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DEPARTMENT OF SCIENCE EDUCATION

ASSESSING STUDENTS' UNDERSTANDING OF SOME ELECTRONICS TOPICS: A CASE STUDY AT AGONA NYAKROM SHS.

BY

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DECEMBER 2014

DECLARATION

CANDIDATE'S DECLARATION

I hereby declare that this dissertation is the result of my own original research and that no part of it has been presented for another degree in this University or elsewhere.

Candidate's Name: MA-MOUN AWAL

Signature:……………………………….

Date:……………………………………

SUPERVISORS' DECLARATION

We hereby declare that the presentation and presentation of the dissertation is supervised in accordance with the guidelines on supervision of thesis laid down by the University of Education, Winneba.

Supervisor's Name :Prof. M K Amedeker.

Signature:………………………………………………………………………..

Date:……………………………………………………………………………..

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Finally, I will express my sincere thanks to my supervisor Prof, M K Amedeker, Ph.D.

DEDICATION

To

The Almighty Allah. Also my parents, brothers and sisters. May the blessings and guidance of the Lord constantly be with you.

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ABSTRACT

This study assessed students' conception of some electronics topics at the Senior High School level. The study was also to find out the effect of using relevant teaching / learning resources on student's understanding of basic electronics concepts such as 'transistors.' The research design was qualitative (descriptive) through experimental – control method. The target populations were students from Agona Nyakrom Municipal Senior High Schools. Ten Senior High Schools (S.H.S.) were selected by simple random sampling. The students used for the study were selected using stratified sampling. The main instruments used were class tests and interviews. The class tests were administered to 200 students. Interview guide was also used to gather information from the students and electronics teachers. It was recommended that students should be empowered to become responsible for their own learning of electronics by creating opportunities that will actively involve them in the learning process. Finally, heads of the Senior High Schools must embark on regular supervision during electronics lessons in order to ensure effective and meaningful lessons.

CHAPTER ONE

INTRODUCTION

Overview

In this chapter a brief discussion of the background to the study is done. The study has been motivated by the fact that a recent educational reform has introduced electronics into the senior high school curriculum as a subject to be taught. As electronics is one of the new subjects related to modern technological development of the world, the study sets out to find how students grasp the concepts of electronics. Three research questions have been formulated to guide the study. It is hoped that findings of the study will be of value to stakeholders in the Ministry of Education and other higher institutions of learning in Ghana.

Background to the study

Teaching of science has been undergoing some major shifts in perspective and approaches over the last century. Each major shift has in turn reformulated the teacher's role calling upon him/her to acquire new skills, understanding of the subject matter and different order of commitment to the emerging perspectives. Since independence there have been many attempts at educational reforms in Ghana. These include the Accelerated Development Plan of 1951, Kwapong Review Committee of 1966, the Dzobo Review Committee of 1974. The 2007 education reform of science has brought in its wake new subjects such as Creative Arts, Information, Communication and Technology (ICT), Basic Design and Technology, Citizenship Education and Electronics. Electronics was introduced into the basic school curriculum to replace environmental studies.

The rationale for the introduction of electronics into the basic school curriculum is to ensure that science and technology form the basis for inventions, for manufacturing and for simple logical thinking and action among Ghanaian children. For - instance, considering the Senior high school syllabus for electronics, integrated circuits and chips have led to the reduction in size of electrical instruments, reduction in power loss in electrical instruments an increase in reliability of electrical monitoring devices and reduction in cost of production of most electrical instruments. IC's and chips have made it possible to produce personal devices like calculators, computers and watches. This means that scientific and technological literacy is necessary for all individuals, especially in developing countries which have to move faster in the attempt to raise the standard of living of their people. Electronics is a fusion of the major branches of science. The study of electronics at the senior high level is expected to equip the young person with the necessary process skills and attitudes that would provide the young person with the interest and inclination toward the pursuit of scientific work. By this attempt the student will begin to accept the subject, as it is now examinable by the West African Examinations council.

Statement of the problem

It is generally acknowledged that the role of science students learning electronics is changing due to changes in science curricula, materials and media. As a result of these changing role, science students learning electronics face the realisation that they have certain cognitive and psychomotor needs which limit their effectiveness as learning science.

According to Popular sources,"It is well - known that in Ghana, science students at the senior high school level are mostly theoretically oriented with no Physics specialty as electronics".Some students especially, those in the rural set up are taught by non- professionals who have little or no knowledge in science. Even though, these students might have used various kinds of coping strategies and safety net in their learning, they still need practically oriented courses such as electronics to learn science meaningfully effectively.

Since, the inception of new educational reform, little and in some cases nothing has been done to help the learners continue with the study of electronics in the senior high schools to its completion as a registered subject ,at the final examination at the West African Examinations council (WAEC). Most significantly is the use of same generalist topics without any further update of the subject prior to the commencement of the reform. Though the reasons for students' inability to effectively learn electronics in the lower senior high school are not apparent, it appears learners at this level lack practical basis due to some inherent difficulties which can be traced to the nature of training received at junior high school. Little emphasis is placed on hands – on activities and acquisition of basic scientific process skills during the training of these students with much emphasis placed on content knowledge. Lack of sustained interest in the learning of electronics in the areas of instructional knowledge, instructional skills and instructional attributes. This study therefore intends to assess the types of concepts students have in electronics.

Purpose of the study:

The study serves two purposes

1. The study would be used to provide an intervention through a number of lessons.
2. To give students the opportunity to exhibit their understanding of concepts in electronics.

Objectives of the study

Three objectives guided this study:

1. present an intervention through a number of lessons.

2. provide feedback to students on concepts they have expressed on topics in electronics.

3. determine students' ability to solve problems on electronics.

Research questions

The study was guided by the following research questions:

1. How can intervention lessons help students to learn concepts in electronics?

2. What role can feedback play in students' comprehension of concepts in physics?

3. What tasks can be used to evaluate students' conceptual understanding in electronics?

Delimitations

Inherent factors in the research or internal factors. This study is bound by these internal factors.

Senior high schools established , did aid the assessing of only two students' understanding of some electronics topics in almost every town and village in the Agona Nyakrom municipality. It was not an easy task to access even two students in the short time at the disposal of the researcher.

Thus all the 66 basic schools in the Agona Nyakrom municipality were selected for the research. Of late students that go to choose subjects in electronics go there without the solid foundation at the J.H.S level built, to facilitate learning of the subject at the

S.H.S. Usually, students who are admitted to study Physics are admitted with higher grades by the authorities of their school and when teaching and learning of the subject fails it is usually challenged to the teacher of the subject.

It would also be expensive teaching as it is sometimes challenging to be able to organize any practical lessons, due to inadequate resources in most Senior High Schools in the country; such as qualified science teachers, laboratory assistants and in some rural schools too, the basic equipment for the subject. In such an instance most heads of departments turn to blame these on the inefficiency of the subject teacher. Agona Nyakrom municipality will therefore be chosen since the schools are close to each other.

Limitation

Those external factors including the researchers own schedules in and outside of his activities in the classroom, and being able to conduct the research. That would otherwise serve as obstacles to the progress of the work. For classroom research, in a J.H.S. problem their level of understanding of the language was taken into consideration. For an interview conducted at this level, I needed to rehearse and use very basic words.

In this regard, the study involved students studying electronics of various backgrounds, who did consider any interaction with them as a sort of examination, was bound to meet the problem of students' unpreparedness to the lessons taught. Student's level of understanding was usually taken into consideration. There is no unanimity of what assessing only two students' conception of some topics in electronics at the senior high school level may be. So the researcher had to exercise extra caution in searching for assessing the students' conception in electronics.

Thus only the Agona Nyakrom Municipality was selected for the research.

CHAPTER TWO

LITERATURE REVIEW

Overview

Documents both published and unpublished, including books, journals and newspapers that have information on the topic are reviewed. The role of teacher's pedagogical knowledge and skills in helping students to understand that the study of Electronics deals with the design of circuits which process signals of relative low power is acknowledged , to be a key factor among the many factors that influence achievement in the lesson taught as student understanding assessment. As a result, to keep abreast with the changes in the Senior High School curriculum would in the classroom (Kamisah , 2006).

Teaching method

Most often than not , students between the ages of sixteen (16) and eighteen(18) are involved in the learning of Electronics at the senior High school level. The main method of providing information for learning is true teaching the lesson by the activity method of learning as scientific knowledge is particularly flexible and the store of knowledge keeps changing (Opong , 1981). The task then of an Electronics Science teacher will be stated as follows:

Pair or small group task whereby the class for the Electronics lesson is broken into pairs or small groups of 2-4 to carry out different activities at the same time. This is useful where the diodes cannot go round the class or where students need to collaborate to work on a bridge rectifier circuit;

Whole class task organisation, in which case all students work on the bridge rectifier containing four diodes at the same time. One of the diodes breaks down so that an open circuit occurs at that point is better done individually, especially when the diodes are easily available;

Demonstration, which can be teacher –demonstration alone or with the assistance of the students, is applicable. Teacher will introduce methods for which the students will be required to describe and explain the shape of the output wave form for a sinusoidal a.c. input will be set to assist students in assimilating this lesson during private study. Teaching the lessons showed that the student do better in the lesson when they are continuously assessed on the semi-conductors for instance, after each lesson. However, the lack of commitment by the teacher to conduct continuous assessment but will be tempted to manufacture marks are attributed causes to the lack of student understanding. These will need measures of intervention to enhance student understanding in some topics taught at the S.H.S level.

Strategies can be devised, Bishops(1985) points out to help the students to become conversant with examination trends at the examination council as this will be the main reason in assessing students understanding in the Electronics topics taught.

Content – Usually, the content is presented briefly with the explanation of how signals are processed in electronics.

Coverage – Students should understand how these signals are produced.

As a complete illustration on the Electronic lessons taught, students should understand that signal processing and application are expensive to produce and take up much more space than their modern replacements. This has made semiconductor devices to be used universally now a day.

To ensure that the basic concepts are understood, end – of – chapter exercises are conducted to ensure proper understanding.

Aims and objectives of Electronics education at the senior High school in Ghana

To provide regular and effective pastoral support and advice for students

to ensure that students understand the fundamentals of the subjects taught , and deal with any academic problem encountered

to monitor the progress and attendance of students as part of the 'early warning system' which aims to identify students showing signs of difficulty

to help students work in a disciplined manner and promote responsibility for their own learning

to obtain formal and informal feedback about Electronics

to promote discussion about wider aspects of the subject of Electronics

to improve student's verbal communication skills in Electronics

Electronics as a discipline is very necessary sine improving assessment depends on students' understanding (Osman,2006) ,and deals with the nature of conversion of electronic signals, the rectification and amplification of the signals. The study of electronics has had and continues to have, a big impact on the world community. The ideas, skills and attitudes derived from the study of Electronics are being widely applied in various scientific and technological developments. The specific example of

Electronics is helping the student understand by conducting student assessment regularly.

Theories of learning

There are several theories of learning that exist. Effective teaching of Electronics is not simple; every action of the teacher should be explicable and backed by sound educational theories and principles Electronics. The underpinning principles of effective pedagogical practices draw upon the established theories of learning and ethos of teaching of the subject. This section will therefore examine a few relevant theories and principles of learning that have implications for Electronics teaching.

A learning theory is simply a proven, accepted and unified set of related principles and knowledge of how Semiconductors might be transistors to provide the frame work for describing the process that characterises how students acquire knowledge and skills to enhance their understanding. The sections following describe some of the theories of learning that have implications for classroom practices, in which an Electronics teacher must be grounded. These are: behaviourism, constructivism, cognitive developmental.

Behaviourist theories of learning

The Behaviourist theory is simply about stimulus – response learning of Electronics. Behaviourists provide definite explanations for learning Electronics by portraying it as a permanent and observable change in behaviour arising from response to external or environmental agents that act on a student (or organism) to "either cause him/her to respond or to increase the probability of a response of a certain kind during the

Electronics lesson" (Bigge & Shermis,1998). The responses are the effects of the stimuli, which are either external or internal physical reactions.

Two principal classes of explanations of learning of Electronics are identified, namely:"those based on contiguity (simultaneity of stimulus and response events) and the effects of behaviour (reinforcement and punishment)". Consequently, an Electronics teacher must take cognizance of the implications of the behaviourist theory for learning of the subject Electronics (Harteley, 1998) by:

Providing activities-oriented learning of Semiconductor devices (passive learning is not productive);

Supporting the learning process with diodes , zinc plate and several other instructional materials to prompt or reinforce learning of Transistors and Integrated circuits;

Providing repetition of the concepts in Electronics and frequent practice of what has been learned about the Transistor to promote retention

Consistently using positive reinforcements, rewards and feedbacks to motivate students in learning the Transistor and Integrated circuits; and

Stating clear that at the end of the lesson the student can distinguish among conductors, semiconductors and insulators as one of the observable instructional objectives as cue for making the teaching process meaningful.

Cognitive developmental theory

According to Piaget's theory (Piaget, 1970; Travers, 1977; Smith 1999), the four stages of cognitive development are:

Sensory – motor (birth to 16 years): A student uses sensory and motor ability to form concepts about the topics in Electronics, and gains understanding of the topic through direct interaction in the lesson. (S) he only recognises the diode and insulator as a result of interaction with them, learns to coordinate movements, and begins to develop mental representations of information on Electronics.

Pre-operational (age 16-17 years): A student grapples with conceptualising concrete physical environment and accumulating physical experiences. (S) he responds to objects and events as they appear to be, and develops the ability to represent them symbolically" inside of her/himself in such a representations can be used in the absence of the diode and insulator"

Concrete operations (ages 17 -18 years) : A student begins to conceptualise and create logical structures to explain her /his physical experiences. During this stage (s)he is able to do some logical reasoning.

Formal operations(18 years onward) : A student's cognitive structures are getting developed for abstract conceptual thinking, and undertakes problem solving in Electronics at a formal logical level.

Cognitive theorists explore how changes in internal structure (piaget's theory) and mental process (Bruner's theory) are linked to learning the subject Electronics. Jean propounded a four-stage model of student development and learning of the Subject Electronics. The underlying notion is that there is increasing complexity or sophistication in learning Electronics as a student undergoes mental, emotional and physical change. That is, with maturation, a student builds a cognitive structure that permits her/him to undertake task that increase in sophistication over and above the experience of an earlier stage.

Each student navigates through these stages that are different pace, and accumulates experiences to reason logically .The implications of this for teaching Electronics are that: (i) subject matter in Electronics should be structured in a hierarchical and logical manner to provide a buildup of experiences;(ii) selection of instructional experience should be guided by individual differences amongst learner; and (iii) there should be wide range of opportunities for students to interact with and explore their immediate environment. Large collections of transistors, usually explains this particularly in the regard of sound amplification.

Constructivist Theory.

The constructivist theory, by Bruner (1960), states that teaching of Electronics is premised on the active nature of learning. The underlying conception of semiconductors as constructivism is that further conduction may be induced in a pure semiconductor by the addition of impurities. This knowledge resides in the individual learner, and as such ,learning Electronics is the process through which an individual tries to make sense of what is taught at lessons by trying to fit it into her/his existing knowledge structure and prior experience(s)

To the constructivists, the student learning Electronics in this lesson can only learn if her/his understanding of the semiconductor provide the framework upon which to fit the explanation of dopping- the result of which is artificially or extrinsic conduction. As Electronics includes the study of all electron effects and applications, the subject is usually confined to the study and design of circuits. The more the information the learner acquires, the more the explanation of semiconductor changes in terms of scope and structure. Also, it is stated that the design of circuits process signals of relatively low power. On the contrary ,learning conflict occur if there is a contradiction between the existing understanding of the semiconductor and the new ideas developed in the lesson , forcing the learner to consider whether to reject the new idea or discard the old .An individual's schema for-instance can take that Pure silicon and germanium, the most common semiconductors, have a diamond – type structure, in which four valence electrons are involved in bonding , either through the process of "adding an action system that is consistent with those that are already organized within the schema" of the learning. On the contrary, assimilation take place by the incorporating of Semiconductor devices into Semiconductors held by the learner of the new subject Electronics (Novak; Conas, 2008), and at the same time "modifying the Semiconductor to make it consistent with the new response" (Travers, 19).It can be appreciated that, these signals therefore might be associated with control, communications, or data handling.

Learning Styles Theory

The theory of learning styles describes the different ways by which learners adopt, receive, and process or react to information that is to be fitted into their cognitive schema. An example of the classification of learning styles is the Felder - Silverman (1998) model, which organises learners into five dichotomous learning styles: sensing /intuitive, visual/ verbal, inductive/deductive, active / reflective, and sequential / global.

Sensing learner *performing* to take information through their sense such as hearing, touch or feeling. They enjoy learning by handling real-life object (tactile cue), or making physical movements like demonstrations or experiments (kinaesthetic) as a way of connecting the diodes. On the other hand. Intuitive learner favour information that comes through their memory, reflection, and imagination on the various Electrical concepts considered.

Visual learners liked to receive information through some media that they could see, like charts, picture, and demonstration whereas verbal learners could learn more through listening and reading.

Reflective learners think introspectively about information before working on them; whereas active learners learned by doing something with the information.

Sequential learning absorbed information *sequentially* and in bits, and liked to build on them gradually; while global learners could absorb materials even in the absence of any previous connection

Inductive learning of Electronics preferred to learn from specific bit which lead to general principles and deduced specific applications in Electronics.

It was further informed that historically, thermionic, or heat based, vacuum tube technology was used to process signals. These tubes are called valves; they are still used for some applications but are expensive to produce and take up much more space than their modern replacements. The Learning Styles Theory in Electronics stresses the fact that students usually perceive and process information in different ways using a combination of their senses and skills. This literature provides different models on how students are characterized according to the way they acquire information (Mc Keanchie 1986; Bigge , Shermis, 1998; Felder, 1988). The crystal remains neutral as students usually appreciate.

A good teacher of the subject is expected to apply a range of active learning approaches by stating that associated with the five electrons are five protons. He usually explains to his students that this surplus electron can easily become available for conduction; this type of impurity is known as a donor element as it donates a free electron. Often he takes a lesson on “A trivalent impurity” for instance; the teacher would state that examples are boron or aluminium (acceptor elements) in order to captivate his /her students’ attention. This he states would contribute the ‘absence of an electron’ or hole. It ensures further enhancement in his delivery.

Principle of learning

The principles suggest that:

What students learn is influenced by their existing ideas on transistors and integrated circuits up to this point in the lesson. The student grasps the concept of semi-conductor devices since their broad experience on the subject increases. The student develops his/her understanding by teacher’s explanation that semi-conductor devices are now almost universally employed. (AAAS, 1993; Smith, 1999)

As thermally mobile electrons move into the hole, the ‘hole’ appears to move around. By this (s)he is made to understand that Semi-conductor devices might be transistors, i.e. single stage amplifier or switching devices , diodes (rectifying devices which turn alternating currents into direct currents) or large collections of these and other devices mounted on one tiny slab of, say silicon.

Learning usually a progression from the concrete to the obstruct from the cumulative experience, the students understand the ‘hole’ acts as a positive charge carrier, just as the electron is a negative charge carrier.

Students learn well when they are actively involved in learning process as they are made to use a 0.6v source applied to a silicon pn junction .Several responses aroused them in the lesson which subsequently removed boredom in the lesson. They have motivation from this and continue to learn that Doping to produce holes produces p-type (p for positive) Semiconductor material and doping to produce electrons produces n-type (n for negative) Semiconductor.

Effective learning by students requires feedback. After marking the exercises quickly their exercise books are returned to them and effective corrections are made and marked to provide useful learning guides that help student to direct their learning towards important goals.

Meaningful content is better learned and retained then less meaningful content.

New meaning is added to the lessons stating that since intrinsic conduction still takes place, there is a combination to conduction from:

Thermally liberated electrons which are fewer and therefore called the minority carriers, and more numerous electrons or holes produced by doping, which are called majority carriers.

This way the concept is made clear and related to the learner's existing knowledge (Novak &Canas, 2008).

Expectation affects performance. Next time before the new lesson begins student are expected to know what happens if a device containing both n- type and p-type materials is placed in a circuit. The response should be that holes travel along decreasing potentials and electrons along increasing potential.

Concept Mappings

The idea of concept mapping as a learning tool was developed by Novak in 1972 as an attempt to explore the changes in student's knowledge of Electronics (Novak & Musonda, 1991; Novak & Conas, 2008). The idea derives from Ausubel's (1963) cognitive theory which places central emphasis on the connection of student's existing knowledge of Electronics on definitions of conductors, semiconductors and insulators as the anchor for subsequent meaningful learning of semiconductor devices. At absolute zero, the conduction band would be empty as it usually is in Electronics. However, semiconductors do not conduct as well as metals. Concept map is a useful tool for organizing and visually representing interrelated structure of concept of semiconductor devices within a domain of knowledge. Also, their conductivity as semiconductors is very dependent on the temperature, increasing as the temperature rises. Such semi-conduction is known as intrinsic, since it is a natural property of the crystal.

Concept maps are useful tool for helping student learn about the structure of knowledge in Electronics, and tie new knowledge to current experience. They are valuable tools for stimulating student's thinking process and representing knowledge in meaningful learning patterns as they try to explain above.

The procedure for using concept maps as an instructional tool in Electronics is as follow (Novak & Canas, 2008):

Studies indicate that if the student's learn a topic ahead of the lessons in the classroom their understanding of the lesson becomes easier for them when the teacher would explain for instance that, for dopping the impurity atom occupies one position in the crystal and contributes either three or five bonding electrons. (S) He is likely to retain information longer, apply it more effectively. This suggests that a teacher could reduce the frustration over student poor understanding. Thus the assessing only two students' understanding of some electronics topics: a case study of Agona Nyakrom SHS.

Cooperative Learning

Further the assessment of students' understanding in the lesson can be enhanced when it is stated that dopping occurs in a semiconductor by the addition of impurities; and this will result in what is known as artificial or extrinsic conduction. The emphasis is on getting students to work together to review the test what is a rectifier? Again they carry out the project in the design and construction of a common-emitter N-P-N transistor amplifier. In addition to promoting group work, cooperative learning facilitated discussions and encouraged students to imbibe essential elements that are beneficial to learning of the semiconductor devices. These benefits are:

Positive interdependence*:* Students learning Electronics are given the chance to try constructing the pnp and npn diagrammatically, as they are easily convinced that by this such transistors as the name implies are composed of a sandwich of semiconductor diodes. Individual contribution affects the work and success of others.

Face-to-face interaction: The interaction can be in –or out –of-class work on the design and construction of a common-emitter N-P-N transistor. It gives students opportunities to interact with themselves, share their knowledge as a team, and support one another to learn.

Individual Accountability*:* Through cooperative learning of Electronics an assignment is given to the students to tell what the semiconductor is. By group work individuals bring their responses and they are marked and assessed for marks to be awarded equally to each member of a group.

Social Skills: As students remain in their groups during the lesson on the semi-conductor device, with each group assigned a leader they are allowed to communicate freely, build trust in their lessons as well as friendship as they learn to resolve their conflicting opinion on what the semiconductor is. As some say it is made of two sandwich devices, others share the opinion that it is between an insulator and a conductor. In the end students agree that semiconductor devices contain both n- and p-type semiconductors. This is an essential feature of scientific literacy that the student must imbibe.

Group process*:* As students remain in their group they derived the commitment the group required to define the semiconductor as they work together over time.

Conceptual framework

The target of the study is directed at students at the S.H.S level, Electronics subject and teaching style / approach suitable for beginners at the S.H.S. Therefore, theories that have to do with the characteristics of these entities as they affect learning of Electronics would be applicable. The activity method of learning is illustrated below using concept maps

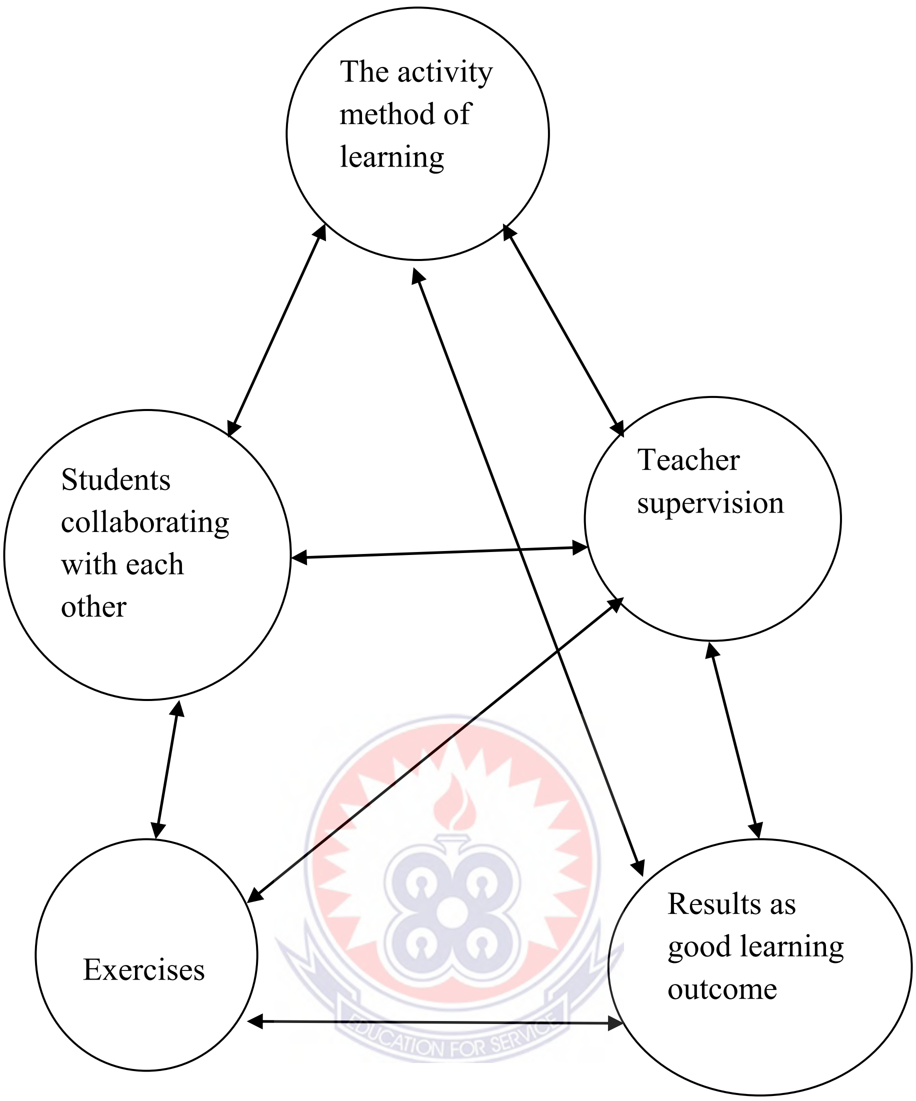

Fig 1.0: A conceptual framework of the activity method .

By this method of learning, students collaborate with each other by the supervision of teacher. They respond to whatever innovative suggestions that the teacher makes towards a successful lesson. He gives students assignments and exercises and communicates the feedback as soon as possible. This he has realised as a successful outcome seen in good results.

CHAPTER THREE

METHODOLOGY

This chapter deals with the activity method of learning which is to be used to provide the intervention needed through a number of lessons, to give students the opportunity to exhibit their understanding of concepts mentioned in the previous chapter.

It will describe the method and procedures to be followed in collecting data for the study. The chapter includes the research design, population, sample, sampling procedure, instruments for data collection, pre-testing, and data collection procedure and data analysis.

Research design

The design used for this study was the descriptive survey. This design mainly dealt with assessing the situation as it is on the ground in the area of assessing students' understanding of some electronics topics. Descriptive design has been used extensively by education policy makers since data obtained through descriptive surveys represent the nature of prevailing conditions, practices, opinions that are held, processes that are going on or trends that are developed (Best, 1995). According to (Osuala, 1991), descriptive surveys are versatile since they point to present needs. He further asserts that descriptive research is basic for all types of research in assessing the situation as a pre-requisite for conclusions and generalization.

The descriptive survey will be used for this study, because it will help in analyzing research questions more effectively, and also has the advantage of gathering information from a large number of sources, relatively cheaper and at relative short time (Norman, 2000).In addition ,descriptive survey helps to generalize from a sample to a population so that inference could be made about some characteristics, or behaviours of the population (Osuala, 1991).

However the descriptive survey is not without some disadvantages. Despite the short comings identified, the descriptive survey will be used because it has the potential for providing a lot of information from quite a large sample of individuals. The design is expected to generate data that will facilitate the assessing of students' understanding in some topics in electronics at Agona Nyakrom senior high school.

Population

The target population in this study comprised all teachers who teach Electronics in the Agona Nyakrom as part of the assessing only two students' understanding of some electronics topics at the SHS level. Although the study was geared towards all school teachers who teach Electronics aspects of science and related integrated sciences in the region, it was not practically possible to cover the entire region due to a number of constraints such as logistics, time, accessibility and human resources. In view of these all school science teachers who teach Electronics in the Agona Nyakrom municipality did constitute the accessible population.

The subjects in the study therefore involved 197 Science teachers comprising 77 science teachers from the rural circuits and 120 from the urban circuits. Urban schools were selected from communities with more than 2500 inhabitants while rural schools were selected from the communities with less than 2500. (Reynells, 2010)

Sampling procedure

All the senior high school teachers who teach Electronics in the public schools in the Agona Nyakrom municipality will be purposively sampled for the study. Stratified random sampling technique will however, be employed to select 10 schools for observation. In this procedure, the schools will be stratified into urban and rural circuits. The names of all the senior high schools in the urban circuits will be written on pieces of papers and shuffled in a box. Five schools will be selected randomly. Secondly, using the same approach, five schools will be selected from the rural. This approach is to give an equal chance for all schools to be selected.

The study is deemed to be one of minimal risk to participants and that the probability and magnitude of harm or discomfort anticipated in the research will not be greater than any ordinarily encountered in daily life, or during the performance of routine physical or psychological examinations or test. This data was prepared by the classroom teacher to teach his lessons in Electronics using the activity method of learning.

Instruments

Data were collected by means of two instruments, teaching the lesson and observation.

Teaching Methods

Most taught topics in Electronics are taught by the teacher who is acting in leading –edge research, ensuring that outdated techniques are eliminated from the course content quickly. Small-group works such as the design and construction of a common - emitter N-P-N transistor amplifier is considered as to also ensure that students have close contact with teacher. Practical skills such as learning to select biasing resistors, two coupling capacitors and a decoupling capacitor are vital part of the lesson in the Electronics subject taught, and it is important that the laboratory and project work should integrate well with the taught subject. As such, not only laboratory experience but also individual and team project work are given a high priority.

Personal supervision

Personal teachers are allocated to every student (the teacher –student relationship is one - on - one basis). The teacher supervises his / her progress in ensuring that students can measure input and output voltages using the voltmeter taking into consideration the zero mark, when taking readings to avoid parallax throughout the course, with regular meetings. This personal contact and guidance is invaluable. Again, suitable load for the amplifier are selected to be able to determine the voltage gain. At the end of the Project work students are guided to write their report.

Lectures

The lecture is the method by the activity method of teaching and learning where we convey the bulk of the theoretical content of the subject Electronics. This traditional technique adopts discipline – and teacher –centered styles. It involves oral presentations of the semi - conductor to be learned by the teacher, generally leaving the students passive. Research evidence suggests that lectures contribute minimally to conceptual understanding in school science (McDermott, 1991; McDermott &Shaffer, 1992; Birke & Foster, 1993; Think Quest Team, 2000 online). It also short –changes the sensing, visual, active, inductive, and sequential learners in Electronics. The strength in using lecture method is that it is efficient in passing more information that the forbidden gap exists between the conduction band and the valence band. It is related that, in conductors, these bands are very close and electrons exist in the conduction band. In a metal, then, the most energetic electrons may be considered free and these enable it to conduct electricity. In insulator, the gap is relatively wide ; the valence band is full and conduction band empty. A large amount of energy must be given to an electron to promote it to the conduction band- the full valence band means that small energy changes within this band are impossible. The gap for semi-conductors is relatively narrow and there are few electrons in the conduction band, and so only a little thermal energy is needed to free electrons for conduction. At absolute zero, the conduction band would be empty. However, semi-conductors do not conduct as well as metals. Further conduction may be induced in a pure semi-conductor by the addition of impurities. The effect of this process (called dopping) is artificial or extrinsic conduction is taught to students quickly. It is useful for introducing the study of Electronics. Although, strictly, Electronics includes the study of all electron effects and applications, the subject is usually confined to the study and design of circuit which process signals of relative low power or summarizing the main points that almost all solid materials are composed of atoms or molecules in geometric arrays, called crystals, held together by bond –forming electrons.Pure slicon and germanium, the most common semiconductors , have a diamond – type structure , in which four valence electrons are involved bonding.Pnp and npn transistors are , as the name implies, composed of a sandwich of semiconductors diodes, or providing factual knowledge to students as a group placed in their study groups mentioned earlier. In the rare cases that a teacher may need to use lectures to communicate information to students, the strategies to maintain students' attention include (Davis, 1993; Mckeanchie, 1994):

Combine with the question: what is a semiconductor? Pausing periodically to ask students to explain the mode of charge movement in a semi-conductor and a metallic conductor. Or seek comments and calling on specific students to answer .Students will pay attention once they are aware that they could be called upon;

Avoid direct repetition of the semi-conductor in a textbook. In case a teacher has to use textbook material directly (he) should find a creative way to keep the students attention and interest;

Use audio-visuals in Electronics lessons depicting the electronic configuration for instance to enhance presentation, and to captivate and sustain students;

End class by summarizing the main points that have been made once again that almost all solid materials are composed of atoms or molecules in geometric arrays, called crystals, held together by bond –forming electrons. Pure silicon and germanium, the most common semiconductors , have a diamond – type structure , in which four valence electrons are involved in bonding. Pnp and npn transistors are, as the name implies, composed of a sandwich of semiconductors diodes;

Make connections to the action of the transistor and everyday phenomena as it produces an enlarged and inverted version of the input current;

Introduce digression tactics by letting students sketch the diagrams for current rectification using the diode to convert from alternating current (A.C) to direct current (D.C) to keep students alert;

Do not talk to the board;

Move around the class without distracting the students

One technique to make lectures more interactive is to adopt the Lecture –Discussion in which the teacher uses questions to provoke thinking and generate discussions.

Tutorials

These allow the subject to be explored in greater depth in a small group. These are supported by problem sheets challenging the student to explain the semiconductor. They should also explain the mode of charge movement in a semi-conductor and metallic conductor which students can address in their own time. Large - Scale problem classes offer additional support for- instance that a semi-conductor has a conduction band gap which exists between a metal and an insulator. It can also be said that in a semi-conductor the gap is relatively narrow and there are a few electrons in the conduction band, and so only a little thermal energy is needed to free electrons for conduction. In metallic conductors the band gaps are very close and electrons exist in the conduction band. All of the theoretical material on the semi-conductor is reinforced by practical work on the design and construction of a common – emitter N-P-N transistor amplifier.

Laboratories

Second year students undergo an intensive laboratory introduction programme at the beginning of their course. They learn about connection of the diode and finding electron voltages using the voltmeter to measure input and output voltages. They will then spend around 6 hours per week in teaching laboratories as most often as not the student will lack these basic skills of measurement in the final examination as they will not be confident enough, due to the lack of practical laboratory work in Electronics. Typically, students work in pairs at each standard practical session as well as the teacher teaching .The group and individual projects also utilize various laboratory facilities.

Project Work

A variety of projects occur throughout the course:

Students combine together with other members of their supervision group to design and construct a common-emitter N-P-N transistor amplifier. They select biasing resistors, two coupling capacitors and a decoupling capacitor. They have measured input and output voltages. Again they select suitable load for the amplifier and determine the voltage gain. The final products are judged by a team of industrial experts and a substantial cash prize is awarded to the winning group. Projects are carefully vetted by the department to ensure that students undertake substantial project in our laboratory.

Observation

Observation will be used to collect data on Electronics science teachers' instructional procedure and interactional style. Electronics lessons will be observed and assessed using a checklist for lesson assessment developed by the Japanese International Co - operation Agency (JICA). The instrument consists of 17 items classified into (i) objective and core points in lesson plan (ii) classroom organization and management and (iii) teaching methodology and delivery. Each item under category will be assessed and ranked with a predetermined scale of 1, 2, 3, 4, and 5 with 1 being the lowest and five being the highest of the scaling.

Pilot study

A pilot study is a small test conducted in the Agona Swedru Municipal of the Central Region of Ghana before conducting the actual study. The purpose of the pilot study is to test the appropriateness of the research instrument. In the light of the analysis of the pilot study result, some modifications may be made in the lesson teaching and observation.

The Agona Swedru Municipal will be chosen for the pilot study because it has almost the same characteristics as Agona Nyakrom Municipal in terms of teacher supply and distribution and qualification. Also, common to the two municipalities is the fact that they both have rural and urban schools.10 Electronics teachers, five rural, five urban will be involved in the pilot study. The lesson is delivered by the teacher in the selected schools after which a lesson on Electronics will be observed for each teacher.

Data collection procedure

The researcher personally collected data through administration of teaching and lesson observation. Letter of introduction from the University (University of Education) together with a permission letter was presented to the heads of senior high schools informing them about the intension to carry out research in their schools. The researcher on his first visit explained to the teachers samples of what they were expected to do. A date was then agreed upon for lesson administration .On the agreed date the researcher did administer the lesson personally. Lessons on Electronics were observed for selected teachers on the day of administering the lesson.

Data analysis plan

Data analysis is the process of simplifying data in order to make it comprehensive. The data collected were being subjected to quantitative analysis using Excel spreadsheets. The responses for the items on assessing the understanding of students at senior high schools in Electronics was scored 4,3,2,1 for ‘’very important’’, ‘’important’’, ‘’little important’’, and ‘’unimportant ‘’ respectively. The responses for the items on instructions on the other hand was scored (3) greatly needed, (2) needed,(1) not needed. A similar approach was used to score the observation checklist. A scale of 1, 2, 3, 4, and 5 with 1 is being the lowest and five being the highest was used to score the various items. The results of the structured observation were used to enrich the item analysis of the administration of teaching and lesson observation.

The information obtained from the responses was put into the package for easy analysis. Analysis was done using simple percentages and mean computed on excel to report the findings. Data was analysed by making use of the research questions. This was done systematically by selecting research questions using the responses from the administration of teaching and lesson observation. This continued until all the research questions and the responses for administration of teaching and lesson observation were exhaustively dealt with.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

Overview

This chapter is devoted to the results of the research obtained from administration of the test items and the interviews conducted. Besides, it also deals with the presentation of analysis and discussions of the results of the data obtained during the study. Responses from the interviews were qualitatively analysed. In all, 200 students took part in answering the test items whereas 40 Science teachers responded to the administration of teaching and lesson observation.

To begin with, the first part of the test items which consisted of the pre-test items was administered to the two groups of students. This was intended to measure students' level of understanding in the concept of 'Electronics' since the same topic had already been taught to students by their teachers. In the second stage of the study, a variety of transistors used to amplify signals or acting as switches were used through the activity approach to teach a lesson for the experimental schools (group 'A') alone after which a post-test was administered. The purpose was to assess students' understanding of concepts in Electronics by providing an intervention through a number of lessons at the S.H.S. and for that matter at the senior high school level so that appropriate recommendations may be made.

To demonstrate sound understanding of question1, '' what is a semiconductor transistor?'' a response should simply indicate that a transistor consists of a semiconductor sandwich .Alternatively, in an npn transistor, a thin layer of p-type silicon is sandwiched between two layers of n-type silicon. In a pnp transistor, the layers are reversed. As recorded in the table 3, 29%(i.e. 29 students) and 27.0%(i.e. 27 students) from experimental group ''A'' and the control group ''B" respectively showed a sound understanding to the pre-test whereas sixty five (65) students from the experimental group 'A' demonstrated sound understanding during the post-test.

A subject's response was classified as partial understanding if the subject could not complete the definitions for the transistor. Eighteen percent (18%) representing 18 students from the experimental group 'A' and 20 students also from the control group 'B' showed a partial understanding of" what is a transistor?" After the post-test with the experimental group, 23 of them showed a partial understanding to the question.

Furthermore, eighteen(18) students from the experimental group and seventeen(17) from the control group showed a partial understanding with specific misconception during the pre-test stage as against three (3) students for the experimental group after the post-test . These responses were full of spelling mistakes and unclear information. Specific misconceptions held by students in the experimental group were twenty five (25) and twenty one (21) for the control group. These figures were reduced to only five (5) in the case of the experimental group after the post-test. The misconceptions contained irrelevant responses like "a transistor is a collector", "transistor is a something that people do to destroy something".

Finally, no understanding held by students during the pre-test was eleven (11) and fourteen (14) respectively for both the experimental and control groups. However, the number of students who showed no understanding after the post-test for the experimental group was just four (4).These subjects did not write anything but left the space blank.

Figure 1, summarizes the responses.

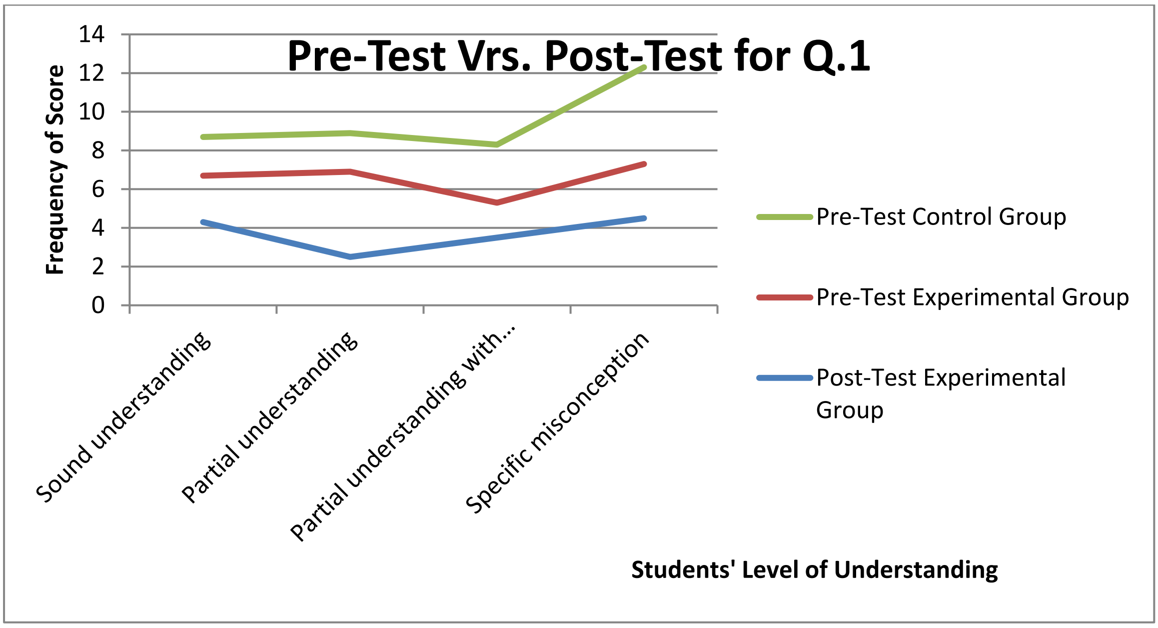

Figure 1:Graphical representation of students' understanding/ performance level to test item

It can be observed from the scatter diagram in Figure1, that the scores for the two pre-test values are very close and low to the horizontal scale. However, the points for the post-test values rise very high above. Again, let us look at the mean score values and their corresponding standard deviations for deviations for all the tests conducted as shown in Table 4.

Table 4: **Mean and Standard Deviation score for the Two Groups of Students on test item 1:**

	Pre-Test		Post-Test
	Control Group	Experimental Group	Experimental Group
Mean Score	2.25	2.29	3.40
Standard Deviation	1.42	1.40	1.04

Then mean score values for the pre-tests(i.e. 2.25&2.29) suggests a strong correlation between the pre-test results for the control group and the experimental group with very low values. On the other hand, the mean score values for the experimental pre-test and its post-test(i.e.2.29&3.40) shows a significant improvement in the performance of students after the post-test.

Table 5: "**Distribution of students' understanding of item 2**

Conception	Control Group	Pre-Test Results Experimental Group	Post-test Results Experimental Group
Sound understanding	28	29	65
Partial understanding	25	18	23
Partial understanding with Specific misconception	17	17	3
Specific misconception	19	25	5
No understanding	11	11	4
Total number of respondents	100	100	100

In the same way as in question one, to demonstrate sound understanding of question two “how are the amplification effects of transistors enhanced?” a response should simply indicate that the amplification effects of transistors are enhanced when they are effectively combined in pairs such as proper combination of two npn transistors which are arranged in a special circuit. Once again the results thereof shows that twenty nine (29) students from the experimental group and twenty eight(eight) students from the control group showed a sound understanding during pre-test. On the contrary , the post –test results indicated that sixty five (65) students showed sound understanding among the experimental group. This represents an increase of two hundred and twenty four percent of the initial pre-test value for the same experimental group.

Similarly a subject’s response was classified as partial understanding if the subject could not be writing definition for the amplification effects of transistors (or definition falls short).After the two pre-tests were conducted for the two groups of students, eighteen (18) students from the experimental group and twenty five(25) from the control groups showed a partial understanding to the question “how is the amplification effects of transistors enhanced?” Also post-test conducted for the experimental group gave the number of students showing sound understanding to be twenty three (23).

The number of students who showed a partial understanding with specific misconception during the pre-tests incidentally happened to be seventeen (17) for both the experimental and control groups, whereas the results for the post test reduced to only three (3).As indicated in the question one, the responses of students to this question again were full of spelling and unclear information.

Specific misconceptions held by students in the experimental group were twenty five (25) and nineteen (19) for the control group during the pre-tests but the figures were reduced to five (5) in the case of experimental group after the post-test. The misconceptions contained wrong responses like "enhancement of amplification effect is not possible", "it is the process of obtaining the unit of heat" etc.

Finally, the number of students showing no understanding during the pre-tests was eleven (11) for both the experimental control groups, but it was four (4) after the post-test. Once again with the no understanding scale these subjects did not write anything left the space blank. These responses have also been summarized in the histogram in figure2.

Figure 2:

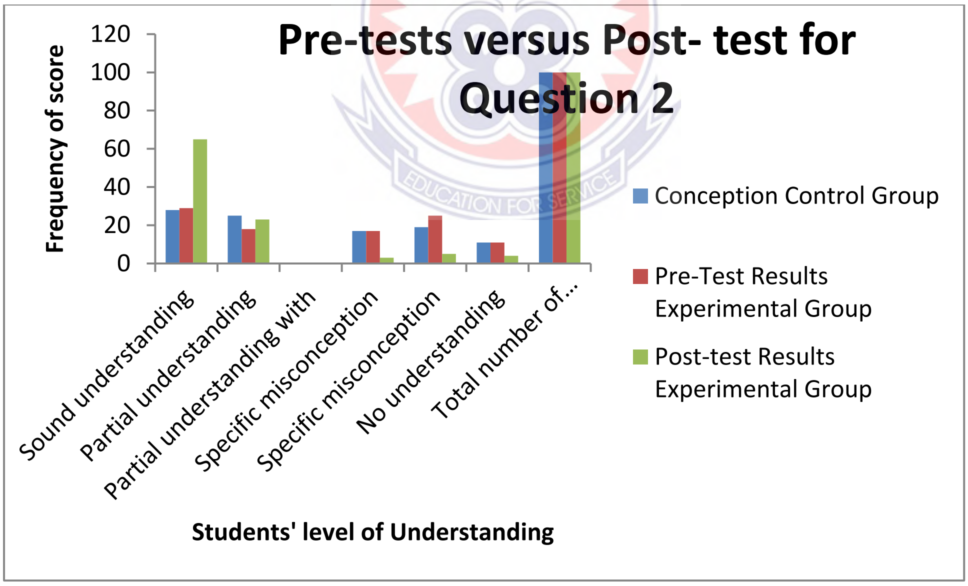

Figure 2: Graphical representation of students' understanding /performance level to test item 2

The histogram clearly shows that a large number of students demonstrated sound understanding to the question after the post-test compared to the two pre-tests. Again looking at the mean score values and their corresponding standard deviations for all the tests conducted as shown in Table 6;

Table 6: **Mean and Standard Deviation Score for the Two Groups of Students on test item 2:**

	Pre-Test		Post –Test
	Control Group	Experimental Group	Experimental Group
Mean Score	2.40	2.27	3.48
Standard Deviation	1.34	1.35	0.93

The averages for test item two in the Table 6 shows that, much more students during the post-test proved to have good understanding by obtaining the mean score of 3.48 as against 3.40 in question one. Mean while, the mean score obtained during the pre-tests were 2.27 and 2.40 respectively for the experimental group and control group, the mean scores gave standard deviation of 0.92638 and 1.3548 respectively. This also implies that the measure of dispersion or fluctuations was high during the pre-test than the post –test.

Table 7: **Distributions of students' understanding of item3**

Conception	Pre-test Results		Post-test Results
	Control Group	Experimental Group	Experimental Group
Sound understanding	28	32	68
Partial understanding	18	16	20
Partial understanding with Specific misconception	10	8	7
Specific misconception	11	14	2
No understanding	33	30	3
Total number of respondents	100	100	100

In this question on Table 7, demonstrating sound understanding for the transistor " is the action of the transistor to produce an enlarged and inverted version of the input current?" a response should simply indicate that this will amplify signal flows between the collector and emitter and through a resistor, across which a varying pd of the same form develops. Here again after the post-test, 68 students representing

68.0% registered a sound understanding as against 32.0% during the pre-test stage for the experimental group.

Similarly a subject's response was classified as partial understanding if the subject attempted to write the correct answer but could not complete it. At this stage, 20.0% of the experimental subjects' demonstrated partial understanding during the post-test as against 16.0% and 18% for the pre-tests(i.e experimental group and control group respectively).

Finally, as many as thirty (30) students from the experimental group and thirty three (33) from the control group showed no understanding during the pre-test stage as against three (3) during the post-test stage. To this question, some of these students gave responses like " Rheostat" , "Valve", "Lamp" and others did not write anything but left the space blank. A graphical illustration to the question there is shown in the figure 3:

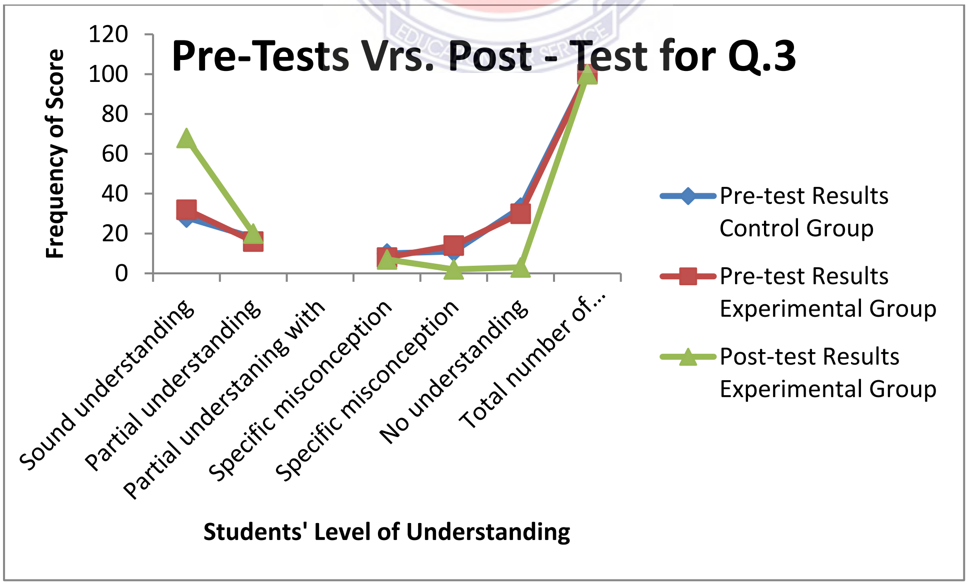

Figure 3:Graphical representation of students' understanding / performance level to test item 3

Below are the statistical values on their averages

Table 8: **Mean and Standard Deviation Score for the Two Groups of Students on test item 3:**

	Pre-Test		Post –Test
	Control Group	Experimental Group	Experimental Group
Mean Score	2.37	2.06	3.48
Standard Deviation	4.51	1.67	0.94

Once again, more students continue to show good performance for the post-test results than they did during the two pre-tests. The Table 8 confirms this by indicating the mean score of 3.48 and a standard deviation of 0.94 for the post –test as against the mean score of 2.06 and a standard deviation of 1.67 during the pre-test for the experimental group.

The good misunderstanding and for that matter good results demonstrated thereof can again be attributed to the fact that students were only required to short answer "it is this signal which forms the output" rather than any long sentence for an answer. This means that giving students long notes as core points would not help them very much.

Table 9: **Distribution of students' understanding of item 4:"would the action of the transistor be to produce an enlarged and inverted version of the input current?"**

Conception	Pre-test		Post-test Results
	Control Group	Experimental Group	Experimental Group
Sound understanding	28	26	67
Partial understanding	25	23	21
Partial understanding with Specific misconception	10	15	6
Specific misconception	15	16	2
No understanding	22	20	4
Total number of respondent	100	100	100

The performance of students to the question four in Table 9 "would the action of the transistor be to produce an enlarged and inverted version of the input current?" showed no difference in trend. This is because sixty seven (67) students from the experimental group representing 67.0% during the post-test stage showed a sound understanding as against 26.0%(i.e. 26 students) and 28% (i.e 28students) respectively for both the experimental and control groups. Also, just about four (4) students showed no understanding by the results of the post-test, as against twenty(20) and twenty two(22) respectively for the pre-tests of the experimental and control groups.

The Table 9 can be represented graphically as in the fig4.

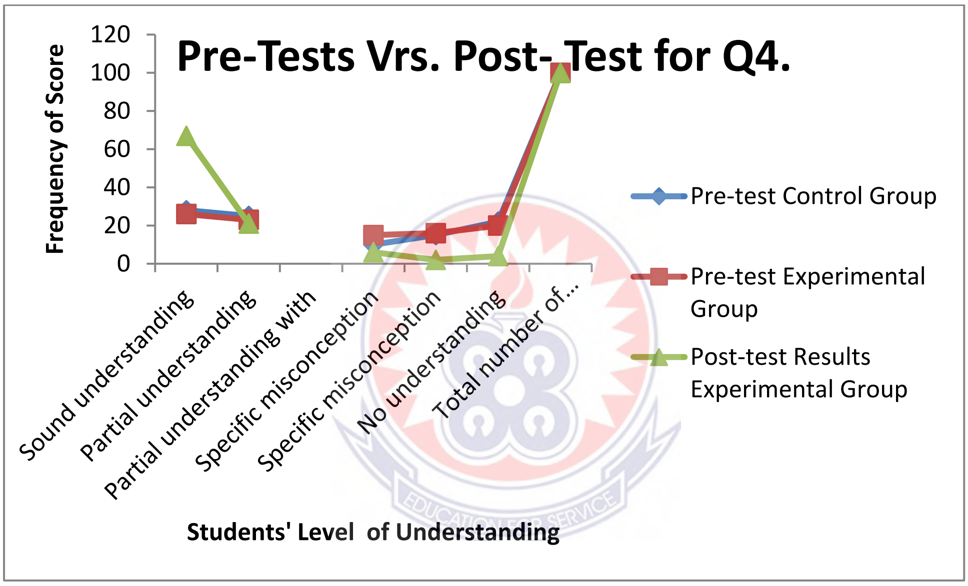

Figure4:

Figure 4: Graphical representation of pupils' understanding/performance level to test item 4

The usual trend of affairs continues as the graph shows a very high peak performance point for the post-test whilst the pre-tests for both two groups (experimental and control) are clustered down horizontally. Also, looking at the statistical values on the averages in Table10;

Table10: **Mean and Standard Deviation Score for the Two Groups of Students on test item 4:**

	Pre-Test		Post-Test
	Control Group	Experimental Group	Experimental Group
Mean Score	2.22	2.18	3.45
Standard Deviation	1.54	1.49	0.99

This result presents the mean score of 3.45 and a standard deviation 0.99 for the post-test of the experimental group thereby justifying students' better understanding as against the initial mean score of 2.18 and a standard deviation of 1.49 during the pre-test.

Comparing the performance of students to the question four in the Table 10 for both the pre-test and post-test , the researcher found out that subjects did not have the exposure or experience to the action of the transistor that it can lead to produce an enlarged and inverted version of the input current. Hence, students were only using trial an error method to guess any action of the transistor at the pre-test stage.

Table 11: **Distributions of students' understanding of item 5:" would the Pnp and npn transistors be composed of a sandwich of semiconductor diodes?"**

Conception	Pre-Test		Post-test Results
	Control Group	Experimental Group	Experimental Group
Sound understanding	28	26	57
Partial understanding	26	14	23
Partial understanding with Specific misconception	19	30	13
Specific misconception	18	15	4
No understanding	19	15	3
Total number of respondents	100	100	100

Showing sound understanding for question five; " would the Pnp and npn transistors be composed of a sandwich of semiconductor diodes?", a response should simply indicate that the " the pnp and npn transistors are , as the name implies, composed of a sandwich of semiconductor diodes" . After the post-test had been conducted , fifty seven of the students representing fifty seven percent(57.0%) from the group 'A' showed a sound understanding as against 26 and 28 students respectively for the experimental and control groups who indicated sound understanding during pre-test stage.

A subject's response was classified as partial understanding if the subject attempted to respond but could not complete it. Here twenty three(23) of the subjects demonstrated partial understanding to the question at the post-test stage whilst fourteen (14.0) students for the experimental group and twenty six (26) for the control group showed a partial understanding at the pre-test stage.

For students who showed partial understanding with specific misconception, the post-test result for experimental group gave twenty three (23) whereas the pre-tests for the misconceptions held by the students during pre-tests were fifteen (15) and eighteen (18) "conduction may not take place by placing a power supply", "in its effect they are two back to back diodes", "however, if the connection base, it is seen that currents of broadly the same value may flow" e.t.c. These figures were reduced to only three (3) students showing no understanding at the end of the post-test. Graphical representation of these data is as shown in figure 5.

Figure 5:

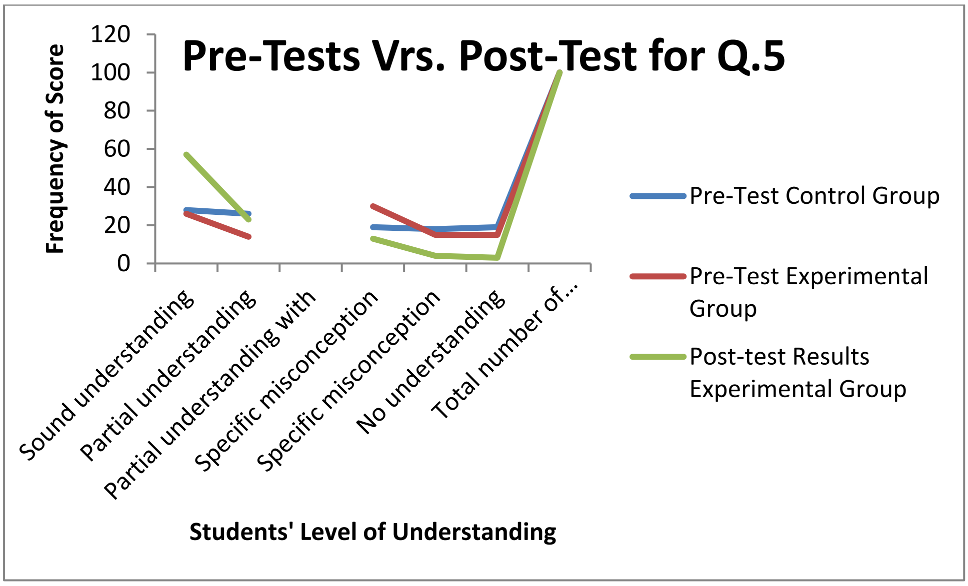

Figure 5:Graphical representation of students' understanding/ performance level to test item 5

The trend of performance above continues to show that students' level of understanding exhibited after the post –test administration is better than those of the pre-tests.

Statistical averages for the above data further shows improvement in student's performance after the post-test and this is shown in Table12.

Table 12: **Mean and Standard Deviation Score for the Two Groups of Students on test item 5:**

	Pre-Test		Post –Test
	Control Group	Experimental Group	Experimental Group
Mean Score	2.19	2.21	3.27
Standard Deviation	1.50	1.38	1.03

Thus a mean score of 3.27 and standard deviation of 1.03 was made after the post – test by the experimental group as against the mean score of 2.21 and standard deviation of 1.38 for the pre-test by the same group of students.

Table 13: **Distributions of students' understanding of item 6**

Conception	Pre-test Results		Post-test Results
	Control Group	Experimental Group	Experimental Group
Sound understanding	27	32	65
Partial understanding	17	13	22
Partial understanding with			
Specific understanding	23	25	8
Specific misconception	16	18	4
No understanding	17	12	1
Total number of respondents	100	100	100

To the question six "In the 'characteristic diagram', is it essential to obtain switching and amplifying ability?" in Table 13, students were required to demonstrate sound understanding by simply indicating that " this is obtained by applying varying input voltages " also they need to know simply that "the collector emitter voltage v_{ce} is developed across the collector and emitter terminals".Thus, after the post-test, sixty – five (65) students from the experimental group showed a sound understanding whereas thirty two (32) and twenty seven(27) for the control group proved to have that sound understanding at the pre-test. This represents more than hundred percent increases in students' level of understanding .Again; a subject's response was classified as partial understanding if the subject attempted to respond but could not complete it. Here twenty two percent (22.0%) of the subjects showed partial understanding at the post-test stage whereas the pre-tests recorded thirteen percent (13%) and seventeen percent (17%) respectively for the experimental and control groups.

Furthermore, eight percent(8.0%) of the responses from the experimental group showed a partial understanding with specific misconception as against the pre-test results where twenty five(25) students for the experimental group and twenty three(23) for the control group .Specific misconceptions held by the experimental group at the post-test were 4.0 %but for the pre-tests the experimental group registered 18.0% and the control group also registered 16%.This time round , only one (1) student showed no understanding after the post-test as against twelve students for the experimental group and seventeen(17) for the control group during the pre-test stages. Graphical representation of the data thereof is as shown in the bar chart in the figure 6:

Figure 6:

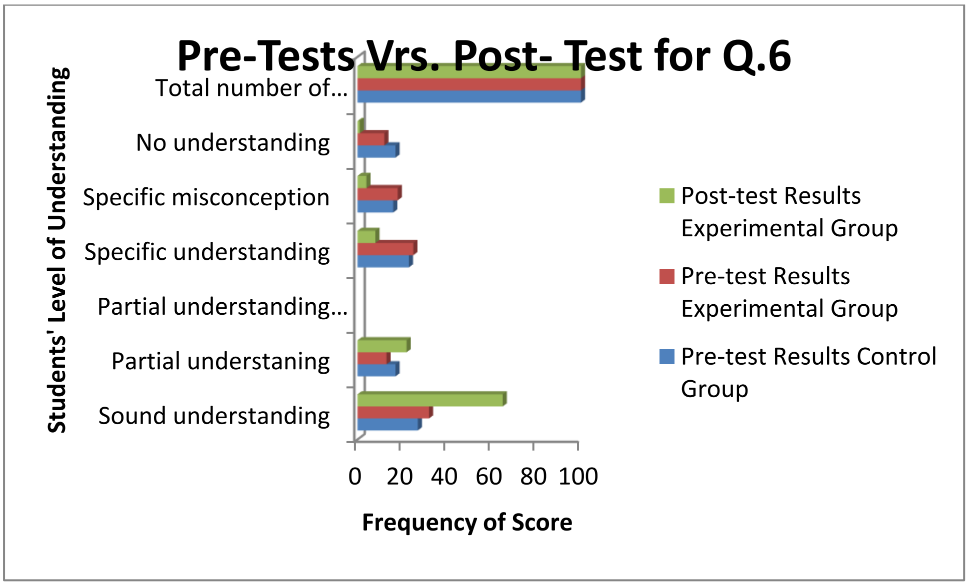

Figure 6:Graphical representation of students' understanding/ performance level to test item 6

The trend of performance above continues to show that after the post-test, many students recorded sound understanding than they did during the two pre-tests. The statistical calculation done on the averages for both the experimental and control groups is also in the Table 14

Table14: **Mean and Standard Deviation Score**

for the Two Groups of Students on test item 2:

	Pre-Test		Post –Test
	Control Group	Experimental Group	Experimental Group
Mean Score	2.21	2.35	3.21
Standard Deviation	1.44	1.40	1.02

The mean score of 3.21 and the standard deviation 1.02 obtained after the post-test as against the pre-test mean score of 2.35 and a standard deviation of 1.40 for the experimental group again indicate a better performance by students after the post-test than the initial pre-test. This suggests that the methodology employed during the post-test enhanced students' level of understanding and therefore performed better at the post-test than during the pre-test.

Table 15: Distributions of students' understanding of item 7

Conception	Pre-test		Post-test Results
	Control Group	Experimental Group	Experimental Group
Sound understanding	20	17	49
Partial understanding	13	12	27
Partial understanding with Specific misconception	17	20	9
Specific misconception	20	12	8
No understanding	30	39	7
Total number of respondents	100	100	100

This question proved a little more challenging for most students especially at the pre-test stages. As many as thirty nine (39) students from the experimental group and thirty (30) from the control group simply replied "yes". However it is in these two states that the switching mode exists, students showed signs of no understanding at the end of the post test.

The correct answer to the question 7 above is “yes, such switches form the basis of microprocessor memory and logic circuits, and so to show sound understanding, respondents were simply required to say these switching modes exists. Forty nine students (49) representing 49.0% showed a sound understanding in the post-test results as against 17 students for the experimental and 20 students during the pre-test. Similarly a subject’s response was partial understanding if the subject attempted to answer but could not complete the response properly. On this occasion, understanding the post-test whereas twelve (12) students of the same group and thirteen (13) students from the control group demonstrated partial understanding with specific misconception during the post-test stage as against twenty at the pre-test stage. Graphical illustration is as presented in fig7:

Figure7:

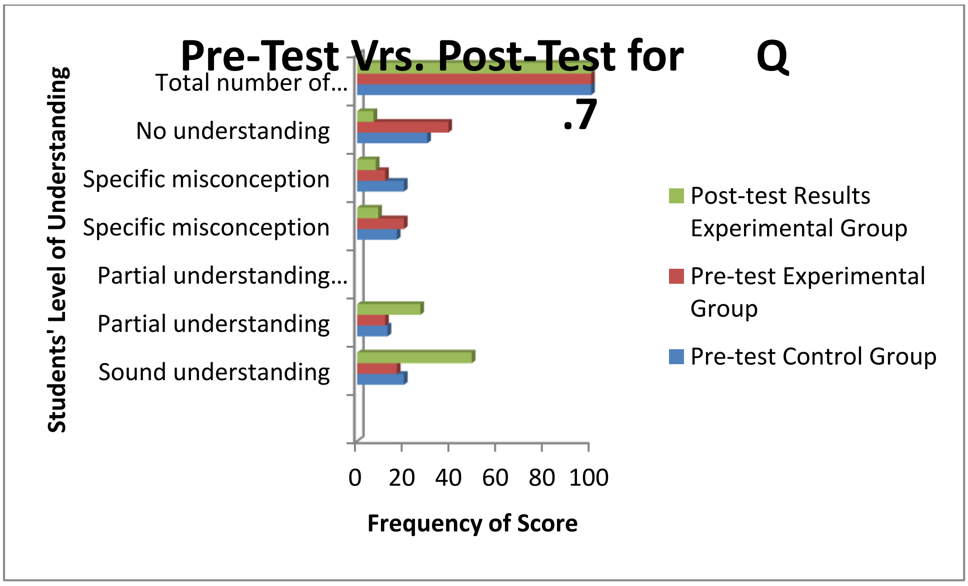

Figure 7: Graphical representation of students' understanding /performance level to test item 7

Even though this question proved a little difficult to students in both groups during the pre-tests, nevertheless, more of the experimental group after post-test from the above graph showed a sound understanding.

The reason for poor performance by students to this question especially after the two pre-tests can be attributed to the fact that students fall short in application questions. That is to say when simple questions demand that students apply the knowledge gain in new situations, it becomes a challenge to them. This is an unfortunate situation because Anamuah-Mensah & Ameyaw-Asabere (2004) identified the purpose of Senior High School Electronics Education in Ghana to include;

- Exciting students in things around them;
- Developing inquiry , problem solving and creative skills;
- Providing foundation for development of human resources for the nation;

- Providing capabilities in Engineering, Electronics research and innovation works;
- Producing scientifically literate citizens

This mean that when teaching students in the senior high schools, it is just appropriate to use things which are familiar to the student and also common in his/her environment and so that the enthusiasm of the student would be aroused. In this way, through playing manner the student would unconsciously develop the needed skills to become scientifically literate.

In general, the experimental group performed better in all the post- test exercises than the pre-tests conducted for the two groups (i.e. both the experimental and the control groups).It seems that the low performance exhibited by the controlled group can be likened to the Chief Examiner's reports for Integrated Science over a three- year period (2005-2007) in which he indicated that the major weaknesses of candidates of the West African Senior School Certificate Examination(WASSCE) as students' inability to show clear mastery of the concepts and inappropriate presentation of facts. Anamuah-Mensah, Mereku and Ameyaw –Asabere, (2004) in a related study observed that students in the classroom, leading to poor performance of students in Electronics examination and other external examination bodies.

However, McKeachie, W. (1994) found that activity method of teaching Electronics assists learners to discover their own knowledge and also leads to the acquisition of process skills such as measuring, recording, analyzing and interpretation of data which the learners may need in the course of their schooling and working in the future.

Again Walklin, L.(1982) in a study indicated that Electronics is a discipline which is understood better through practical activities, and concluded that materials and equipment play a very important role in the teaching and learning of Electronics. This is because learners are helped to develop scientific skills, knowledge and attitude toward Electronics. It is therefore easy to conclude that students in the experimental group understand and perform better in the task given.

The research questions were also analyzed based on the responses provided to the item statements as they appear in the administration of teaching and lesson observation. This is meant to provide a clear picture of the teaching methodology and strategies used by teachers at the senior high school level, during Electronics lessons.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Overview

This chapter deals with the summary of the main findings and conclusions derived from the study as well as recommendations and suggestions for further studies.

Summary of the Study

This section deals with summary of the research and its findings. The aim of this study was to determine the effect of using the activity method in Electronics instructions at the Senior High School Level in the Agona Nyakrom municipality.

Specific objectives of the study were to:

Look at the teaching methodology and strategies used by teachers at the Senior High School Level, during Electronics lessons.

Find out whether teachers at the Senior High School Level are familiar with the use f the activity method of teaching Electronics.

Determine the extent at which students are encouraged to actively participate in Electronics lessons.

Look at the effect of using the activity method of teaching Electronics, on students understanding of Electronics concepts.

The target of the study included the S.H.S. students and their Electronics teachers. The instruments used in the study were class tests, lesson observation, and interview schedules. The random sampling procedure was employed to select the schools as well as the students in the municipality. In all, two hundred and forty(240) subjects were used for the study comprising of two hundred (200) students from the S.H.S and forty (40) Electronics teachers.

The entire results collected were transcribed and analysed using excels spreadsheet, version 1 for windows (Microsoft inc., 2007).

Responses from the analysis of the students' performance in the class tests collected revealed that students in the experimental group who were taken through activity lesson performed better in the post-test than in the pre-tests.

Discussion

The consequence of excellent students' understanding includes good performance in class and making an excellent grade during the final examination at WASSSCE. This denial leads to poor students' understanding in some topics in Electronics lessons.

It can be asserted that females' studying Electronics and their male counterparts freely coming together in their groupings should not be undermined as assessment of students' understanding is enhanced by this. This can be monitored by the teacher within the classroom and allowable places where students meet freely to revise their lessons taught.

Furthermore, the study has shown that assessing students' understanding in some topics in Electronics has far reaching consequences such as psychological trauma, failure at examination and student subsequently dropping from school, among others. It is surprising to realize from the study that male students below twenty years were also found to be encouraged among their female counterparts during the study.

Conclusions

In the light of the findings of the study, it is confirmed that females were the most who often did involve themselves in Electronics lessons. It can therefore be concluded that the study of Electronics was not gender based.

The study also revealed that there existed some form of relationship between the student and the teacher of the Electronics lessons. It was discovered that the student was known by the teacher in the progress of their lessons.

It was also found that age has influence on the assessing the understanding of students in Electronics lessons. It should however be noted that the youths were most opened to understanding. On the other hand, the middle aged was the group indulging in most difficult situations of understanding due to aging effects and learning.

Furthermore, it was revealed that assessing the understanding did not transcend social status.

Recommendations

Based on the results of the study and the conclusions drawn from it, the following recommendations are made so that assessing the understanding of students in some topics in Electronics lessons at the S.H.S. level may be enhanced.

The study has shown that females are the one that have been encouraged most to study Electronics at the S.H.S. level due to their high involvement in the lesson. It is therefore imperative on policy makers, stakeholders, Ghana education service and the ministry of education of our countries to enhance the assessment of students' understanding in some topics in Electronics lessons at the Senior High School.

REFERENCES

Aboa-Offei, J. (2010).'Teacher development in relation to teacher productivity

in contemporary Ghana.'In *A paper delivered at the March edition of 2010 West African Examination Council's montly seminar in Accra.*

Adentwi, K. (2000).*Curriculum Development:an Introduction.Kumasi*. Retrieved September 3rd, 2010, from SKIES printing works Alliance for Excellence Education.(2009) Measuring and Improving the Effectiveness of High School Teachers : http://widgeteffect.org/.

Baird,W. a.(1989). A survey of secondary science teachers' needs. *School Science and Mathematics.*,89(4), 272 - 284.

Best,J. a.(1995). *Research in Engelwood cliffs.* New Jersey: Pretice Hall , Inc.

Bishops,G. (1985).*Curriculum development,a text book for students.*London: Macmillian Publishers.

C.,C.(2002). *La valutazione delle competenze, in(C.Coggi and A.Notti Eds.).* Retrieved September 1st,2010, from Docimologia, Pensa - Multimidia, Lecc.pp.56 - 90: http://www.adn.teaching.ro/articol

Champaigne, A., Sherwood, S., & Cezíturk, O. (2004). *Brining the science assessment standard into the classroom*. Retrieved May 26, 2005, from http://Cela.albany.edu/publication/article.science.htm

Cohen, L., Manoin, L., & Morrison, K. (2007). *Research methods in education* (6th ed.).Abindawol: Routhleig.

Darling-Hammond, L. (2000). *Teacher Quality and Student Achievement:A Review of State Policy Evidence.Education Policy Analysis Archives,8.*Retrieved July 20, 2010, from http://www.epaa.asu.edu/epaa/v8n1

De Buueger - Vander Borght, C. (1996). *L' e`piste`mologie dans la pratique dela classe?* Retrieved September 1st, 1995, from Actes des XVIIie`mes Journe`es Internationales sur la Communication, l'Education et la Culture Scientifiques Chamonix:Giordan A.,Martinand J- L. PP. 193 - 196.: http://www.informaworld.com/smpp/title

Education, A. F. (2009). *Measuring and improving the effectiveness of high school teachers.* Retrieved September 3rd, 2010, from http://widegeteffect.org/.

Gani, A. (2012). The study of substance conmsumption in Ghana.*a scholarly journal* , *1* (2),18-23.

Hackling, M. H. (2007). The psychology of teacher education. In J. L. Reglan (Ed.), *Feeding infants at the earlyages of development* (pp. 137-154). New York: Mac Millan Press.

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Harvey, L. (2009). *Analytic Quality Glossary*. Retrieved September 1st, 2010, from Quality Research International.:

http://www.qualityresearchinternational.com/glossa

Kamisah, O. L. (2006). What Malaysian science teachers need to improve their science Instruction:a comparison across gender, school locationand Area of specialisation.*Eurasia journal of mathematics, science and technology education.*,2(2),59-60.

Ketele, D. (1996). *L' e`valuation des acquis scolaries:quoi? Pourquoi? Pour quoi? Cited by Roegiers X.*Retrieved September 1st, 2010,from (2000) Une pe`dagogie de l' integration.Compete`tences et inte`gration des acquis dansl'enseignement.Bruxelles.De Boeck p.128:

http://www.springerlink.com/index

Madkwe, D. (1992). *Identification of principals',biology Teachers' and students' perception of an effective biology teacher.Lagos:University of Education, Science and Sports(2007) teacher*. Retrieved from Teaching Syllabus for Integrated Science(CRDD-Accra): http://widgeteffect.org/.

Madkwe, D. (1992). *Identification of principals', biology Teachers' and students' perception of an effective biology teacher.* Lagos: University of Nigeria.Ministry of Education, Science and Sports(2007).Teaching Syllabus for Integrated Science.(CRDD -Accra).http://widgeteffect.org/.

Norman, E. (2000). *How to design and evaluate research in education.* New York: McGrawHill Company.

Opong, 1. (1981). Science Education in Primary Schools:The Product of Science or the way to Science. *Journal of the Science Teachers Association of Nigeria*,19(2).16-18.

Osman, K. H. (2006). What Malaysian science teachers need to improve their Istruction:A comparison across gender, school location and Area of specialization. *Eurasia Journal of Mathematics, Science and Technology Education* ,2(2),37-38.

Osuala, E. (1991). *Introduction to research methodology.* Onitsa: Africa - FEB Publishers.

Quality., N. C. (2008). *Improving instruction through effective teacher evaluation.* Retrieved September 3rd, 2010, from http://widgeteffect.org/.

Reynells,L.a.(2010).*What is rural?*Retrieved September 30th, 2010, from http://www.census.gov/population/census data/urdef.txt

Anamuah-Mensah, Ameyaw- Asabere, A. (2004). The Fusion of Modern and Indigenous Science and Technology :How should it be done? *African Journal of Educational Studies in Mathematics and Science Teaching* ,38,899-917.

Anamuah-Mensah, J. M.-A. (2004). *TIMSS 2003 Results from Ghanaian Junior Secondary 2 students.*Accra:University of Education Winneba/Ghana Education Service,Inspectorate Division.

McKeachie, W. (1994). *Teaching Tips:A Guidebook for the Beginning College Teacher*. Lexington: Mass,DC: Health & Co.

Walklin, L. (1982). *Instructional techniques and practice*. London: Leckhampton Stanley Thorns Publishers.

APPENDICES

APPENDIX A

UNIVERSITY OF EDUCATION, WINNEBA

ADMINISTRATION OF TEACHING AND LESSON OBSERVATION

The instrument consists of 17 items classified into

(i) Objective and core points in lesson plan

(ii) Classroom organization and management, and

(iii) Teaching methodology and delivery.

Each item under category will be assessed and ranked with a predetermined scale of 1,2,3,4, and 5 with 1 being the lowest and 5 being the highest of the scaling.

Indicate your administration of teaching and lesson observation by placing a tick[√] in the appropriate column that represents your rating.

Part 1: Objective and core points in lesson plan

The student after the lesson has done the following:

Distinguished among conductors, semiconductors and insulators

Very high [ ] high [ ] average [ ] low [ ] very low [ ].

Distinguished between intrinsic and extrinsic semiconductors and their productions

Very high [ ] high [ ] average [ ] low [ ] very low [ ].

Described the formation and action of P-N junction diode.

Very high [ ] high [ ] average [ ] low [ ] very low [ ].

Described the construction and action of the bipolar junction transistor

Very high [ ] high [ ] average [ ] low [ ] very low [ ].

Described transistor biasing

Very high [ ] high [ ] average [ ] low [ ] very low [ ].

Outlined the characteristics of an N-P-N transistor as a small signal amplifier.

Very high [ ] high [ ] average [ ] low [ ] very low [ ].

Part 2: Classroom organization and management.

Is classroom organization well

Very high [ ] high [ ] average [ ] low [ ] very low [ ].

Is there responsibility and self-respect among students?

Very high [ ] high [ ] average [ ] low [ ] very low [ ].

Are the personal, emotional and social needs of students properly handled by the teacher?

Very high [ ] high [ ] average [ ] low [ ] very low [ ].

Has the teacher given rewards, praises, punishment and reinforcements appropriately?

Very high [ ] high [ ] average [ ] low [ ] very low [ ].

Part 3: Teaching methodology and delivery.

Utilizing a variety of evaluation devices and procedures in ascertaining students' progress, eg. Tests, take –home assignments, projects e.t.c.

Very high [ ] high [ ] average [ ] low [ ] very low [ ].

Developing instructional objectives in behavioural terms

Very high [ ] high [ ] average [ ] low [ ] very low [ ].

Responding appropriately to each student's questions directly related to the lesson of the day

Very high [ ] high [ ] average [ ] low [ ] very low [ ].

Utilising available educational resources of the community for instructional purposes

Very high [ ] high [ ] average [ ] low [ ] very low [ ].

Communicating understandably with students by giving clear, explicit directions and explanations

Very high [ ] high [ ] average [ ] low [ ] very low [ ].

Varying teaching style by the use of wide range of teaching techniques – laboratory discussion, demonstration, problem solving, lecture, field trips, e.t.c.

Very high [ ] high [ ] average [ ] low [ ] very low [ ].

Giving students guidance in writing their notes and recording and interpreting results of practical work rather than giving them teacher made notes.

Very high [ ] high [ ] average [ ] low [ ] very low [ ].

APPENDIX B

LETTER OF PERMISSION

UNIVERSITY OF EDUCATION, WINNEBA
DEPARTMENT OF SCIENCE EDUCATION
P. O. BOX 25, WINNEBA - TEL. NO. 0202041079

October 23, 2013.

Dear Sir,

TO WHOM IT MAY CONCERN
INTRODUCTORY LETTER

The bearer of this letter, Ma-Moun Awal with Index Number **7100130028** is a Student offering Master of Education in Science Education in the Department of Science Education in the above University.

He is conducting a research on "*Assessing Students' Understanding of Some Electronics: A Case Study at Agona Nyakrom SHS*".

Your school has been selected as part of his sampling area.

I hope you would assist him to do a good thesis write-up.

Thank you.

DR. K. D. TAALE
Head of Department

CONSENT FORMS.

We write to you as parents to seek your consent for this exercise to assess your ward's understanding in electronics at the Senior High School Level :A case study of a senior High School in Agona Nyakrom.Please respond to us by filling out this form.

Name of parent:...

Location:...

Address:...

....

Name of student:...

Course of study:...

Class level of student:..

Please give us your consent by signing this consent form.

……………………………………………………………

Signature

Thank

APPENDIX C

(Appendix C)

NYAKROM SENIOR HIGH TECHNICAL SCHOOL.

DATE: 27/09/2013

SUBJECT : SHS ELECTIVE PHYSICS.

TOPIC/LESSON : ELECTRONICS

CLASS/LEVEL : SHS "THREE".

TWICE WEEKLY

CLASS NAME : 3 SCIENCE.

Objective(s): At the end of the lesson students should be able to: (i) distinguish among conductors, semiconductors and insulators (ii) distinguish between intrinsic and extrinsic semiconductors and their production (iii) describe the formation and action of P-N junction diode (iv) describe the construction and action of the bipolar junction transistor (v) describe transistor biasing (vi) outline the characteristics of an N-P-N transistor as a small signal amplifier.

P.K.: Students are conversant with the definition of conductors, semiconductors and insulators.

Teaching Aids/Materials: Zinc plate, diodes and plastic insulators.

Reference(s): Abbey, Essah, Anto. Electronics. Physics For Senior Secondary Schools: G-E-S.

The study of electronics

Although, strictly, electronics includes the study of all electron effects and applications, the subject is usually confined to the study and design of circuits which process signals of relatively low power. These signals might be associated with control, communications or data handling.

Historically, thermionic, or heat based, vacuum tube technology was used to process signals. These tubes are called valves; they are still used for some applications but are expensive to produce and take up much more space than their modern replacements. Semiconductor devices are now almost universally employed. Such devices might be transistors, i.e. single stage amplifiers or switching devices, diodes (rectifying devices which turn alternating currents into direct currents) or large collections of these and other devices mounted on one tiny slab of, say, silicon. Such arrays are known as integrated circuits, all the above components are solid state devices.

Solid state materials

Almost all solid materials are composed of atoms or molecules in geometric arrays, called crystals, held together by bond-forming electrons.

We have already studied the Bohr model of the hydrogen atom. In it, only certain levels of energy may be attained by the orbiting electron. If several atoms are brought together, as in a crystal, the charges present interact, producing so many allowed energy levels that they may be considered to have broadened into bands. The highest energy band is known as the conduction band and the next highest the valence band; it is this latter which is concerned with bonding. The gap between the two bonds (If it exists) is a set of forbidden energy levels, in which the electron may not exist, just as intermediate orbits are disallowed in the Bohr model for hydrogen. In conductors, these bands are very close and electrons exist in the conduction band. In a metal, then, the most energetic electrons may be considered free and these enable it to conduct electricity.

In an insulator, the gap is relatively wide, the valence band is full and the conduction band empty. A large amount of energy must be given to an electron to promote it to the conduction band – the full valence band means that small energy changes within this band are impossible (because of Pauli exclusion principle). Even though the most energetic electrons require too much energy to become free enough to conduct. (Although, at very high temperatures, glass may be made to conduct - a very memorable demonstration). The gap for semiconductors is relatively narrow and there are a few electrons in the conduction band, and so only a little thermal energy is needed to free electrons for conduction, for example, the heat available at room temperature is sufficient - At absolute zero, the conduction band would be empty. However, semiconductors do not conduct as well as metals. Also, their conductivity is very dependent on temperature, increasing as the temperature rises). Such semi-conduction is known as intrinsic, since it is a natural property of the crystal.

Semiconductors

Further conduction may be induced in a pure semiconductor by the addition of impurities. The result of this process (called dopping) is artificially or extrinsic conduction. Pure silicon and germanium, the most common semiconductors, have a diamond-type structure, in which four valence electrons are involved in bonding.

Fig 1.1. Bonding in an intrinsic semiconductor

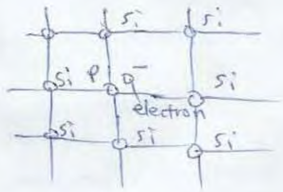

Fig. 1.2. Doping.

where applicable continue from here.

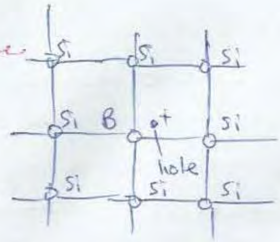

Fig1.3 p-type doping.

The impurity atom occupies one position in the crystal and contributes either three or five bonding electrons (see fig1.2). In the case of a five or pentavalent impurity, such as phosphorus, an electron is 'left over', though it should be remembered that the crystals remains neutral — associated with the five electrons are five protons. This surplus electron can easily become available for conduction. This type of impurity is known as a donor element as it donates a free electron.
A trivalent impurity, such as boron or aluminium (acceptor elements), contributes the 'absence of an electron' or hole (fig1.3). As thermally mobile electrons move into the hole, the 'hole' appears to move around. The 'hole' acts as a positive charge carrier, just as the electron is a negative charge carrier.

Doping to produce holes produces p-type (p for positive) semiconductor material, and doping to produce electrons produces n-type (n for negative) semiconductor. Since intrinsic conduction still takes place, there is a contribution to conduction from

1. thermally liberated electrons which are fewer and therefore called the minority carriers, and
2. More numerous electrons or holes produced by doping, which are called majority carriers.

If a device containing both n- and p-type materials is placed in a circuit, holes travel along decreasing potentials and electrons along increasing potential.

The resulting current, through direct (since charge always flows in the same direction) is hardly uniform, so some means of smoothing is usually employed, as in fig. 1-9. Here a capacitor stores and releases charge to (iron out the lumps) caused by alternate forward and reverse biasing. The remaining ripple used to be removed with an inductor, impedes the flow of such an AC component, but now the reverse breakdown in special diodes called Zener diodes is used. This breakdown voltage remains constants for a range of currents so output voltage may be (locked) at this value. Zener diodes are available with a range of (Zener) breakdown voltages.

Pnp and npn transistors are, as the name implies, composed of a sandwich of semiconductor diodes fig 1.10.

It is clear that conduction may not take place by placing a power supply across it (other than that associated with the thermally liberated minority carriers) since, in effect, they are two diodes back to back. However, if we ^the base connection (fig 1.11) is added, it is seen that there currents of broadly the same value may flow through the two sections of n-type material, since one flow from base to emitter introduces charge carriers into the device. By Kirchoff's Law it is clear that extra current ~~that~~ is very small. In other words, then, the presence of a tiny base current into one terminal of our device controls a relatively heavy one into and out of the other two terminals. We have made an electronic relay (or current-controlled switch) and an amplifier. To complete each circuit, we have added components shown. The essence of a transistor's switching and amplifying ability is best observed in a 'characteristics' diagram (fig 1.12). This is obtained by applying varying input voltages and measuring the voltage V_{ce} developed across the collector and emitter terminals. It is seen that if input voltage V_{be} is less than about 0.6V, V_{ce} is high and if V_{be} exceeds 0.6V, the output falls to almost zero. It is in these two states that the switching mode exists, such switches form the basis of microprocessor memory and logic circuits.

applications but are expensive to produce and take up much more space than their modern replacements. Semiconductor devices are now almost universally employed. Such devices might be transistors, i.e. single stage amplifiers or switching devices, diodes (rectifying devices which turn alternating currents into direct current) or large collections of these and other devices mounted on one tiny slab of, say, silicon. Such arrays are known as integrated circuits; all the above components are solid state devices.

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Fig 1.1 Boding in an intrinsic semiconductor

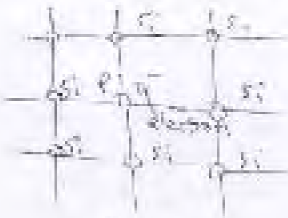

Fig. 1.1 - Doping.

where applicable [illegible]

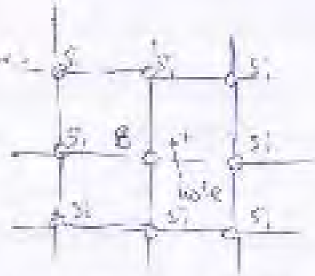

Fig. 3 p-type doping.

The impurity atom occupies one position in the crystal and contributes either three or five bonding electrons (see fig. 2). In the case of a five or pentavalent impurity such as phosphorus, an electron is 'left over', though it should be remembered that the crystal remains neutral — associated with the five electrons are five protons. This surplus electron can easily become available for conduction. This type of impurity is known as a donor element as it donates a free electron.

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2. More numerous electrons or holes produced by doping, which are called majority carriers.

[illegible] a device containing both n- and p-type materials is placed in a circuit, holes travel along decreasing potentials and electrons along [illegible]

Semiconductor devices

Semiconductor devices contain both n - and p-type semiconductors. If two such materials are placed together to form a junction, some recombination of electrons and holes takes place which does leave the materials electrically charged in the region of the junction (fig 1-4). There is created a region of no charge, where recombination takes place, bordered by a positively charged region in the n-type side and a negatively charged region in the p-type side. The region ~~method~~ of recombination is called the depletion layer.

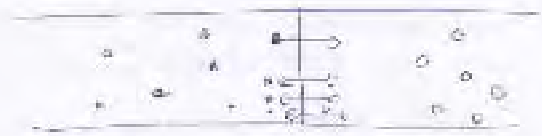

Fig 1.4. Diffusion of electrons and holes at a pn junction

A pd of about 0.6V is required to force charge carriers over this potential barrier in the case of silicon, and about 0.2V for germanium. Since free charge carriers are now less abundant in this region it is called the depletion layer, as shown in fig 1.5. If a potential difference is applied, as in fig 1.5, it is clear that the depletion layer will get broader and conduction is even more difficult.

In fig 1.5b charge carriers may be accelerated across the layer. Such a device which only allows conduction in one direction is called a rectifier — several types exist; this one is a junction diode.

The minority carriers may contribute to a small reverse current too. So a practical diode is by no means ideal. But forward pd increases, resistance falls. In reverse bias, reverse currents are of the order of microamps for germanium and picoamps for silicon, though these rise rapidly with temperature. If the applied field is too great, ionisation of the crystals begins, conduction begins. Rectification is the modification of AC to DC. It is achieved in the following methods (fig 2)

The resulting ... in the same direction) is hardly uniform, so some means of smoothing is usually employed, as in fig. 1-9. Here a capacitor stores and releases charge to iron out the 'lumps' caused by alternate forward and reverse biasing. The remaining ripple used to be removed with an inductor, impedes the flow of such an AC component, but now the reverse breakdown in special diodes called Zener diodes is used. This breakdown voltage remains constants for a range of currents so output voltage may be (locked) at this value. Zener diodes are available with a range of (Zener) breakdown voltages.

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Semiconductor devices

Semiconductor devices contain both n- and p-type semiconductors. If two such materials are placed together to form a junction, some recombination of electrons and holes takes place which does leave the materials electrically charged in the region of the junction (fig 1-4). There is created a region of no charge, where recombination takes place, bordered by a positively charged region in the n-type side and a negatively charged region in the p-type side. The region ~~called~~ of recombinations is called the depletion layer.

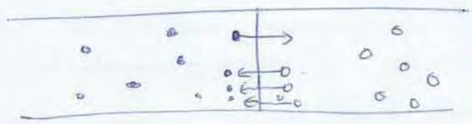

Fig 1-4. Diffusion of electrons and holes at a pn junction.

A pd of about 0.6V is required to force charge carriers over this 'potential barrier' in the case of silicon, and about 0.2V for germanium. Since free charge carriers are now less abundant in this region, it is called the depletion layer, as shown in Fig. 1.5. If a potential difference is applied, as in fig 1.6a, it is clear that the depletion layer will get broader and conduction is even more difficult.

In fig 1.6b charge carriers may be accelerated across the layer. Such a device, which only allows conduction in one direction, is called a rectifier — several types exist; this one is a junction diode.

The minority carriers may contribute to a small reverse current too, so a practical diode is by no means ideal. As forward pd increases, resistance falls. In reverse bias. Reverse currents are of the order of microamps for germanium and picoamps for silicon, though these rise rapidly with temperature. If the applied field is too great, ionisation of the crystals occurs and conduction begins. Rectification, or the modification of AC to DC is achieved in the following networks (half-wave rectification (fig 1-8), full-wave rectification (fig. 1.9)).

In between these extremes the characteristic line is sloping steeply, showing that a small change in input voltage causes a large change output voltage. This region is used in the amplifying mode. It should be noted that, because the line slopes downward, an inversion takes place: under amplification, a 180° phase change will result; under switching, high input causes low output and vice versa.

The action of the transistor is to produce an enlarged and inverted version of the input current. This amplified signal flows between the collector and emitter and through a resistor, across which a varying pd of the same form is developed. It is this signal which forms the output.

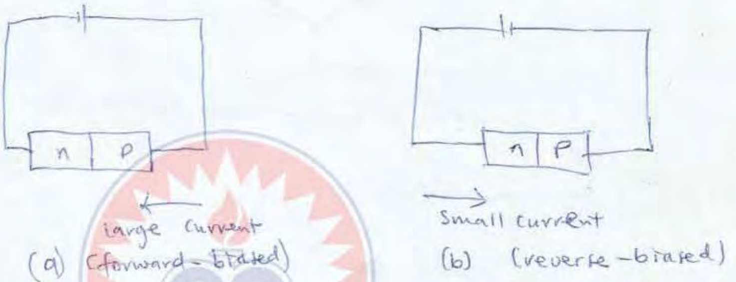

fig 1.12 Reverse-biased and forward-biased diode.

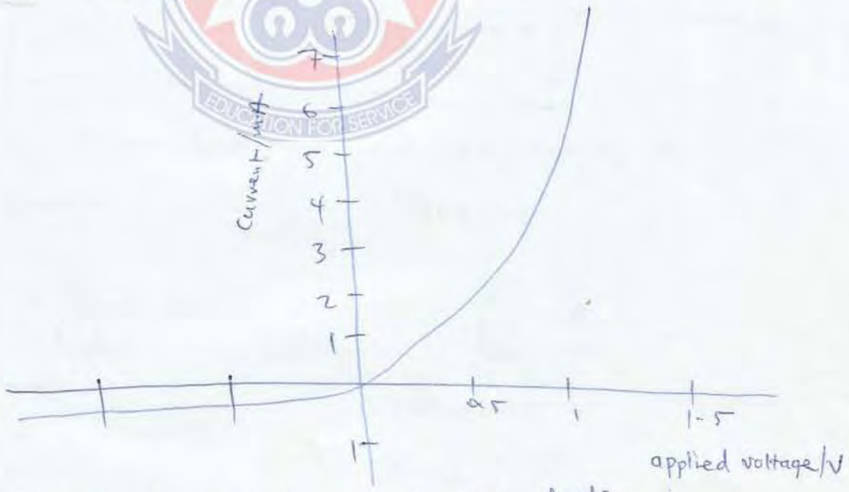

fig. 1.13 Characteristic curve of a diode.

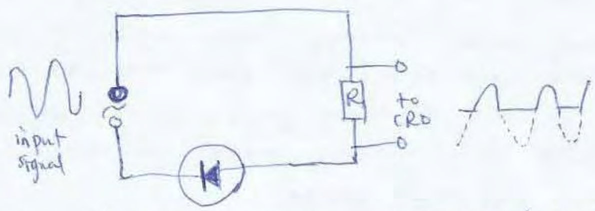

fig 1.14 Producing a half-wave rectified signal

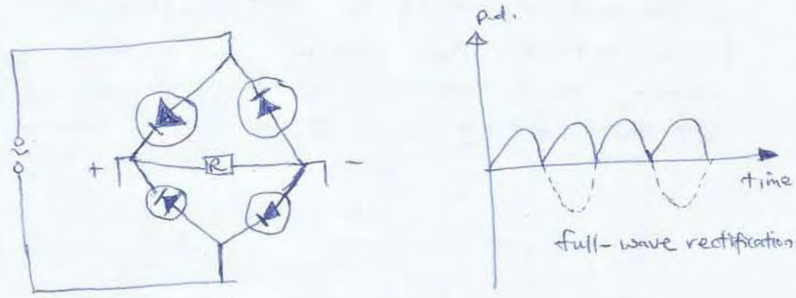

fig. 1.15 Full-wave rectification

fig. 1.16 Using a smoothing capacitor

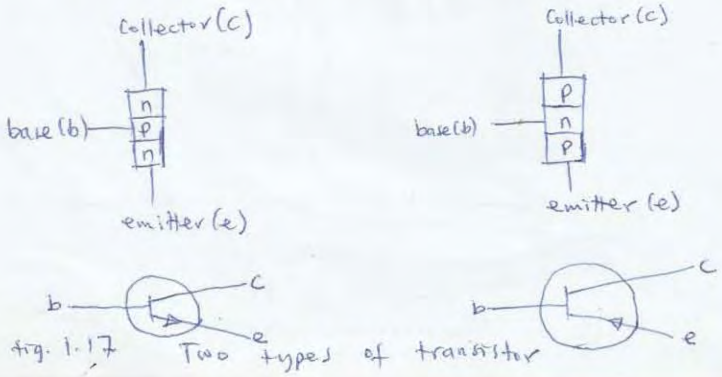

fig. 1.17 Two types of transistor

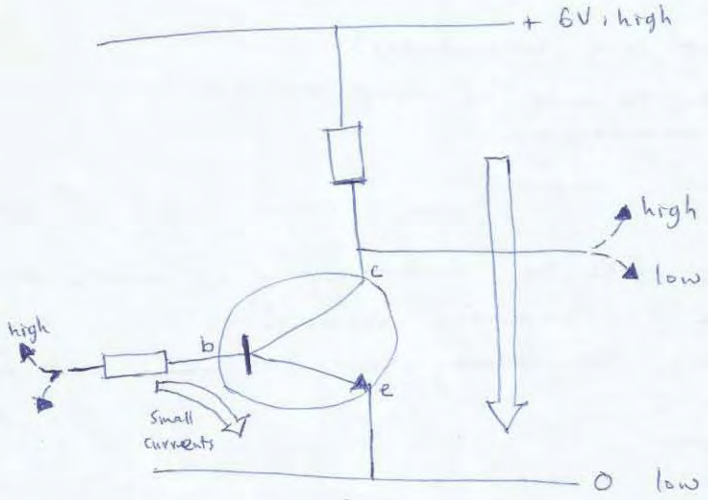

fig 1-18 Small changes to the base control large changes at collector.

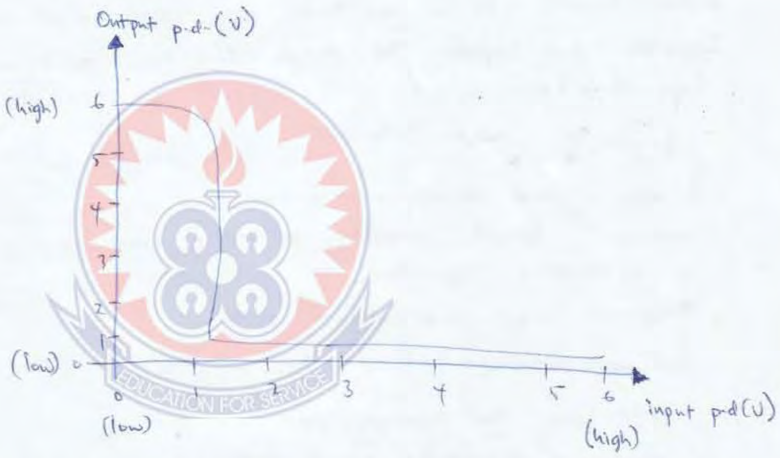

fig 1-19. Characteristic curve.

Assignment

1. a. What is a semiconductor?

b. Explain the mode of charge movement in a

(i) a semi-conductor

(ii) metallic conductor

2. a. Why does the conductivity of an intrinsic semi-conductor increase as temperature increases?

b. Explain the following terms as ~~useful~~ used in semi-conductors

(i) donor

(ii) acceptor

(iii) majority carriers

(iv) minority carriers.

3. In a bridge rectifier circuit containing 4 diodes, one of the diodes breaks down so that an open circuit occurs at that point. Describe and explain the shape of the output wave form for a sinusoidal a.c. input.

Project

Design and construct a common-emitter N-P-N transistor amplifier. Select biasing resistors, two coupling capacitors and a decoupling capacitor.

Measure input and output voltages.

Select suitable load for the amplifier.

Determine the voltage gain.

Write a report on your work.

Electronics

Combination of transistors

As we have already discussed, transistors are used to amplify signals or act as switches. The amplification effects of transistors are enhanced when they are effectively combined in pairs such as proper combination of two npn transistors which are arranged in a Special circuit called a Darlington pair. The Darlington pair is made up of two transistor connected together to form a single unit. In the Darlington pair, the emitter of an npn transistor is connected to the base of the other npn transistor. The collectors of the transistors in the circuit are also connected together.

In a Darlington pair. the current applied to the base is enhanced by the second transistor. A very high current gain results results and the signal is amplified to twice its original value.

Amplification is also magnified by a combination of an npn and a pnp transistor in another circuit called a complementary pair. In a complementary pair the emitter of an npn transistor is connected to the emitter of a pnp transistor.

a complementary pair.