28
52.	12	18	15	21
53.	14	16	15	18
54.	14	15	14	21
55.	13	19	15	24
56.	13	20	14	25
57.	12	22	12	27

58.	14	21	11	26
59.	14	20	13	25
60.	13	19	14	23
61.	11	18	20	21
62.	17	17	21	21
63.	18	21	14	26
64.	14	24	11	23
65.	12	22	11	24
66.	13	21	13	22

(B)

SPSS Analysis of mean, standard deviation, range and variance for the achievement test

Descriptive Statistics

	N	Range	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
Control_Group _Pre_Test	66	10	13.76	.261	2.120	4.494
Control_Group _Post_Test	66	11	18.39	.277	2.252	5.073
Experimental_Group _Pre_Test	66	13	13.52	.274	2.227	4.961
Experimental_Group _Post_Test	66	10	22.92	.315	2.556	6.533
Valid N (listwise)	66					

(C)

SPSS analysis of ANCOVA for the achievement test

CONTROL GROUP TOTAL

S/N	**CIRCUIT DESIGN**	**SA 5**	**A 4**	**N 3**	**D 2**	**SD 1**	$\bar{X}$	**REMARK**
1	This method of teaching circuit designing increases the level of attention.	5	7	11	17	26	2.21	Rejected
2	makes learning more enjoyable	8	4	7	18	29	2.20	Rejected
3	increases the level assimilation	7	5	12	19	25	2.26	Rejected
4	increases the level of concentration	11	7	8	17	23	2.48	Rejected
5	is more interactive	6	13	8	15	24	2.42	Rejected
6	encourages collaborative learning	5	8	4	26	22	2.20	Rejected
7	encourages self learning	6	6	8	19	27	2.17	Rejected
8	makes it easier to check errors	11	12	8	20	15	2.80	Rejected

9	reduces the chances of error	15	8	9	19	17	2.80	Rejected
10	can replace the teacher to an extent	14	13	8	23	8	3.03	Accepted
11	makes the process more interesting	8	4	8	19	27	2.20	Rejected
12	There is no need for an alternative method of designing circuits	12	7	8	20	19	2.60	Rejected
S/N	**CIRCUIT ANALYSIS**							
13	This method of teaching circuit analysis increases the level of attention.	11	7	12	16	20	2.60	Rejected
14	makes learning more enjoyable	12	7	8	17	22	2.55	Rejected
15	increases the level assimilation	12	4	10	20	20	2.52	Rejected
16	increases the level of concentration	7	12	12	12	21	2.60	Rejected
17	is more interactive	11	7	17	16	19	2.64	Rejected
18	encourages collaborative learning	14	12	5	15	20	2.77	Rejected
19	encourages self learning	15	8	7	28	8	2.91	Rejected
20	makes it easier to check errors	11	13	10	19	13	2.85	Rejected
21	reduces the chances of error	15	7	8	21	15	2.79	Rejected
22	is more precise	7	12	7	19	15	2.62	Rejected
23	is more retentive	16	7	11	15	17	2.85	Rejected
24	can replace the teacher to an extent	11	8	12	20	15	2.70	Rejected
25	There is no need for an alternative method of teaching this subject.	16	10	8	14	20	2.82	Rejected

EXPERIMENTAL GROUP TOTAL

S/N	**CIRCUIT DESIGN**	**SA 5**	**A 4**	**N 3**	**D 2**	**SD 1**	$\bar{X}$	**REMARK**
1	This method of teaching circuit designing increases the level of attention.	29	17	4	9	7	3.79	Accepted
2	makes learning more enjoyable	28	19	10	7	8	3.72	Accepted
3	increases the level assimilation	22	24	4	8	8	3.67	Accepted
4	increases the level of concentration	27	19	4	9	7	3.78	Accepted

5	is more interactive	26	27	4	5	4	4.00	Accepted
6	encourages collaborative learning	24	18	13	4	7	3.73	Accepted
7	encourages self learning	27	23	4	9	7	3.77	Accepted
8	makes it easier to check errors	27	19	11	5	4	3.91	Accepted
9	reduces the chances of error	23	27	5	7	4	3.88	Accepted
10	can replace the teacher to an extent	26	18	11	4	8	3.75	Accepted
11	makes the process more interesting	25	19	11	7	4	3.82	Accepted
12	There is no need for an alternative method of designing circuits	23	26	8	5	4	3.89	Accepted
S/N	**CIRCUIT ANALYSIS**							
13	This method of teaching circuit analysis increases the level of attention.	23	15	9	12	7	3.53	Accepted
14	makes learning more enjoyable	23	21	8	8	7	3.67	Accepted
15	increases the level assimilation	23	23	8	4	8	3.74	Accepted
16	increases the level of concentration	26	16	7	8	7	3.72	Accepted
17	is more interactive	23	19	12	6	4	3.80	Accepted
18	encourages collaborative learning	22	19	12	5	7	3.68	Accepted
19	encourages self learning	30	17	7	4	8	3.86	Accepted
20	makes it easier to check errors	26	21	11	4	4	3.92	Accepted
21	reduces the chances of error	27	19	9	4	7	3.83	Accepted
22	is more precise	23	18	12	8	5	3.70	Accepted
23	is more retentive	19	22	8	7	4	3.75	Accepted
24	can replace the teacher to an extent	25	19	11	4	7	3.77	Accepted
25	There is no need for an alternative method of teaching this subject.	27	16	8	5	10	3.68	Accepted

SPSS RESULTS

DESCRIPTIVES VARIABLES=CGPRT CGPOT EGPRT EGPOT /STATISTICS=MEAN STDDEV MIN MAX SEMEAN.

Descriptives

Notes

Output Created	14-Dec-2012 22:10:45

Comments		
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	Cases Used	All non-missing data are used.
Syntax		DESCRIPTIVES VARIABLES=CGPRT CGPOT EGPRT EGPOT /STATISTICS=MEAN STDDEV MIN MAX SEMEAN.
Resources	Processor Time	0:00:00.000
	Elapsed Time	0:00:00.014

[DataSet1] C:\Users\Prof. Akor\Documents\DATA FINAL.sav

Descriptive Statistics

	N	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
CGPRT	66	9.00	19.00	13.8030	.25749	2.09189
CGPOT	66	13.00	24.00	18.3485	.28193	2.29040
EGPRT	66	8.00	21.00	13.5455	.27497	2.23388
EGPOT	66	18.00	28.00	22.8636	.32163	2.61291
Valid N (listwise)	66					

DESCRIPTIVES VARIABLES=CGII EGII /STATISTICS=MEAN STDDEV MIN MAX SEMEAN.

Descriptives

Notes

Output Created	14-Dec-2012 22:22:11
Comments	

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	Cases Used	All non-missing data are used.
Syntax		DESCRIPTIVES VARIABLES=CGII EGII /STATISTICS=MEAN STDDEV MIN MAX SEMEAN.
Resources	Processor Time	0:00:00.015
	Elapsed Time	0:00:00.014

Descriptive Statistics

	N	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
CGII	25	2.17	3.03	2.5836	.05153	.25763
EGII	25	3.53	4.00	3.7744	.02015	.10075
Valid N (listwise)	25					

UNIACONOVA **EGPRT** WITH **CGPRT** /METHOD=SSTYPE(3) /INTERCEPT=INCLUDE /PRINT=DESCRIPTIVE TEST(LMATRIX) /CRITERIA=ALPHA(.05) /DESIGN=CGPRT.

Univariate Analysis of Covariance

[DataSet3]

Descriptive Statistics

Dependent Variable:EGPRT

Mean	Std. Deviation	N
13.5455	2.23388	66

Tests of Between-Subjects Effects

Dependent Variable:EGPRT

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	299.948[a]	1	299.948	786.254	.000
Intercept	.577	1	.577	1.513	.223
CGPRT	299.948	1	299.948	786.254	.000
Error	24.415	64	.381		
Total	12434.000	66			
Corrected Total	324.364	65			

a. R Squared = .925 (Adjusted R Squared = .924)

UNIANCOVA **CGPOT** WITH **CGPRT** /METHOD=SSTYPE(3) /INTERCEPT=INCLUDE /PRINT=DESCRIPTIVE TEST(LMATRIX) /CRITERIA=ALPHA(.05) /DESIGN=CGPRT.

Univariate Analysis of Covariance

Descriptive Statistics

Dependent Variable:CGPOT

Mean	Std. Deviation	N
18.3485	2.29040	66

Tests of Between-Subjects Effects

Dependent Variable:CGPOT

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	313.319[a]	1	313.319	724.815	.000
Intercept	21.771	1	21.771	50.363	.000
CGPRT	313.319	1	313.319	724.815	.000
Error	27.666	64	.432		
Total	22561.000	66			
Corrected Total	340.985	65			

a. R Squared = .919 (Adjusted R Squared = .918)

UNIANOVA **EGPOT** WITH **EGPRT** /METHOD=SSTYPE(3) /INTERCEPT=INCLUDE /PRINT=DESCRIPTIVE TEST(LMATRIX) /CRITERIA=ALPHA(.05) /DESIGN=EGPRT.

Descriptive Statistics

Dependent Variable:EGPOT

Mean	Std. Deviation	N
22.8636	2.61291	66

Tests of Between-Subjects Effects

Dependent Variable:EGPOT

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	388.331[a]	1	388.331	448.276	.000
Intercept	111.367	1	111.367	128.559	.000
EGPRT	388.331	1	388.331	448.276	.000
Error	55.442	64	.866		
Total	34945.000	66			
Corrected Total	443.773	65			

a. R Squared = .875 (Adjusted R Squared = .873)

UNIANOVA **EGPOT** WITH **CGPOT** /METHOD=SSTYPE(3) /INTERCEPT=INCLUDE /PRINT=DESCRIPTIVE TEST(LMATRIX) /CRITERIA=ALPHA(.05) /DESIGN=CGPOT.

Descriptive Statistics

Dependent Variable:EGPOT

Mean	Std. Deviation	N
22.8636	2.61291	66

Tests of Between-Subjects Effects

Dependent Variable:EGPOT

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	423.783[a]	1	423.783	1356.818	.000
Intercept	5.786	1	5.786	18.525	.000
CGPOT	423.783	1	423.783	1356.818	.000
Error	19.990	64	.312		
Total	34945.000	66			
Corrected Total	443.773	65			

a. R Squared = .955 (Adjusted R Squared = .954)

UNIANCOVA **EGII** /REGWGT=**CGII** /METHOD=SSTYPE(3) /INTERCEPT=INCLUDE /PRINT=DESCRIPTIVE TEST(LMATRIX) /CRITERIA=ALPHA(.05).

Univariate Analysis of Covariance

Descriptive Statistics[a]

Dependent Variable:EGII

Mean	Std. Deviation	N
3.7834	.16140	25

a. Weighted Least Squares Regression - Weighted by CGII

Tests of Between-Subjects Effects[b]

Dependent Variable:EGII

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.000[a]	0	.	.	.
Intercept	924.548	1	924.548	35490.996	.000
Error	.625	24	.026		
Total	925.173	25			

Corrected Total	.625	24				

a. R Squared = .000 (Adjusted R Squared = .000)

b. Weighted Least Squares Regression - Weighted by CGII