UNIVERSITY OF EDUCATION, WINNEBA

USING CONCEPTUAL CHANGE MODEL OF SCIENCE INSTRUCTION TO IMPROVE JUNIOR HIGH STUDENTS' UNDERSTANDING OF ELECTRICITY

FREDERICK SAMUEL ASARE- AHENE

JULY, 2011

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A project work in the Department of Science Education, Faculty of Science Education, submitted to the School of Graduate Studies, University of Education, Winneba in partial fulfillment of the requirements for award of the Master of Education (Science) degree.

JULY, 2011

DECLARATION

STUDENT'S DECLARATION

I, Frederick Samuel Asare-Ahene, declare that this project work with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

SIGNATURE: ……………………………………………………………………

DATE: ………………………………………………………………………….

SUPERVISOR'S DECLARATION

I hereby declare that the preparation and presentation of this work was supervised in accordance with the guidelines for supervision of project work as laid down by the University of Education, Winneba.

NAME OF SUPERVISOR: ………………………………………………………..

SIGNATURE: ……………………………………………………………………

DATE: …………………………………………………………………………

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May the good Lord bless you all abundantly for the selfless work done.

DEDICATION

This book is dedicated to the glory of God, to my dear wife Ms. Miriam Lartey- Baah, my children and to my family.

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ABSTRACT

The main purpose of this study was to use conceptual change model of science instruction to improve the understanding of JHS two pupils of Kibi in the study of the following basic concepts of electricity: electric circuits, electric current, conductors, voltage and resistance. Furthermore, the study also attempted to determine the alternative conceptions and misunderstandings of the pupils on the concepts of electricity. The sample for the study was 115 JHS pupils and six science teachers. The pupils and teachers were drawn from two Junior High Schools in Kibi namely KPCE Demonstration JHS and Kibi State JHS. The instruments used in this study were questionnaires and tests. The data collected from the pre-test and post-test were analyzed using t-test. The findings showed that there was significant improvement in the level of the performance of the pupils after the intervention. Again, it was revealed that most of the alternative conceptions and misunderstandings determined through the questionnaires were either reduced or were eliminated. The research finding that conceptual change approach to science instruction helped to improve the JHS pupils' understanding of electricity is recommended for the teaching of electricity in the Junior High Schools in Kibi circuit and throughout the country. It is further recommended that the conceptual change approach to science instruction should be introduced into the science programme in Colleges of Education and made part of the course on methods of teaching science.

CHAPTER ONE

INTRODUCTION

Overview

This chapter presents the background to the study, the statement of the problem, the purpose of the study and the research questions that guided the study. Again, it looks at the educational significance of the study, the delimitation and the organization of the study.

Background to the Study

Electricity is an extremely flexible form of energy and can be adapted to many sets of applications which include transport, heating, lighting, communications and computation. In transport, electricity is used to drive the wheels of electric trains, buses and cars. The communication aspects of electricity involve the use of radios, television sets, computers, cell phones and fixed phones. At homes and industries electricity is used to generate heat for cooking, baking and laundry. It is also used to operate refrigerators, fans, air conditioners, washing machines, dryers and mowers. The manufacturing industries rely on electricity to drive virtually every moving part in the industries, for example, electricity is used to operate electric saws, cutters, conveyor belts, furnaces, and drills that are used in industries. Whatever the process carried out in the industries, electricity is involved somewhere (Wald & Matthew, 1990).

In accordance with the various economic and social values of electricity as listed above Junior High School (JHS) pupils need to acquire scientific knowledge and skills about electricity which is of great importance to students and pupils of all levels of education in the country. Pupils, especially JHS pupils, need knowledge on electricity to enhance their academic study through the use of multimedia like computers, television sets and radios. Acquired knowledge and skills on electricity help pupils to connect electrical gadgets to electricity and avoid overloading a single electrical socket with many appliances. Pupils need to be educated on the do's and don'ts of electricity so as to make wise use of electricity. JHS pupils who have relevant knowledge and skills about electricity should be motivated to learn much about electricity.

Many pupils use various electrical gadgets at home for play, in the kitchen and for academic studies. These activities have become possible because of the modern technological and electronic industries that produce many and varied gadgets for the open markets. Pupils use electronic devices which are operated by electricity with little knowledge about electric circuits and safety measures on electricity. They lack knowledge on power ratings of different gadgets and sometimes they do connect low power rating devices to high voltage electricity (Boateng, 2009). They may sometimes plug in some electrical devices on try and error basis, especially electrical gadgets with two- pin plugs. It is possible that most often they cause serious damage to the gadgets at home due to the poor electrical connections.

Electricity gives comfort to many people but there are also several potential dangers associated with its wrong usage. Many serious accidents such as electric shock, fire outbreaks, and burns have occurred in some homes and industries. In some cases, people have been electrocuted. Many of the accidents related to electricity are likely due to ignorance of people on the correct use of electricity, wrong connections of domestic appliances, wrong wiring of premises including poor earthing and the use of very inferior socket outlets and plugs which fit loosely (Boateng, 2009). It is therefore imperative to educate pupils on right concepts about electricity at the basic school level of education so that they would be able to use electricity wisely and with care, and be able to prevent the dangers associated with it. This might have influenced the JHS Science Curriculum Developers to include a section on electricity in Integrated Science Syllabus. Especially so, since our main source of energy for domestic and industrial use is electricity.

The 2007 Integrated Science syllabus for Junior High Schools specified some objectives and fundamental topics on electricity to be studied in Junior High School form two. The specific objectives to be achieved through pupils' learning about electricity are as follow:

a. to describe ways of generating electrical energy.
b. to demonstrate the flow of current using a simple electric circuits.
c. to demonstrate the use of electricity measuring instruments.
d. to describe electrical gadgets and their modes of operation.
e. to wire an electric plug and explain the use of a fuse in electrical appliances.
f. to outline some effects of illegal electrical connection.
g. to explain ways of conserving electric energy.

The topics to be studied are as follow:

a. Ways of generating electrical energy.
b. Simple electric circuits.
c. The use of electrical measuring instruments.
d. Electrical gadgets and their modes of operation.
e. Electric plugs and fuses in electrical appliance.

f. Effects of illegal connections.

g. Ways of conserving electric energy.

In order to determine the learning difficulties of pupils in the Junior High Schools and to improve upon teaching and learning in the municipality, the East Akim Municipal Education Office of the Ghana Education Service (GES) assesses pupils' academic performance through Performance Monitoring Test (PMT) each term. The performance of the pupils was low in Integrated Science in the first three years (PMT Report, 2008, 2009, & 2010) of the programme. The analysis of the test results of JHS two pupils on the PMT showed that pupils performed poorly on questions especially, those on electricity. The pupils were able to define some concepts and provided correct answers to factual questions but generally showed little understanding of the concepts of electricity. For instance, they were unable to answer questions that demanded application of knowledge on electricity. The pupils also lacked process skills on electricity as they could not apply their knowledge on how to connect electric circuits or interpret circuit diagrams that were made up of more than three components. Again, the pupils found it difficult to draw circuit diagrams using the conventional symbols of electricity.

The causes of pupils' poor performance on examination on electricity are many. First, the abstract nature of some concepts on electricity. For example the concepts of current and resistance are confusing to students so they are unable to develop conceptual understanding of these concepts. For example, the word current means the immediate present or most recent in everyday communication. However, the concept of current scientifically means the rate of flow of charge. Another example is the word resistance which means opposition to somebody or something in our everyday talk which is different from its scientific meaning of ability of a substance to resist the flow of electricity through it. Also concepts such as conductors, circuits, resistance and power are used in everyday communication with different conceptual meaning from their scientific meaning. Thus, pupils' everyday meanings of these concepts may have influenced their understanding of these scientific concepts. This may result in possible conflict between the scientific and everyday meaning of the common concepts where it is likely to create pupils' conceptual difficulty in understanding of the concepts (Ngman-Wara, 2011). This conflict can be resolved by means of conceptual change approach in teaching the concepts.

The poor performance of the junior high school two pupils of Kibi on concepts of electricity needs to be improved if the objectives set in the 2007 integrated science syllabus are to be achieved. This can be done through enhancing the understanding of the JHS two pupils' concepts on electricity through the use of constructivist model of conceptual change approach of science teaching and learning and the use of the 5Es model of teaching science. The 5Es instructional model has the following five phases of teaching and learning: engagement, exploration, explanation, elaboration and evaluation.

Problem Statement

JHS two pupils of some schools in Kibi seem to have misunderstandings and alternative conceptions of basic concepts on electricity. Misunderstanding of concepts refers to a preconceived notion in which something that a person knows and believes does not match what is known to be scientifically correct (Driver, 1989). The term alternative conceptions has been used here to denote student understandings of scientific concepts that are not aligned with the current understanding of scientists (Driver, 1989). These two problems manifested themselves through the analysis of test items on electricity in the Performance Monitoring Tests (PMT) that were conducted by East Akim Municipal Education Office of Ghana Education Service (GES) from 2008 to 2010, that is, the first three years after the introduction of the 2007 Integrated Science Syllabus for JHS. Reports by the training and examination officer of the GES office on the PMT showed that the pupils' performance on electricity was poor. The pupils showed lack of process skills on electricity, did not understand basic concepts of electricity and also could not answer questions on application of concepts on electricity. It also came to light that the pupils had misunderstandings and alternative conceptions about the following concepts: electric current, circuits, voltage, resistance, and conductors. Misconceptions about concepts on electricity are learning problems that cannot be eliminated by traditional methods of teaching.

Purpose of the Study

The main purpose of this study was to use a conceptual change teaching model to improve the understanding of JHS two pupils of Kibi in the study of basic concepts on electricity. According to the constructivist theory, learning is an active process in which the learner uses sensory input and constructs meaning out of it (Ackerman, 1996). Hence, the report in the project work will provide useful hands-on learning and minds-on activities on electrical circuits, electric current, resistance, conductors and voltage to help the pupils understand these concepts and improve their academic performance.

Objectives of the Study

The following objectives were formulated to guide the study:

1. To determine junior high school two pupils' alternative conceptions of electric current, conductors, resistance, conductors and voltage.
2. To use conceptual change teaching model to improve junior high school two pupils' understanding of some basic concepts in electricity.
3. To determine if there is a significant change in the level of understanding of the Kibi junior high school two pupils when the conceptual change teaching model is used to teach the concepts of electricity.

Research Questions

In order to achieve the purpose of this study, the following research questions were formulated to address the situation:

1. What are Kibi JHS two pupils' misunderstandings and alternative conceptions on electric current, circuits, resistance, conductors and voltage?
2. Will conceptual change teaching model help JHS two pupils correct their misunderstandings and alternative conceptions on electric current, electric circuits, resistance, conductors and voltage?
3. Is there any significant change in the level of understanding of JHS two pupils on concepts of electricity when conceptual change teaching model was used to teach the concepts on electricity?

Hypothesis

The null hypothesis to test the problem of the study is stated below:

There is no significant effect of the use of conceptual change teaching model on JHS two pupils' conceptual understanding of the basic concepts of electricity.

Significance of the Study

The significance of this study are many. First, the study may be of help to junior high school pupils in Kibi in their efforts to understand concepts of electric current, circuits, conductors, resistance and voltage which are abstract concepts of electricity. Secondly, the outcome of the study may encourage JHS science teachers to adopt the conceptual change teaching model for science instruction.

The findings of the study may be of benefit to text book writers. They may find it useful to incorporate the model of this study on electricity in textbooks for JHS. In science education, the findings of the study will help curriculum designers and developers, particularly the Curriculum Research and Development Division (CRDD) of the Ghana Education Service, to incorporate the use of conceptual change teaching model for science instruction to the teaching of scientific concepts especially concepts in electricity. Another significance of the study is that the developed hand-on activities in the study are likely to provide a useful practical means for JHS pupils to acquire scientific knowledge and process skills in electricity. It will also enhance understanding and application of concepts in electricity to real life situations. Also, the findings of the study will provide some information which may be useful to integrated science teachers of junior high schools about how pupils understand concepts on electricity.

Delimitation

This study was limited to two junior high schools at Kibi namely Kibi Presbyterian College of Education (KPCE) Demonstration Junior High School and Kibi State Junior High School. One hundred and fifteen pupils and six junior high science teachers were involved in the study. The study was also limited to the following basic concepts of electricity: simple electric circuits, electric current, conductors and insulators, voltage and resistance.

Organization of the Study

The study is organized into five chapters. Chapter One discusses the background of the study, problem statement, purpose of the study, research objectives, research questions, significance of the study, delimitation and organization of the study.

Chapter Two is the literature review. It reviewed and discussed literature that is relevant to the study. The review included a discourse on the theoretical framework of the study, existing research on conceptual change model of science instruction on electricity, students' misconceptions on electricity, constructivist learning theory and hands-on activities on electricity.

Chapter Three outlined the methodology of the study. It describes the research design, population of the study, sample and sampling procedure, instruments used in data collection, validity and reliability and data collection and analysis procedures. Chapter Four discusses the analysis of data and the findings of the study.

Finally, Chapter Five presents the summary of results and conclusion. This includes the major findings, recommendations, conclusions, limitations of the study and suggestions for further research. The study ended with references and appendices.

CHAPTER TWO

LITERATURE REVIEW

Overview

This chapter reviews the literature that relates to the use of conceptual change model of science instruction to improve pupils' understanding of electricity. The review covers the theoretical framework and the empirical evidence of the studies. It also reviews the misconceptions relating to the teaching and learning about electricity.

Constructivism and Conceptual Change

Constructivism is a set of beliefs about knowledge that begin with the assumption that reality exists but cannot be known as a set of truths because of the fallibility of human experience (Gray, 1997). According to Gray (1997), constructivism is also a view of learning based on the belief that knowledge is not a thing that can be simply given by the teacher at the front of the classroom to students in their desks. Rather, knowledge is constructed by learners through an active mental process of development. Learners are the builders and creators of meaning and knowledge. Constructivism has become one of the dominant alternative approaches to science teaching and learning. The constructivist instruction in science education is inspired by the following premises (Haney, Czerniak, & Lumpe, 2003):

a. Learning is meaning construction.
b. The meaning of the parts is as important as the meaning of the whole, regarding concepts.

c. A student's construction of individual knowledge is seen as an active process, not mere passive receiving from others.

d. The understanding of new information is dependent on a student's existing ideas.

In relation to these premises Haney, Czerniak and Lumpe (2003) mentioned that the constructivist approach to teaching and learning has formed one of the complete models for explaining the progression of a student's concept development and conceptual change.

Constructivist teaching approach is based on constructivist learning theory. This theoretical framework holds that learning always builds upon knowledge that a student already knows; this prior knowledge is called a schema. Because all learning is filtered through pre-existing schemata, constructivists suggest that learning is more effective when a student is actively engaged in the learning process rather than attempting to receive knowledge passively. One of the primary goals of using constructivist teaching approach is that students learn how to learn if they are given the training to take initiative for their own learning experiences. According to Gray (1997), the characteristics of a constructivist classroom are as follow: the learners are actively involved, the environment is democratic, the activities are interactive and student-centred and finally the teacher facilitates a process of learning in which students are encouraged to be responsible and autonomous. Furthermore, in the constructivist classroom, students work primarily in groups and learning and knowledge are interactive and dynamic. There is a great focus and emphasis on social and communication skills, as well as collaboration and exchange of ideas. This is contrary to the traditional classroom in which students work primarily alone, learning is achieved through repetition, and the subjects are strictly adhered to and are guided by textbooks. Some of the activities which are encouraged in constructivist classrooms are:

a. Experimentation: students individually perform an experiment and then come together as a class to discuss the results.

b. Research projects: students research a topic and can present their findings to the class.

c. Field trips: these allow students to put the concepts and ideas discussed in class in a real-world context. Field trips would often be followed by class discussions.

d. Films: these provide visual context and thus bring another sense into the learning experience.

e. Class discussions: this technique is used in all of the methods described above. It is one of the most important distinctions of constructivist teaching methods.

The conceptual change approach was brought to the field of learning and instruction from the philosophy and history of science by science educators who saw certain analogies between theory changes in the history of science and students' learning of science (Posner, Strike, Hewson, & Gertzog, 1982). This theory is based on Piaget's notion of disequilibrium and accommodation. Since the 1970s researchers such as Novak (2002) and Driver and Bell (1986) realised that students bring to the science learning classrooms alternative frameworks or misconceptions that are robust and difficult to extinguish. Posner et al. (1982) saw these alternative frameworks as theories that need to be replaced by the currently accepted, correct scientific views through a process of conceptual change.

Conceptual change is generally defined as learning that changes an existing conception, that is belief, idea, or way of thinking (Duit, 1991)). According to conceptual change theory, one cannot cognitively understand new scientific information that conflicts with the one's existing knowledge, and it is this conflict that leads to scientific misconceptions. Teaching for conceptual change primarily involves uncovering learners' misconceptions about a particular topic or phenomena and using various techniques to help the learners change their conceptual framework (Duit, 1991). Different researchers have used different terms for conceptual change. Some of these common terms are: weak and strong restructuring (Carey, 1985), branch jumping and tree switching (Thagard, 1992), conceptual capture and conceptual exchange (Hewson & Hewson, 1983), differentiation and reconcepualization (Dykstra, 1992) and enrichment and revision (Vosniadou, 1994). Each of the theoreticians has developed his or her own terminology, but there is common ground among the various perspectives of conceptual change. Conceptual change involves changes in students' assumptions about the world and ways of learning. Several factors such as pre-existing conceptions, prior achievement, prior attitude, post attitude, motivation and logical thinking ability can affect students' understanding of scientific concepts and their applications. In order to help overcome students' alternative ideas or difficulties in science and to provide meaningful learning in science, a number of conceptual change strategies have been suggested. One of such is the conceptual change approach. This strategy originated from constructivist framework in general. Thus, the conceptual change approach is mainly used for removing students' misconceptions in science and increasing students' understanding of scientific concepts.

The Need for Conceptual Change

Children's conceptual frameworks develop from their experiences as they mature. However, frequently their misconceptions of the world around them do not agree with the scientific explanation so it is important when planning instruction to know how these misconceptions differ from the scientific explanation, and why children construct these ideas. Hancock (1994) stated that a misconception is any unfounded belief that does not embody the element of fear, good luck, faith, or supernatural intervention. According to White (1992), other researchers have also explained misconception as different ways of thinking by students in a topic as compared to the experts in the field. Thus, misconceptions are concepts that are not scientifically true but are explained by students in a manner specific to them. Misconceptions are very stable in general, so traditional instruction is not sufficient to remediate them (Hestenes, 1987; McDermott & Shaffer, 1992; White, 1992). Overcoming misconceptions is not simply adding new information to the individual's mind, so care should be taken to ensure the interaction of new knowledge with existing knowledge, provided that the new knowledge may replace the existing knowledge (Hewson & Hewson, 1983). Replacing the existing faulty knowledge with the scientifically sound one is one of the aims of conceptual change (Hewson & Hewson, 1983; Novak, 2002).

Assimilation and accommodation, introduced by Piaget (1950) are considered to be necessary conditions for conceptual change. Assimilation refers to the recognition of a physical or mental event fitting into an existing conception. When an event cannot be assimilated under held conceptions, then accommodation takes place. According to Piaget (1950), assimilation occurs when a learner already has an idea which the new knowledge would be linked with. It is quite likely, however, that students will have existing knowledge that is at variance with the new conception and accommodation will be needed. Accommodation occurs when the learner restructures or changes his or her preconceptions, resulting in a conceptual change (Hewson & Hewson, 1983; Posner, Strike, Hewson, & Gertzog, 1982).

Models for Conceptual Change Approaches

The conceptual change model proposed by Posner, Strike, Hewson, and Gertzog (1982) described two types of conceptual change: assimilation occurs when students use existing concepts to deal with new phenomena and accommodation which is a more radical change that occurs when the student's current concepts are inadequate to allow him or her to grasp some new phenomenon successfully. The student then must replace or reorganise his or her central concepts. This model has dominated the research on learning in science, although some variations have been proposed. For example, Shymansky and Kyle (1983) described learning as the addition of new valid ideas or the deletion of invalid concepts, propositions or linkages and the reorganization of the learner's knowledge network. He used the term conceptual growth to apply to these processes.

The advantage of the model proposed by Posner et al. (1982) was that it provided an explanation for how conceptual change might occur. They suggested that accommodation will begin when there is dissatisfaction with an existing conception. Then it will proceed as the student considers a new conception to be more intelligible (able to be understood), plausible (makes sense), and fruitful (having the potential to solve new problems). The status of a conception would be marked by the extent to which it is intelligible, plausible, and fruitful (Hewson & Thorley, 1989) and so instructional sequences should be designed to reduce the status of students' misconceptions and raise the status of scientific conceptions. However, this is not necessarily an easy process. Misconceptions are often strongly held, and a number of previous studies have documented the difficulties in reducing students' misconceptions in science; even after weeks of instruction there may still be students who retain their original ideas almost unchanged (Champagne, Klopfer, & Gunstone, 1981; Shymansky & Kyle., 1983). The process of accommodation in particular is considered to be a difficult one for students to achieve. For example, Posner et al. (1982) stated there are good reasons to suppose that for students, accommodation will be a gradual and piecemeal affair. Students are unlikely to have at the outset a clear or well-developed grasp of any given theory and what it entails about the world. For them, accommodation may be a process of taking an initial step toward a new conception by accepting some of its claims and then gradually modifying other ideas. It involves much fumbling about, many false starts and mistakes, and frequent reversals of direction. A number of studies have provided empirical evidence that radical conceptual change is a difficult and time-consuming process for students (Beeth & Hewson, 1999; Tao & Gunstone, 1999).

Posner, Strike, Hewson and Gertzog (1982) developed a model of conceptual change and Hewson and Hewson (1983) elaborated it. Posner et al. (1982) presented four conditions for conceptual change. These are dissatisfaction, intelligibility, plausibility, and fruitfulness. That is, students should first of all be dissatisfied with their own existing ideas. Then, the new conception should be intelligible to the students. In other words, the new concept shall make sense to the students. Students are presented new concepts and they are given some explanation. However, these new concepts should correspond to the knowledge in other areas (plausibility). Finally, they should be fruitful. That is, they should lead to new insight (fruitfulness). Conceptual change therefore refers to how people can gain new scientific knowledge, and how this knowledge undergoes a gradual process of acceptance. It is very difficult for a learner to understand a new idea through assimilation if there is no basis for the new knowledge in the learner's existing schema. Instead, over a period of time or events the learner must go through a conceptual change, where their schema is modified and the new knowledge is accommodated. Learning for conceptual change is not merely accumulating new facts or learning a new skill. In conceptual change, an existing conception is fundamentally changed or even replaced, and becomes the conceptual framework that students use to solve problems, explain phenomena, and function in their world.

Hewson and Thorley (1989) indicated that a model of conceptual change includes two major components: the conditions and the person's conceptual ecology. According to Posner et al. (1982), a learner's conceptual ecology consists of their conceptions and ideas rooted in their epistemological beliefs. This conceptual ecology perspective has proven very influential**.** From a conceptual ecology perspective, the constituent ideas and epistemological beliefs highly influence a learner's interactions with new ideas and problems. Misconceptions are therefore not only inaccurate beliefs; misconceptions organize and constrain learning in a manner similar to paradigms in science. In other words, prior conceptions are highly resistant to change because concepts are not independent from the cognitive artifacts within a learners' conceptual ecology. In order to experience a person's conceptual change, the conditions should be satisfied. On the other hand, a person's conceptual ecology supplies the context to cause conceptual change. They also stressed that a change in the status of conceptions plays a central role in the model of conceptual change. They stated that discrepant events, demonstrations or analogies are mainly used in conceptual change teaching but teachers should pay attention to two other things, diagnose the conceptions and monitor the status of old and new conceptions that occur in students' mind.

Conceptual Change Instructional Models

A number of instructional tools have been developed from the various (perspectives) constructivists' models for conceptual change teaching. The useful conceptual change instructional tools for this study are 5Es instructional model, conceptual change text, demonstration, cooperative learning, discussions and hand-on activities.

One of the first things a teacher must do when considering how to teach students is to acknowledge that each student does not learn in the same way. This means that if the teacher chooses just one style of teaching (direct instruction, collaborative learning or inquiry learning), the students will not be maximizing their learning potential. Obviously, a teacher cannot reach every student on the same level during one lesson, but implementing a variety of learning styles throughout the course allows all the students to have the chance to learn in at least one way that matches their learning style. In order to improve students' science achievement, several teaching strategies like investigative-oriented laboratory approach (Ertepinar & Geban, 1996), discussion and laboratory combined format (McCormick, Mackinnon, & Jones, 1999), hands-on instruction (Pyle & Akins-Moffatt, 1999) and cooperative learning are used. For instance, Pyle and Akins-Moffatt (1999) examined the effects of visually enhanced instructional environments on students' conceptual growth. The results showed that the use of visual enhancements was an effective extension strategy for hands-on learning.

If teachers are familiar with constructivist idea and those ideas fit in their value system, then constructivist ideas can be taught to students at school context (Duit, 1991). Based on the constructivists, researchers suggest that no matter what is on the list of critical content, students will not learn unless teaching practices are designed to promote learning. Yager and Luts (1994) pointed out the importance of appropriate teaching and giving more importance to how we teach than what we teach. This is one of the bases of this study in teaching the basic concepts of electricity to the understanding of the junior high school pupils.

Duschl and Gitomer (1991) indicated that the constructivist instruction in science emphasises knowledge formation including learning cycle, conceptual change teaching model, generative model, and using of analogies, etc. There can be several constructivist formats to use in science classrooms. For example, Lord (1994) preferred to use the constructivist model that involved engagement, exploration, explanation, elaboration, and evaluation phases also called the 5Es in a lesson on cell division. He stated that cooperative group learning has a crucial role in constructivism. The teacher's roles change from a presenter to a facilitator. A teacher plans the activities that challenge and promote the students to work collaboratively. According to Lord (1994), the constructivist model encourages students to remain on task, to be accountable for their learning and to retain the information longer than they would in traditionally taught classes. He added that students enjoy their classes taught using constructivist teaching approaches more than lectures. Constructivist teaching requires different approaches. A constructivist teacher will:

a. Encourage and accept student's autonomy, initiation, and leadership.
b. Allow student thinking to shift content and instructional strategy based on student responses.
c. Ask students to elaborate on their responses.
d. Allow wait time when asking questions.
e. Encourage students to interact with each other and with the teacher.
f. Ask thoughtful and open-ended questions.
g. Encourage students to reflect on experiences and predict future outcomes.
h. Ask students to articulate their theories about concepts before the teacher presents his/her understanding of the concepts.
i. Look for students' alternative conceptions and design lessons to address any misconceptions (Yager & Luts, 1994).

Constructivist and conceptual change perspectives on learning have given rise to a number of models of constructivist classroom teaching. The 5Es model which has been used for this study is an effective model that provides a framework for structuring a science lesson in consistent with a constructivist approach of teaching and learning. The theoretical framework of the 5Es model has been discussed below.

5 Es Instructional Model

The Biological Science Curriculum Study (BSCS), a team led by Principal Investigator Roger Bybee, developed the instructional model for constructivism, called the Five Es (Bybee, 2006). Other models have been adapted from this model including the 6Es and 7Es models (Lord, 1994). According to Lord (1994), the 5Es lesson planning model is gaining popularity in the science education communities because the science teachers are continuously striving to use the model to improve their instructional practices by enhancing student- learning through the use of coordinated and coherent sequencing of lessons. Recent research reports on how people learn based on the brain, mind, experience and school (Bransford & Cocking, 2000) and how students learn science in the classroom (Donovan & Bransford, 2005), have confirmed the effectiveness of using the 5Es instructional model in teaching. According to Donovan and Bransford (2005), the sustained use of an effective research-based instructional model such as the 5Es instructional model can help students learn fundamental concepts in science and other domains. An instructional model must therefore be effective, supported with relevant research and it must be implemented consistently and widely to have the desired effect on teaching and learning. The effectiveness of the 5Es model to promote pupils' understanding of concepts motivated the researcher to use it as one of the instructional strategies in this study.

The 5Es lesson planning model shifts the learning environment from one which is very instructor-centred to one that is very learner-centred (Donovan & Bransford, 2005). The five phases of the 5Es model in teaching and learning are: engagement, exploration, explanation, elaboration and evaluation and these have been explained below. The engagement phase sets the context, raises questions and elicits students' existing beliefs. The exploration phase involves investigation work in which students gain firsthand (and, where possible, concrete) experience of the phenomenon of interest. The explanation phase draws on students' beliefs from the engagement phase, concepts introduced by the teacher or from text reading. These are used to construct explanations for the experiences of the exploration phase. Further practical work provides more experiences of the phenomenon, this time in a different context, so that the elaboration phase can involve students applying conceptions developed in the explanation phase to new contexts, thus extending and integrating their learning. The evaluation phase provides an opportunity for students and the teacher to assess developed conceptions and compare them to their beliefs at the engagement phase (Guzetth, Synder, Glass, & Gamas, 1993)

Active learning techniques can empower students to make good decisions and take an active role in their own learning, increase their motivation to learn, foster and value the diverse voices of students and reduce disciplinary problems. In light of these factors of learning, the teaching strategies below which are based on the constructivist approach of teaching were employed to effect conceptual understanding in the learners.

Conceptual Change Texts

Conceptual change text is an instructional strategy or tool which is of importance to the study. Conceptual change texts are used to improve students' science achievement. Each conceptual change text starts with a question relating a science concept to students' alternative ideas (perceptions). After the first question, some common misconceptions regarding this question are first presented to students. Then, students are introduced to scientifically correct explanations of the given concept in the text. After that, the text continues with the second question. The aim of the conceptual change text is to make students realize the scientifically wrong statements and then change them to the scientifically correct ones.

Demonstrations

The nature of the hands-on activities of the study calls for the use of demonstration as an instructional strategy. Demonstrations illustrate and reveal a science process or a principle. Not only is demonstration a strategy used when a teacher is performing an experiment to the students, but also it may be used when a teacher is showing something under microscope, demonstrating a model, poster etc. to the students. Thus, demonstrations can be interest arousing, entertaining, motivating and they can cause one to wonder about the science concepts being presented. Teachers mostly prefer to perform demonstrations instead of laboratory work, in particular, in big classes or when laboratory equipment is insufficient. It may save time, money, materials and efforts. Sometimes a student or a group of students may perform demonstrations in a class. In that case, the teacher serves as a guide. Demonstrations can be used for science teaching and learning. They can be used for several purposes such as to start or support the teaching of practical science concepts, to help communicate ideas in science, or as a means of measuring student learning by instructors. For example, they can be used to enhance students' conceptual understanding of chemistry (Bownen & Phelps, 1997).

Cooperative Learning

A cooperative learning environment was one of the necessary factors that were needed for the hands- on activities of the study. A cooperative learning environment is necessary for successful conceptual change instruction**.** Cooperative learning is a structured, systematic instructional strategy during which students work together towards a general goal in a small group. The best known types of cooperative learning, from more teacher-centred to more student-centred approaches are student teams achievement division, jigsaw, constructive controversy (structured debate) and group investigation (Cooper, Robinson, & Mckinney, 1994). Small group instruction may involve several instructional strategies such as demonstrations, worksheets and small group discussions. Cooperative learning strategy may also be used in conceptual change oriented instruction.

Discussions

Small group discussion sessions can be used in large and small size classes to complement lectures. Discussions can be guided by the teacher (teacher-centred) or by the students (student-centred). In any case, discussions are more dynamic if students are provided with prerequisites.

Related Studies

The related studies on conceptual change model of science instruction supported the need for the researcher to use the model to improve JHS pupils' understanding of basic concepts on electricity.

Stoffert (1994) applied the conceptual change constructs to teacher education. The results revealed that the new strategies made teacher candidates dissatisfied with their pre-existing ideas. The teacher candidates expressed that the new strategies were intelligible and fruitful.

Eryilmaz (2002) investigated the effects of conceptual assignments and conceptual change discussions on students' misconceptions and achievement regarding force and motion. The treatment time period of the study was eight weeks. The study involved six physics teachers and their 18 classes, consisting of 396 high school physics students. All students were administered the Force Misconception and Force Achievement Tests as pre-test and post-test. The results of the study indicated that the conceptual change discussion was an effective tool for reducing the number of misconceptions students held about force and motion. Additionally, the conceptual change discussion was found significantly effective in improving students' achievement in force and motion.

Hewson and Hewson (1983) used the conceptual change model to examine the effects of students' prior knowledge and conceptual change strategies on science learning. In that work, pre-test and post-tests relating the concepts of mass, volume and density were used to assess the conceptual change of students. They reported that the experimental group students showed significant improvement in the acquisition of science conceptions. Barnett and Morran (2002) addressed the students' pre-existing ideas in their study of children's alternative frameworks of the moon's phases and eclipse. The study focused on supporting students in identifying their own existing understanding and reflecting on how their understanding evolves over time rather than directly addressing students' alternative frameworks (misconceptions). The results of the study suggested that basic school students (pupils) could develop complex understanding of astronomy concepts and the direct engagement of students' alternate framework might not be necessary if the students were covered by learning activities that provide students opportunities to examine and reflect on their understanding.

Tianyu and Thomas (1991) investigated the effects of conceptual change text and application questions in 139 college students who were learning electricity concepts. According to the results of the study, the conceptual change texts and the application questions improved the acquisition of qualitative concepts of the students. Similarly, Sharon and Chambers (1997) explored the relationships between gender, interest and experience in electricity, and the conceptual change text manipulations on learning basic direct current concepts. The conceptual change text provided a better conceptual understanding of electrical concepts than the traditional didactic text. To support conceptual change texts oriented instruction with other tools may bring more successful results to the study. According to Cakir (2002), some researchers used a mixed conceptual change methodology in their studies.

Previous studies give some evidences that cooperative learning is an effective learning strategy (Watson, 1991; Weaver, 1998). For instance, Weaver (1998) found that the students favoured laboratory or hands-on activities and the interest in these types of activities could promote conceptual change when combined with discussion and reflection. Alesopoulou and Driver (1996) studied a small group discussion in physics, focusing on peer interaction modes in pairs and in fours. Their study revealed that the students progressed significantly more in their physics reasoning in four people group than the pairs. Also Schmidt, De Volder, De Grave, Moust, and Patel (1989) assessed the effects of prior knowledge activation through small group discussion. The results of the study suggested that such activation of prior knowledge could be a successful instructional strategy.

Misconceptions Related to the Teaching and Learning about Electricity

Electricity is one of the basic areas of physics whose applications encompass many aspects of our everyday life, yet it is an area in which students develop views and misconceptions that are very different from the scientific knowledge or concepts. Many researches that identify the different misconceptions about current, voltage, resistance, and other electricity- related concepts have been published and the findings revealed that common misconceptions are held by students across the board, from elementary to university and college as well as by prospective physics teachers (Arons, 1997; Cohen, Eylon, & Ganiel, 1983; McDermott & Shaffer, 1992; Shipstone, Rhoneck, Karrqvist, Dupin, Joshua, & Licht, 1988). It was also found that these misconceptions were not confined to one country or to one educational system, but were common to various countries with different educational systems (Shipstone et al., 1988).

Misconceptions on electricity are the major problems in the study of electricity. The concept of electricity has a history of cultural perception which says that electricity is not a human invention, and may be observed in several forms in nature, a prominent manifestation of which is lighting (Encrenaz , 2004). In the 19th century, electricity was not part of the everyday life of many people, even in the industrialized western world. The popular culture of the time accordingly often depicted it as mysterious, quasi-magical force that could slay the living, revive the dead or otherwise bend laws of nature. That attitude began with the experiments of Luigi Galvani in which the legs of dead frogs were shown to twitch on application of animal electricity (Encrenaz, 2004). During that era, the masters of electricity, whether frictional or real including scientists such as Thomas Edison, Charles Steinmetz and Nikola Tesla were popularly conceived of as having wizard-like powers (Van & Bowdoin, 2002). Similarly, in Ghana there is cultural belief that lighting is associated with the god of thunder and could be evoked to strike and kill an evil doer. There is also the belief that lighting may not strike a person who has a copper ring on the finger. In the Twi language electricity is literally called the 'strength of lighting' (Adofo, 1990). These local ideas are misconceptions in the minds of young people before they start their formal education.

Junior High School (JHS) pupils have some misconceptions about some concepts of electricity. Before formal education on electricity children handle many gadgets which are operated on electricity, for example electric iron, refrigerators, radios and television sets. They also learn and gain many experiences through their interactions with materials in the environment. What they learn on their own are termed children's (pupils') perceptions. When pupils enter the classroom with wrong perceptions or misconceptions about scientific phenomena, these misconceptions would affect how the corresponding scientific explanations are learned (Hewson & Hewson, 1983; Driver, Squires, Rushworth, & Wood Robinson, 1994). Therefore, pupils' misconceptions in science can be a problem for teachers and they should be overcome through instruction (Beeth, 1998).

An example of pupils' perception on electricity is that electricity can be generated by using a single copper wire. In simple experiments on electric circuits, a single copper wire is used to connect a bulb and a dry cell to light the bulb. This experiment is found in many of the books that are used in primary schools. The pupils become confused when two copper wires are connected to light a bulb as in parallel connections (Gyan & Tufour, 2000).

Some research studies on students' misconceptions in physics show that there are many misconceptions on concepts of electricity due to the abstract nature of electricity. The main reason why electricity concepts are so confusing to students is the difficulty to give a unique and concrete definition of electricity. Many terms about electricity are not directly inferred from observations, but they are rather mentally constructed to represent the events that occur under suitable conditions. Examples are the concepts of resistance, current and voltage. Among different concepts related to electric circuit, the understanding of electric current has been the most investigated (Fredette & Lockhead, 1980: Shipstone, 1985). Findings about the conceptions of current reveal that many students adopt one or more conceptual model of electric current that are not compatible with the scientifically accepted conservation of current model. Among these models, the most predominant ones are: the unipolar model, whose adopters do not recognize the need for a closed circuit, and therefore treat electric components as electric sinks that transform the current sent by a battery into light and or heat (Fredette & Lockhead, 1980;

McDermont & Shaffer, 1992; Shipstone, 1988); the attenuation model, whereby the current leaving a battery from one end is used-up by the element in the circuit, and the unused portion goes back to the other terminal of the battery (e.g. Evans, 1978; McDermott & Shaffer, 1992; Shipstone, 1985); and the Sharing model, where the current sent by a battery is split and shared among the different components in the circuit (McDermott & Shaffer, 1992; Saxena, 1992; Shipstone, 1988). Another concept that gives students problem is voltage. They find it difficult to understand the concept of voltage. Studies have revealed that voltage is often conceived as a mere outcome of a mathematical relation, or and as an attribute or a property of current rather than its cause (Cohen, Eylon, & Ganiel, 1983; Psillos, Kouramas, & Tiberghien, 1988). Consequently, an ideal battery is often seen as a source of constant current rather than voltage, regardless of the circuit configuration (e.g. Cohen et al., 1983; Evans, 1978; McDermott & Shaffer, 1992; Saxena, 1992; Shipstone, 1988). Furthermore, another concept that students find problem with is resistance. A number of studies revealed that many students fail to develop a conceptual understanding about resistance and its role in a circuit. They tend to view resistors as the locus of current dissipation in the form of heat or light (Cohen et al., 1983), or as a mere theoretical link between voltage and current (Licht, 1987). They also failed to distinguish between equivalent resistance of a network and resistance of an individual element, especially when accounting for a dynamic change (McDermott & Shaffer, 1992). Furthermore, McDermott and Shaffer (1992) and Saxena (1992) reported that many students tend to focus on the number of elements or number of branches rather than on the configuration and thus have problems in accepting that the equivalent resistance of a parallel network decrease when the number of elements increases (Cohen et al., 1983; McDermont & Shaffer, 1992).

Some research studies also investigated students' reasoning approaches to the concept of electric circuits. These studies revealed that when reasoning about an electric circuit, many students failed to consider a circuit as a whole, where any change in any of the elements affects the whole circuit. Instead, they demonstrate local reasoning, by which students focus their attention on one point in the circuit and ignore what is happening elsewhere, such as considering the battery as a constant source of current regardless of the circuit configuration (e.g. Cohen et al., 1983; McDermott & Shaffer, 1992a; Shipstone, 1988), and or sequential reasoning, by which students believe that when any dynamic change takes place in a circuit, only elements coming after the point at which the change occurs are affected (e.g. Licht, 1987; Shipstone, 1988). In other researches, involved in the investigation of students' misconceptions about simple electric circuits, the most frequently encountered findings were that:

a. The concepts of current, energy and potential difference are not respected as different concepts and are used interchangeably with each other.(Cohen, Eylon, & Ganiel, 1983)
b. Current is consumed by circuit components (Shipstone, 1984).
c. Current comes out from the positive (+) pole of the battery and enters the bulb where it is consumed to light the bulb which is not affected by the second wire connected between the negative (-) pole and itself (Shipstone, 1985).
d. Current comes out from both poles of the battery and clashes in the bulb to light it (Shipstone, 1985).

e. Current is divided equally in each line of the parallel circuits (Shipstone, 1985).

f. A change before the bulb affects the brightness of the bulb in circuit connected in series but the same bulb is not affected by a change in anywhere of the circuit after the bulb (Shipstone, 1985).

g. Batteries are constant current sources (Shipstone, 1985).

The misconceptions outlined above were reported in studies conducted with students in different countries and with different age groups. A research by Shipstone, Rhoneck, Jung, Dupin, Joshua, and Licht (1988) is an important research work because it showed that students in five European countries under study also had similar misconceptions about simple electric circuits.

It will not be surprising that similar problems are likely to be encountered in Ghana, a developing country, where schools and technology are not as advanced as those of developed countries. A number of problems affect the teaching and learning about electricity in junior high schools at Kibi which also affect the pupils' understanding of some concepts on electricity. This leads to pupils' low academic performance in tests on electricity. The junior high schools lack basic teaching and learning materials which are used for hands-on activities during teaching and learning about electricity (GES, Kibi PMT Report, 2009). Also, majority of the teachers who teach integrated science in the JHS in the municipality are not qualified science teachers, so they are not able to teach challenging concepts on electricity in the junior high school science syllabus (GES, Kibi PMT Report, 2010). They also lack practical skills in designing and constructing improvised materials for their lessons on electricity. Hence, they teach electricity using the lecture method of teaching. They teach their lessons without using the instructional methods like discussion, brain storming, demonstration and activity methods that have been suggested in the science syllabus. Through primary, junior high schools to senior high schools the pupils (students) have been exposed to didactic teaching and are prone to rote learning. The pupils are not equipped with concepts and skills for pupil-centred teaching. Furthermore, the emphasis on success in public examinations and the constraint in covering the intensive science syllabus encourage the use of didactic teaching, which makes it possible to cover the prescribed examination syllabus within the schedule timetable (Ngman-Wara, 2011). It is widely felt that classroom discussions and other interactive teaching activities deter efficient progress in teaching and are thus considered as an unwise use of precious lesson time.

Summary

Electricity is one of the constituents of the theme energy in Integrated Science whose applications encompass many aspects of our everyday life, yet it is an area of science with many pupils' alternative conceptions. The alternative conceptions about electricity are due to its abstract nature of the concepts involved. Many researchers have investigated into the following areas of electricity which are studied in junior high schools: simple circuit, current electricity, conductors, resistance and voltage but their studies were carried out in foreign countries using methodologies and teaching-learning materials that are not available in this country. Furthermore, the use of conceptual change approach in teaching science is not a popular strategy of teaching in junior high schools in the country. Many teachers use the traditional teacher-centred approach to teach lessons in science. Therefore, very little research, if any, had been conducted about students' understanding of basic electricity concepts in junior high schools in Kibi in the East Akim municipality.

Conceptual change is generally defined as learning that changes an existing conception (i.e. belief, idea, or way of thinking). Teaching for conceptual change primarily involves uncovering pupils' preconceptions about a particular topic or phenomena and using various techniques to help pupils change their conceptual framework.

Misconceptions may originate from several reasons such as previous learning, teacher expectations, everyday life experiences, school activities and social practices. Electricity is an aspect of integrated science where available researches show that students have many misunderstandings and alternative conceptions. The main reason for pupils' difficulty in electricity is the difficulty to give a unique and concrete definition to electricity. Many concepts about electricity are not directly inferred from observations, but they are rather mentally constructed to represent the events that occur under suitable conditions. Misconceptions are very stable in general and so traditional instruction is not sufficient to remediate them. Therefore science teachers and curriculum designers need to know which alternative framework of pupils is specifically found in science so that they may use teaching strategies that enhance conceptual change.

CHAPTER THREE

METHODOLOGY

Overview

This chapter discusses the research methodology that was employed in the study. It deals with the research design, the population, the sample and sampling techniques, the research instruments, research procedure, validity and reliability of the instruments used for data collection, interventional process, post-interventional process, data collecting procedure and finally the method of data analysis.

Research Design

This study used an action research design, where the researcher identified a problem situation and attempted to change it through intervention. According to Alhassan (2006), an action research is a problem solving research devoted to the solution of an immediate problem in a given situation. Hence, action research is a research directed to find ways of solving practical problems of practitioners. It is also an attempt to bridge the gap between knowledge production and knowledge utilization. Also, McLean (1995) defines action research as any systematic inquiry conducted by a researcher to gather information about the ways that a particular school operates, how they teach, and how well the students learn. Information is gathered with the goal of gaining insight, developing practice for effecting positive changes in the school environment and on educational practices in general, and improving students' outcomes.

Action research design has numerous strengths. First, it is a means that equip teachers, especially science teachers, with new strategies, skills and methods of teaching and learning new challenging concepts with understanding. Secondly, action research is a means of injecting new ideas into teaching and learning of some concepts. Thirdly, the results of the research serve as a useful means of improving the normally poor communication between practising teachers and academic researchers. Finally, action research has the ability to solve immediate problems and contributes to the generation of knowledge if it is successfully conducted (Carr & Kemmis, 1986).

According to Elliot (1991), action research design has its weaknesses. First, despite its capacity to diagnose and solve a classroom problem immediately, the findings are only limited to the classroom or a local setting. The study cannot be extended to other schools in the municipality or in the country as a whole. Notwithstanding these limitations, action research design was considered the most appropriate for carrying out this study to improve the understanding of pupils of KPCE Demonstration Junior High School and Kibi State JHS on concepts of Electricity. Also the researcher chose action research design because it would enable him to come out with his own initiative, strategies and intervention to find immediate solution to the learning problems, especially misconceptions that affect junior high school two pupils' understanding of concepts about electricity at Kibi. The abstract nature of concepts on electricity, lack of teaching-learning materials and misconceptions of students about electricity affect their scientific understanding of concepts on electricity and hence their poor academic performance.

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Population

The researcher determined the target population and accessible population and used them in the study. Target population is the entire group of pupils to whom the researcher wishes to generalize the study findings. Accessible population is the portion of the population to which the researcher has reasonable access; it is a subset of the target population**.** Data from the Eastern Regional Office of the Ghana Education Service (GES Report, 2011) indicate that the region has 1,525 junior high schools out of which 1160 are public schools and 365 are private junior high schools. The total population of the JHS pupils in the region is 145,885 out of which 120,922 are in public schools and 24,963 are in private schools. The study is supposed to improve the conceptual understanding of all the 145,885 JHS pupils in the study of basic concepts on electricity. In this study, it is assumed that most of the communities in the region enjoy electricity supply and so the pupils have their perceptions on electricity.

The accessible population from which a sample was drawn was the junior high schools in Kibi. Kibi is the municipal capital of East Akim Municipal Assembly in the Eastern Region of Ghana. The main socio-economic activities of the people in the municipality are farming and trading. However, some people work in public sectors while some others are also engaged in small scale gold mining activities. The municipality has 291 basic schools comprising 195 primary schools and 96 junior high schools. There are nine junior high schools, nine primary schools and two senior high schools at Kibi. However, Kibi Presbyterian College of Education (KPCE) Demonstration Junior High School and Kibi State Junior High School were used for the study. The two junior high schools have a population of 240, each school has 120 pupils. There are twenty teachers on the staff of the two schools including six science teachers. Each junior high school has three science teachers and seven teachers of other subjects.

The pupil population of KPCE Demonstration junior high schools is made up of children from the rural Akwadum village and Kibi while that of Kibi State JHS is made up of children from Ahwenease village and Kibi. Forty-five percent of the population of the students of each of the two junior high schools comes from the nearby villages. The parents of the pupils from the two villages are mostly farmers and traders while those of the pupils from Kibi are engaged in official work and self employment. The pupils from Kibi are exposed to the use of many and varied gadgets of electricity at homes and this also exposes them to the acquisition of basic concepts on electricity. Thus, the home background of the child has an influence on his or her understanding of concepts on electricity.

Sampling Technique

The researcher purposively selected KPCE Demonstration Junior High School and Kibi State Junior High School for the study. The researcher used purposive sampling technique for the study because he considered the participants of the two schools to be typical of individuals possessing the traits of mixed abilities on the study of concepts of electricity. According to Bernard (2002), judgmental or purposive sampling is a method in which the researchers select participants that they judge to be typical of the individuals possessing a given trait. With regards to this study, the trait that the researcher considered was that the performance of the JHS pupils in the study of electricity was low in the

Performance Monitoring Test (PMT) conducted by the East Akim Municipal Education office. The two junior high schools also have a good record of participation in educational research in the municipality. The headteachers and staff in the two schools readily cooperative and work with educational researchers on matters relating to improvement of pupils' learning. The study was limited to the JHS two pupils because they had problems in understanding concepts of electricity. In addition, electricity is taught only in the second year of the junior high school level.

The researcher used intact classes instead of experimental and control groups because all the pupils had earlier exhibited low performance level in learning the following concepts of electricity: electric circuits, electric current, voltage, conductors and non-conductors and resistance. Secondly, the researcher wanted each pupil to benefit from the practical approach of teaching and learning concepts of electricity in the junior high schools through the use of improvised teaching and learning materials. Thirdly, the subtopics that were treated were challenging to the pupils. They had many misconceptions about the concepts in the syllabus and therefore needed to improve their conceptual understanding of those topics.

Instruments

The researcher used tests and questionnaires as the research instruments to collect data to answer the research questions.

Tests

A test is a procedure or a device for measuring a sample of behaviours of learners. This takes the form of tasks or a series of tasks with the view of obtaining information on an individual's behaviour in a specific area of study or an area of investigation (Brown, 1996). According to Brown (1996), a test can also be described as a way of observing and describing the characteristics of a person. It can also be considered as a stimulus that allows a researcher to gather information from students in a classroom setting. In action research, a researcher may adopt this technique in order to collect information on the problem under investigation. In this study two tests, a pre-test and a post-test were used to collect data for analysis on the performance of the sample. The pre-test was used to collect baseline data on the pupils' knowledge of the concepts under consideration to diagnose the extent of the problem. The data were also used to identify pupils' problems and their misconceptions about electricity and to apply the appropriate intervention required in the study. Multiple choice test was used because this type of objective test is highly structured, i.e. the pupils cannot bring in any material that is not asked for and get the answer correct. Also a multiple choice test can cover a greater part of the content. It also has a high reliability and can be used to measure a variety of learning objectives. Marking of multiple choice items is objective and the test is easy and quick to mark. Two disadvantages of multiple choice test are that it takes a long time to construct the test items and also the answers are opened to a certain degree of guessing. However, the advantages of multiple choice test outweigh the disadvantages.

The pre-test (Appendix C1) consisted of 20 multiple choice test items. The test items were based on the subtopic: simple circuits, conductors and non-conductors, resistance, voltage and electric current found in (JHS teaching syllabus for Integrated Science (GES, 2007). The specific objectives on these subtopics were used as criteria to be achieved through the test. So the researcher converted the specific objectives on application of knowledge, process skills and comprehension into test items. Items were distributed as follows: seven on electric circuits, three on electric current, conductors and voltage, and two each on non- conductors and resistance. The pre-test items were re-ordered and used as the post-test in order to determine whether there had been any significant change in the level of understanding of the basic concepts of electricity as a result of the intervention (Appendix D1).

Test Validity

Test validity, which is the degree to which a test measures what it claims or purports to be measuring, is a very important aspect of test construction (Brown, 2000). The central issue with regard to validity is whether the test really measures the ability or skills or behaviours that it is supposed to measure. According to Nitko (2001), validity is the soundness of the interpretations and uses of students' assessment results. It can also be defined as the appropriateness or correctness of inferences, decisions or descriptions made about individuals, groups or institutions from test results. According to Brown (2000), content validity which is one of the three areas of validity includes any strategies that focus on the content of the test. To determine content validity, test developers investigate the degree to which a test (or item) is a representative sample of the content of the objectives or specifications the test was originally designed to measure. One condition for a test to be valid is that it must necessary be reliable and therefore be able to serve as a useful evaluation tool.

To ensure content validity of the test the researcher took the following measures. First, the items covered all the subtopics on electricity in the JHS two science syllabus namely: electricity, electric current, conductors and non-conductors, voltage and resistance. Four test items representing 20% of the items were on knowledge and understanding, 8 test items representing 40% are on application of knowledge and 8 items also representing 40% were on process skills. Secondly, the items were based on the specific objectives on the unit.

The face validity of the test was determined by three physics tutors of Kibi College of Education and my supervisor a senior lecturer in the Department of Science Education of the University of Education, Winneba. They individually examined and offered suggestions that will help improve the items to ensure their clarity and relevance to the specific objective stated in the syllabus.

Test Reliability

Fundamental to the evaluation of any test instrument is the degree to which test scores are free from measurement error, and are consistent from one occasion to another, when the test is used with the target group (Taale & Ngman-Wara, 2003). According to Taale and Ngman-Wara (2003), a test should be sufficiently reliable to permit stable estimates of the ability levels of individuals in the target group. They added that reliability is closely related to the type of interpretation to be made. In all instances in which reliability is determined, we are concerned with the consistency of the results, rather than with the appropriateness of the interpretations made from the results.

In this study, there was a large number of test items enough to improve reliability. The items were also of varied difficulty levels to cater for the needs of all or majority of the pupils. According to Taale and Ngman-Wara (2003), in the interest of constructing a measuring instrument of maximum quality and utility most items included should be in the middle range of difficulty. Enough time was given to the pupils to react to the test items. The test items covered only areas of the syllabus which was under study. The pre-test was pilot-tested on 40 JHS two pupils of Kibi Presby JHS. The pupils were of mixed ability and they were taught by a science teacher whose academic and professional qualifications were the same as the science teachers of the sampled schools. They were also exposed to the same school environmental conditions. After the test had been scored, the scores obtained were used for the determination of the reliability coefficient (see Appendix G). The overall Cronbach alpha coefficient was 0.8 and interpreted as useful (Mc Daniel, 1994). The outcome of the pilot test showed that the items were appropriate and reliable for the purpose of the study.

The difficulty level of the test items was also determined as followed: the number of pupils who answered an item correctly was divided by the total number of pupils who answered the item to give the item difficulty level. Mathematically, this can be represented as:

$$\text{Item difficulty level (p)} = \frac{\text{No. of pupils who answered an item correctly}}{\text{Total no. of pupils who answered the test item}}$$

The difficulty level was about 0.56. or about 0.6. According to Seif (2004), often items with difficulty levels between 0 - 0.2 and 0.8 – 1.0 are discarded because they are either too difficult or too easy, respectively. When item difficulties are approximately equal, it is an estimate of test reliability giving an indication that the specific objectives sets for the pre-test had been achieved. It also indicated that most of the items were in the middle range of difficulty (Taale & Ngman-Wara, 2003).

Questionnaire

A questionnaire is one of the four major instruments used to gather information and perhaps the most widely used instrument for data collection. According to Adentwi (2005), the use of a questionnaire in educational research has several advantages. The researcher decided to use a questionnaire in the study because, first, it is relatively economical. Secondly, the items of a questionnaire are standardized so questionnaires are more objective than interviews. Thirdly, it is relatively quick to collect information using a questionnaire and the anonymity of respondents is also assured. Two of the disadvantages of the use of a questionnaire are that, first it has a poor recovery rate, that is, the individuals are tempted not to complete and return the questionnaires. Secondly, questionnaire items could be responded wrongly because respondents may not understand them. The researcher took appropriate measures to rectify the two weaknesses on the use of a questionnaire in the study. The researcher prepared two sets of questionnaires, one for the pupils (Appendix E) and the other for the teachers (Appendix F). The questionnaire for the pupils was used to determine the pupils' misconceptions on the concepts of electric circuits, electric current, conductor and non-conductors, voltage and resistance. The questionnaire consisted of 20 statements on misconceptions and statements of facts. There were 10 statements of facts and 10 misconceptions. The breakdown was as follows: there were two misconceptions and two statements of facts each on electric current, electric circuits, resistance and voltage. Furthermore, there was one misconception and one statement of fact each on conductors and non-conductors.

There were three options for each item to choose from. The pupils were to tick whether they agreed or disagreed with each given statement or had no idea about it.

The questionnaire for the science teachers (Appendix F) was to find out their educational background and to seek their views on the effectiveness of the intervention process. The science teachers were to tick their right responses to each item on the questionnaire. The items on the questionnaire were centred on the effectiveness of the teaching and learning materials which were used in the study, the pupils' participation in the three lessons on basic concepts of electricity, group and general discussions to address the pupils' misconceptions on electricity and the effectiveness of the model which was used to effect conceptual change on concepts of electricity. The researcher involved the science teachers throughout the study. During the pre-test and the post-test they were allowed to observed the marked scripts and to determine the mean scores, median, mode and standard deviations and compare the pupils' performances in the two tests. During the intervention process the science teachers were allowed to move round the class to observe the pupils as they interacted with the improvised electric circuit boards and other teaching and learning materials to find out facts on electricity for themselves. They were also given the chance to ask the pupils probing questions to determine whether they understood the lessons.

Face validity refers to the extent to which a test appears to measure what it is intended to measure (Carmines & Zeller, 1979). The face validity of the questionnaires was determined by three education tutors of Kibi College of Education and my supervisor, a senior lecturer in the Department of Science Education of the University of Education, Winneba. They individually examined and offered suggestions that will help improve the items and to ensure their clarity and relevance to the objectives of the questionnaires. The draft questionnaires were amended as appropriate following the face validity testing. The questionnaires were pilot-tested on two science teachers and 40 JHS two pupils of Kibi Presby JHS who had earlier taken part in the pre-test for internal consistency of the questionnaire. The results showed that the internal consistency was high with Cronbach's alpha of 0.86 and the test-retest reliability of 0.79. The results suggest good construct validity. Construct validity is the degree to which a test measures an intended hypothetical construct (Carmines & Zeller, 1979). The findings also demonstrate that the questionnaires meet psychometric criteria for reliability and construct validity**.**

Interventional Process

The interventional process was designed to address the misconceptions of the pupils under study and to help them understand the various basic concepts of electricity. The interventional process was based on conceptual change model of science instruction through the use of hands-on activities with small group discussions. The teaching and learning activities were evaluated at the end of the period of the study.

The researcher prepared three activity-based lessons on electricity. Lesson one was on electric current and conductors, lesson two was on electric circuits, and lesson three was on voltage and resistance (Appendix A1, A2, & A3). Each lesson lasted for seventy minutes, equivalent two periods on the school time table. The teaching and learning materials which were designed and constructed by the researcher for the activities were: improvised electric circuit boards, aluminum strips serving as conductors, bulb holders and dry cell terminals. Generally, the teaching and learning materials that were used for the three lessons were: worksheets, improvised electric circuit boards made from plywood, aluminum bolts and nuts, aluminum strips which served as conductors, pieces of thick and thin copper wires, various conducting materials, various insulating materials, ammeters, voltmeters, electric stove element or resistance wire, 1.5V torch light bulbs, and dry cells.

The pupils worked in groups, where each group was made up of five pupils with one as the group leader. Each group was given a set of teaching-learning materials required for the activities and work sheets. The work sheets contained the procedures to follow with the aid of circuit diagrams to conduct the activities. There were series of questions to discuss after each observation made during the course of the activities and at the end of each activity (Appendix B1, B2 & B3).

Methodology of the Lessons

The researcher used the 5Es model of lesson presentation to teach the three lessons of the study. The activities for the various stages of each lesson have been described in relation to the 5Es model (Appendix B4).

Data Collection Procedure

The researcher used pre-interventional activities namely the administration of a pre-test and questionnaires to define or diagnose the perceived problem before the actual intervention. The pre-test and questionnaires were administered to the pupils on the same day by the researcher through the help of the assistant headmaster of each of the two JHS.

First, the pupils took the pre-test which lasted for 30 minutes and after that the questionnaires were administered. The post-test was administered after the intervention process using a procedure similar to that of the pre-test. With regard to the administration of the questionnaires, first the pupils were told that the questionnaires were for a research purpose and that the study will help improve the teaching and learning about electricity in junior high schools. Furthermore, the pupils were advised to respond honestly to the items on the questionnaires and that the study may not have any negative effects on them. The researcher administered the questionnaires to the pupils and collected them all after a period of one hour. All the 115 multiple test papers and questionnaires were collected back.

The post-intervention process evaluated the outcomes of the action taken. The pre-test items were re-ordered and used as the post-test. (Appendix D1, & D2). The strategy was used to determine whether there had been any significant improvement in the level of understanding of the pupils or not in relation to learning about the basic concepts of electricity.

Data Analysis

The data from the pre-test and the post-test on the study were analysed using descriptive statistics, which included frequency counts, percentages, mean, standard deviations and graphs as well as inferential statistics using t-test. The t-test analyses were used to determine whether there was a significant change in the level of understanding of the JHS two pupils when the conceptual change model was used to teach the concepts of electricity. The researcher used paired two sample for means t-test in the analysis because the sample was first pre-tested to determine the baseline mean score and then exposed them to some kind of treatment after which a post-tested was conducted for the purposes of comparison with the pre-treatment mean score.

The analysis of the data on the pre-test and post-test attempts to provide an answer to the second research question which states: will conceptual change teaching model help JHS two pupils to understand some concepts of electricity? First, the researcher converted the raw scores which the pupils obtained on the 20 pre-test items into percentages. Secondly, he grouped the scores which were discrete and counted the frequency of each discrete score. The percentage frequency of each discrete score was then calculated. Furthermore, the researcher tabulated the data of the pre-test and post-test under the headings scores and frequency count. The researcher then used the data analysis of Microsoft excel to obtain the descriptive statistics of the data and the results gave the calculated mean, mode, median and standard deviation. Microsoft excel was also used to draw bar graphs of the pupils' percentage scores on the x-axis against the number of pupils (frequencies) on the y-axis to show trends in the tests. Finally, a paired two sample for means t-test was used to find the significant mean difference between the pre-test and post-test mean scores using Microsoft excel. The decision rule which was used in the data analysis was that in all cases with t-tests the decision rule for rejecting the null hypothesis is $t < -t_{\alpha/2}$ or $t > t_{\alpha/2}$, where t is the calculated t value and $t_{\alpha/2}$ is the critical t value (Zimmerman, 2011).

The questionnaire for the pupils was to seek an answer to the first research question which states: what are Kibi JHS two pupils' misconceptions on the concepts of electric circuits, electric current, conductor, voltage and resistance? The researcher used the manual method to code each of the concepts on electricity separately. The coding involved the following steps. First, the researcher made a table with two main columns namely statements and responses. The column of the responses was then divided into four in relation to the three options of the responses namely agreed, disagreed and no idea and total response. The researcher took the pupils' questionnaires one after the other and marked the corresponding responses against the corresponding statements on the questionnaires. The frequency counts and percentage frequencies were determined for each statement on the questionnaire for a concept on electricity. The total responses were then determined for a concept. The same procedure was used for each of the other concepts on electricity on the questionnaire. The researcher used manual coding technique to count the responses that the science teachers gave to the five statements on the questionnaire. The frequencies were converted into percentages. The responses consisted of four options namely: strongly agreed, agreed, disagreed and strongly disagreed. The total percentage frequencies of the responses to the statements were calculated.

CHAPTER 4

RESULTS AND DISCUSSION

Overview

This chapter presents the results and discussion of the results of the study gathered through questionnaires, pre-test and post-test administered during the intervention process. The responses of the JHS science teachers on their views on the intervention measures of the study have also been gathered. The data collected were presented in the form of tables however bar charts were included to illustrate and support the discussion.

Research Question One

What are Kibi JHS two pupils' misunderstandings and alternative conceptions on electric circuits, electric current, conductors, voltage and resistance?

The responses of the JHS two pupils on the questionnaire are presented in Tables 1 to 5.

Table 1: Pupils' Scientific Ideas and Incorrect Ideas on the Concept of Electric Circuits.

Statement	Responses (%)			Total
	Agree No. (%)	Disagree No. (%)	No idea No. (%)	
One copper wire between a bulb and a cell is all that is needed to light a bulb.	80 (70%)	29 (25%)	6 (5%)	100%

Electric current does not flow through closed electric circuits.	75 (65%)	36 (31%)	4 (4%)	100%
An electric circuit has to form a closed loop for current to flow.	29 (25%)	80 (70%)	6 (5%)	100%
The two main types of electric circuits are series and parallel connections.	75 (65%)	40 (35%)	0 (0%)	100%

Table 1 shows the results of the JHS two pupils' scientific ideas, lack of ideas and incorrect scientific ideas on the concept of electric circuits. It is observed that between 65% and 70% of the pupils gave wrong responses to the two incorrect statements on the questionnaire on electric circuits. The two incorrect statements were that: one copper wire between a bulb and a cell is all that is needed to light a bulb and that electric current does not flow through closed electric circuits. The two non-scientific statements were distracters to help determine the pupils' misconceptions on electric circuits. The sources of the pupils' incorrect statements may be their experiences encountered in daily life, instructional language by teachers and parents and by text books. Majority of the pupils held similar views and therefore could not differentiate between statements on electric circuits that are scientific facts and misconceptions. Seventy percent of the pupils did not know that an electric circuit has to form a closed loop for current to flow. It was also observed that between four and six percent of the pupils had no idea on the statement of facts and misconceptions on electric circuits. The results further showed that the pupils had learning difficulties on electric circuits because few pupils, between 25% and 31% of the pupils, were able to identify the misconceptions and the statements of facts on electric circuits. Finally, the result shows that all the pupils had scientific idea about the two main types of electric circuits namely the parallel and series connections. According to

Hewson and Hewson (1983), to bring about conceptual change the pupils must be dissatisfied with the current understanding and sought an available alternative that seems plausible.

Table 2: Pupils' Scientific Ideas and Incorrect Ideas on the Concept of Electric Current.

Statement	Responses (%)			Total
	Agree No/ %	Disagree No/ %	No idea No/ %	
Current is the flow of energy	90 (78%)	15 (13%)	10 (9%)	100%
Current is used up in a circuit	105 (91%)	10 (9%)0	(0%)	100%
Current supplied by a cell is not always the same with regard to the circuit features.	10(9%)	103 (89%)	2 (2%)	100%
Positive and negative current do not clash to light a bulb.	9 (8%)	106 (92%)	0 (0%)	100%

The analysis of the data in Table 2 revealed that the JHS two pupils had incorrect ideas on the concept of electric current. Out of the total pupils' sample of 115 who were under study, 90 pupils representing 78% agree with the statement that current is the flow of energy. The statement is not a scientific fact but a misconception about the flow of electric current. Furthermore, 91% of the sample also had an incorrect idea (a misconception) that current is used up in a circuit. Between 10 to 15% of the sample knew that these two statements: current is the flow of energy and that current is used up in a circuit are misconceptions. It was also observed from the results that between eight and nine percent of the sample knew that the following two statements are scientific facts about electric current: that current supplied by a cell is not always the same with regard to the circuit features and that positive and negative current do not clash to light a bulb in a circuit. Between 89% and 92% of the sample had misconceptions with the two statements of facts and therefore disagreed with the statements. Very few pupils, representing 10% of the sample had no ideas on the given statements on the questionnaire about electric current. It was also observed that they had no ideas on these two statements: current is the flow of energy and current supplied by a cell is not always the same with regard to the circuit features. It is only through conceptual change approach of teaching electricity that the pupils may understand the concept of electric current.

Table 3: Pupils' Scientific Ideas and Incorrect Ideas on the Concept of Conductors and Non-conductors of Electricity

Statement	Responses (%)			Total
	Agree No/ %	Disagree No/ %	No idea No/ %	
All electric wires are insulated	80 (70%)	25 (22%)	10 (8%)	100%
Copper wire is not the only conductor of electricity.	10 (9%)	105 (91%)	0 (0%)	100%
A non- conductor is a material which does not contain movable electric charge.	9 (8%)	86 (75%)	20 (17%)	100%
Electric current cannot pass through aluminium materials because they are non-conductors.	100 (87%)	12 (10%)	3 (3%)	100%

Table 3 presents the JHS two pupils' scientific ideas, incorrect ideas (misconceptions) and difficulties on the concept of conductors and non- conductors of electricity. The analysis of the results showed that between 70% and 87% of the sample had misconceptions on these two statements: that all electric wires are insulated and that electric current cannot pass through aluminium materials because they are non-conductors of electricity. However, few pupils (ranging between 12% and 22%) knew that the two statements were misconceptions and did not agree with the statements. It was also observed that majority of the pupils ranging between 75% and 91% had these scientifically true statements wrong; that copper wire is not the only conductor of electricity and that a non-conductor is a material which does not contain moveable electric charge. The two statements were learning difficulties of the pupils. Furthermore, it was also observed that there were few pupils ranging between three and 17% who had no ideas on the misconceptions and statements of facts on the questionnaire on conductors and non-conductors of electricity. Generally, the pupils had learning difficulties on the concepts of conductors and non-conductors of electricity.

Table 4: Pupils' Scientific Ideas and Incorrect Ideas on the Concept of Voltage.

Statements	Responses (%)			Total
	Agree No/ %	Disagree No/ %	No idea No/ %	
It is possible to have voltage without current, but current cannot flow without voltage.	10 (9%)	105 (91%)	0 (0%)	100%
Voltage is supplied by a cell or battery.	100 (87%)	10 (9%)	5 (4%)	100%
Voltage is not used up in components of an electric circuit.	99(87%)	11 (9%)	5 (4%)	100%
Current is the same thing as voltage	100 (87%)	10 (9%)	5 (4%)	100%

The analysis of the data in Table 4 shows that generally the sample had some learning difficulties on the concept of voltage. The two incorrect statements (misconceptions) on the questionnaire on voltage were: that voltage is not used up in the components of an electric circuits and that current is the same thing as voltage. It was observed that 87% of the pupils had incorrect ideas which are also termed as misconceptions on voltage while nine percent of the pupils knew that the two statements were not scientifically correct statements on voltage. Majority of the pupils representing 91% of the sample disagreed with the statement of facts that it is possible to have voltage without current but current cannot flow without voltage. It was only nine percent of the sample that agreed with that scientific statement of fact. Furthermore, as many as 87% of the sample agreed to the statement of fact that voltage is supplied by a cell or battery. About four percent of the pupils had no ideas on the statements of facts and misconceptions on the questionnaire on voltage.

Table 5. Pupils' Scientific Ideas and Incorrect Ideas on the Concept of Resistance

Statements	Responses (%)			Total
	Agree No/ %	Disagree No/ %	No idea No/ %	
A conductor has no resistance.	105 (91%)	10 (9%)	0 (0%)	100%
A resistor consumes electric current.	105 (91%)	10 (9%)	0 (0%)	100%
Resistance of a material determines the flow of electric charge.	9 (8%)	16 (14%)	90 (78%)	100%
Resistance of a component of an electric circuit depends only on its own properties.	10 (9%)	10 (9%)	83 (82%)	100%

Table 5 represents the pupils' scientific ideas and incorrect ideas on the concept of resistance. The analysis of the data on the table shows that the pupils had incorrect ideas (misconceptions) on the concept of resistance. The two incorrect statements on the questionnaire on resistance were that: a conductor has no resistance and that a resistor consumes electric current. It was observed that 91% of the pupils agreed with the two statements which were misconceptions. It was only nine percent of the sample that disagreed with the incorrect statements which are misconceptions on resistance. The two statements of facts were that; resistance of a material determines the flow of electric charge and that resistance of a component of an electric circuit depends on its own properties. The analysis of the results showed further that majority of the pupils ranging between 82% and 90% had no idea on the two statements of facts on resistance. Very few pupils representing between eight and nine percent of the sample agreed with the two statements of facts. Generally, the pupils had learning difficulties on the concept of resistance and the problem could be solved through conceptual change approach to science instruction.

Research Question Two

Will conceptual change teaching model help JHS two pupils to understand some concepts of electricity?

The results of the performances of the JHS two pupils of Kibi in the pre-test and post-test of the study had been presented in Tables 6 and 7.

Table 6 represent the performances of the pupils of KPCE Demonstration and Kibi State JHS in the pre-test and post-test.

Table 6: Performance of JHS Two Pupils of KPCE Demonstration and Kibi State JHS in the Pre-Test and Post-Test.

Scores (%)	Frequencies of Pretest Scores	Frequencies of Post Test Scores
15	17	0
20	21	0
25	19	0
30	17	0
35	9	0
40	9	7
45	8	10
50	10	15
55	4	2
60	1	9
65	0	12
70	0	22
75	0	8
80	0	13
85	0	2
90	0	4
95	0	10
100	0	1
Total	115	115
Mean score	30.2	66.7
Standard deviation	12.1	16.1

The data show generally that there was a significant improvement in the performance of the sample when conceptual change model of science instruction was used in teaching the basic concepts of electricity leading to a significant change in the level of understanding of the pupils. The pre-test scores of the sample ranged from 15% which was the minimum score to 60% with a mean score of 30.2 and a standard deviation as 12.1. The analysis of the data showed that 14.9% of the sample representing 17 pupils scored 15% and one pupil representing 0.9% of the sample scored 60%. The median of the pre-test score was 30% and the mode was 20% which was obtained by 19 pupils representing 18.5% of the sample.

The post-test scores of the pupils ranged from 40% to 100% with a mean score of 66.7 and a standard deviation as 16.1. The minimum score of 40% was obtained by seven pupils representing 6.1% of the sample but only one person representing 0.9% of the sample scored 100%. As many as 22 pupils representing 19.1% of the sample scored 70% which was the mode and median of the scores. Furthermore, the mean scores and the standard deviations of the pre-test and post-test scores indicated a possible significant improvement in the pupils' understanding of basic concepts of electricity. Figure 2 and Figure 3 show the data of the pre-test and post-test in the form of bar graphs.

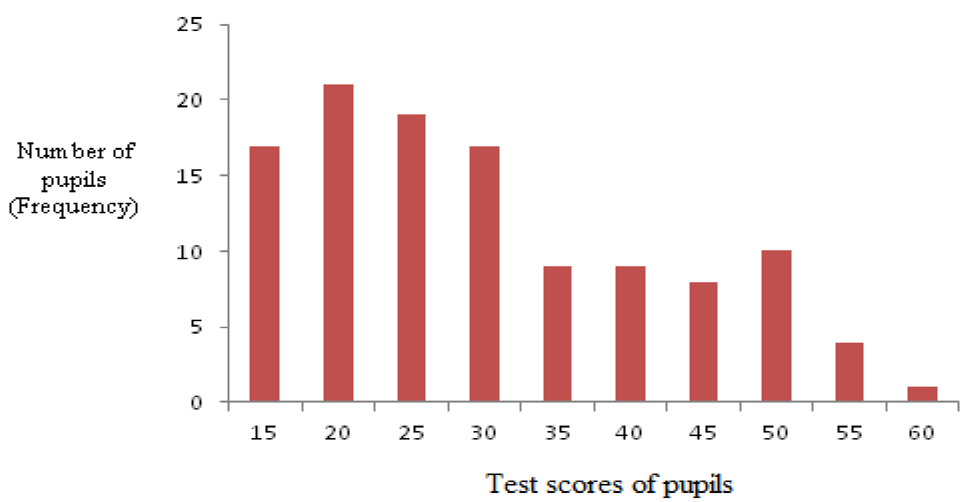

Figure 2. Performance of JHS Two Pupils of KPCE Demonstration and Kibi State JHS in Pre-Test

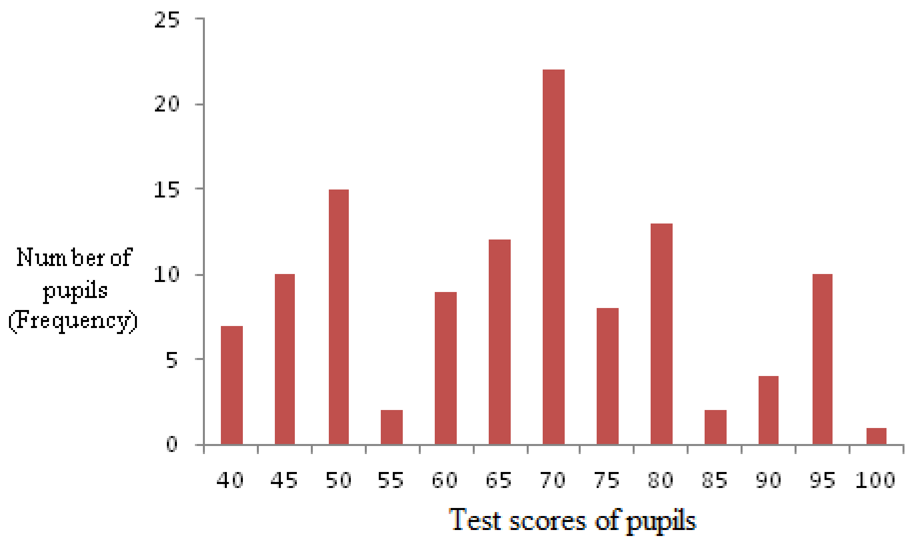

Figure 3. Performance of JHS Two Pupils of KPCE Demonstration and Kibi State JHS in the Post-Test

Research Question Three

There is no significant change in the level of understanding of JHS two pupils on concepts of electricity when conceptual change teaching model is used to teach the concepts of electricity.

The data analysis of this research question is based on the data in Table 7. A paired two sample for means t-test was used to compare the mean scores of the pre-test and post-test of the use of conceptual change model of science instruction to improve JHS two pupils' understanding of basic concept of electricity. The paired t-test was to help determine whether there was significant mean difference between the pre-test and post-test mean scores. The results of the pre-test and post-test to be used to determine whether there had been a significant change in the pupils' level of understanding have been presented in Table 7.

Table 7: Comparison of Mean Performances of the JHS Two Pupils in Pre-Test and Post-Test.

Tests	Mean	T-test Calculated	T-test Critical	df	p
Pre-test	30.22				
Post-test	66.70				
		72.7218	1.9809	114	2.31×10^{-97}

Table 7 shows the results of the mean performance of the JHS two pupils in the pre-test and the post-test. The analysis of the data in the table showed that there was a significant difference in the mean scores of the post-test (mean=66.70, standard deviation = 16.10) and pre-test (mean= 30.22; standard deviation = 12.10). Between the pre-test and the post-test, the calculated t- value (t- statistic) of 72.72 is greater than the critical t-value of 1.98 so there is a significant difference between the mean scores and the null hypothesis is rejected at a significance level of 0.05. These results suggest that the use of conceptual change model of science instruction to teach the basic concepts of electricity improved the understanding of the JHS two pupils. Hence there was a significant change in the level of understanding of the pupils on concepts of electricity when conceptual change teaching model was used.

Views of Science Teachers

The researcher, in attempt to find out the views of the science teachers of the JHS two classes on the effectiveness of the intervention process presented the data on the questionnaire as shown in Table 8.

Table 8: Views of Science Teachers on the Interventional Process

Statement	Responses				Total
	Strongly agree No.	Agree No.	Disagree No.	Strongly disagree No.	%
Pupils were guided to carry out all the activities in groups through effective use of work sheets.	6				100
The teaching-learning activities were relevant and suitable to the class and helped to explain concepts on electricity as well as develop process skills.	6				100
The practical activities together with the general class discussion helped the pupils to address their misconceptions on electricity.	6				100
The model that was used in the teaching about electricity to JHS two pupils was effective to enhance pupils' understanding and must be adopted by science teachers.	6				100

The analysis of the data from Table 8 showed that all the science teachers strongly agreed with statements on the questionnaires showing that the model used for the study was very effective to improve the pupils' understanding of basic concepts on electricity. First, they strongly agreed that during the lessons the pupils were guided to carry out all the activities in groups through the use of worksheets with questions for group discussions. Secondly, the teachers strongly agreed that the teaching and learning activities were relevant and suitable to the class and they helped the pupils to explain concepts on electricity and to develop process skills. Thirdly, they strongly agreed that the practical activities together with the general class discussions helped the pupils to address their misconceptions on basic concepts on electricity. Finally, they strongly agreed that the model that was used in teaching about electricity was very effective to enhanced pupils' understanding and recommended the adoption of the model by science teacher in the East Akim Municipality. The science teachers were professional teacher who hold Diploma in Basic Education.

Discussion

The main findings of the study were that first there was a significant improvement in the understanding of the JHS one pupils of KPCE Demonstration and Kibi State JHS when the conceptual change model of science instruction was used to teach basic concepts of electricity. There was also a significant mean difference between the pre-test mean score and post-test mean score of the pupils' pre-test and post-test scores. Furthermore, the improvised teaching and learning materials together with the practical activities were very effective in improving the understanding of the pupils and in the acquisition of basic knowledge and process skills on electricity. The pupils were very active in the three demonstration lessons, manipulating teaching- learning materials, discussing their observations, drawing conclusions and making generalisations on basic concepts of electricity which were under study. The study helped the pupils to correct their misconceptions on the following concepts of electricity: electric circuits, electric current, conductors and non- conductors, voltage and resistance.

The data analysis of the pupils' questionnaire revealed that most of the misconceptions and conceptual difficulties reported in the literature review (e.g. Cohen et al., 1983; Evans, 1978; Licht, 1987; McDermott & Shaffer, 1992; Psillos et al., 1988; Saxena, 1992; Shipstone et al., 1988) were found to exist among the JHS two pupils of Kibi State JHS and KPCE Demonstration JHS.

On the concept of electric circuit, the two misconceptions which were their conceptual difficulties together with their percentage responses were as follow: 70% of the responses were of the view that one copper wire between a bulb and a cell is all that is needed to light a bulb while 65% responded that electric circuit does not have to form a closed loop for current to flow. Marking the pre-test, it was observed that many of the pupils had misconceptions on a closed circuit due to the use of the local language. In everyday language, expressions such as "close the switch" to light off a lit bulb and "open up the switch" to light bulb are used.

A significant number of pupils thought that one wire between a cell and a bulb was enough to light the bulb and that the second wire to be found in working circuits in everyday life simply serves to bring more current to the bulb or is an earth wire. According to Tiberghien (1983), children use very general explanations for the functioning of a simple electric circuit. Usually, they establish a causal connection between the cells and the bulb. On series and parallel circuit 35% of the pupils also had difficulties in identifying the two types of circuits in circuit diagrams and hence their inability to determine that the two main types of electric circuits are series connection and parallel connection.

On the concept of electric current, the two misconceptions of the pupils and their percentage responses were as follow: 90% of the responses on electric current is the flow of energy while 91% on current is used up in a circuit. Scientifically, the current supplied by a cell is always the same regardless of the circuit features and it is not used up in the circuit. The pupils were also of the view that the positive and negative current do clash to light a bulb. In the views of the pupils, current is used up in a circuit because current decreases when it passes through a bulb. According to Osborne (1983), Karrqvist (1985), and Shipstone et al. (1988), misconception of consumption of the current by circuit components is frequently encountered in literature. Some pupils thought that positive current leaves from the positive terminal and negative current leaves from the negative terminal of the cell and they meet and produce energy in the bulb. This view is called clashing currents theory (Shipstone et al., 1988). The clashing current theory is a misconception. Current travels from the positive terminal of a cell and then completes the circuit by passing all circuit elements and finally reaches the terminal. Current is not used up in a circuit, what flows into a component must flow out. Current passes through a component in an electric circuit (Karrqvist, 1985).

The two misconceptions of the pupils on voltage were together with their percentage responses were: 87% of the responses on “current is the same thing as voltage” and the same percentage (87%) of the responses on “voltage is not used up in components of an electric circuit”. A large number of the pupils (91%) lacked the scientific idea that it is impossible to have voltage without current; no current, no voltage. However, they had the scientific idea that voltage is supplied by a cell or battery because cells and batteries normally bear the inscription of the voltage supplied.

At the pre-intervention stage, the pupils had difficulties in viewing voltage as the primary concept in the circuit and as the cause of current to flow in a circuit. Their misconception of a cell or battery as a constant source of current as response in the questionnaire led them to form the concept that when there is no current there is no voltage distribution in the circuit. The same finding was also reported by Karrqvist (1985), Shipstone et al. (1988) and Borges and Gilbert (1999). Scientifically, voltage attempts to make current flow and current will flow if the circuit is complete. It is possible to have voltage without current in a circuit, but current cannot flow without voltage according to Demetrius and Hurd (1969). Voltage is a measure of the energy carried by the charge. Thus, it is the energy per unit charge. The proper name of voltage is potential difference. Voltage is supplied by a battery, cell or a power supply and it is used up in components in a circuit but not in wires. Voltage is across a component and it is the difference between two points in a circuit (Psillos, Kouramas, & Tiberghien, 1988).

The two misconceptions of the pupils on conductors and their percentage responses were: 70% of the responses on “all electric wires are insulated” and 87% of the responses on “electric current cannot pass through a material which is made of aluminium”. As many as 91% of the pupils disagreed that “copper wire is not the only conductor of electricity. The analysis of the results showed that the pupils had no idea of the scientific fact that a conductor is a material which contains movable electric charges and this difficulty initially affected their understanding of the concept of conductors. According to Abbott (1987), a conductor is a material which contains movable electric charges. The movable charged particles are electrons. Aluminium materials are conductors of electricity. Aluminium wire is not normally used as a conductor in housing applications because it has technical problems that can lead to structural fires. It has a tendency to form an electrically resistive surface oxide within connections, leading to heat cycling of the connection unless protected by a well-maintained protective paste (Psillos, Kouramas, & Tiberghien, 1988).

The two misconceptions of the pupils on the concept of resistance together with their percentage responses were: 91% of the responses on "a conductor has no resistance" and the same percentage (91%) of the responses on "a resistor consumes electric charge". As many as 91% of the pupils had no idea that resistance as explained by Hammond (1969) is a feature of a material and that determines the flow of electric charge. The resistance of a component of an electric circuit depends only on its properties (Hammond, 1969). Many of the pupils were of the view that in a circuit there would be no resistance in the components if there is no current passing.

In general, the analysis of the misunderstandings of the pupils revealed the fact that they varied substantially among the pupil in their resistance to conceptual change since there were various percentages of pupils who agreed with or disagreed with the given statements on electricity on the questionnaires for the pupils.

The analysis of the results of the post-test taken as a measure of the acquisition of conceptual understanding (See Table 6 & 7) showed that the implemented approach was successful in enhancing conceptual understanding of the following basic concepts of electricity: electric circuits, electric current, conductors, voltage and resistance. A comparison of the mean scores of the pre-test and the post-test showed that the pupils were able to achieve scores higher than the mean score of the pre-test. Furthermore, it can be inferred that all the pupils benefited from the conceptual change model of teaching electricity to overcome their conceptual difficulties on electricity.

The study adopted probably the most widely accepted model of conceptual charge that was proposed by Posner, Strike, Hewson and Gertzog (1982). They argued that conceptual change could take two forms namely assimilation and accommodation. Assimilation occurs when individuals add information to the existing knowledge structures. This occurred in the study when the pupils acquired new knowledge on basic concepts of electricity and added it up to their previous knowledge. Accommodation which is a more radical change occurs when a central concept is replaced or reorganized. This also occurred in the study when the pupils abandoned their misconceptions and replaced them with the plausible information about the basic concepts on electricity. The advantage of the model was that it provided an explanation of the conditions necessary for conceptual change. In the study, accommodation began when there was dissatisfaction with an existing misconception on electricity. The hands-on activities led the pupils to consider new conceptions on electricity to be more intelligible (able to be understood), plausible (make sense), and fruitful (having the potential to explain more situations.

According to Hewson and Thorley (1989), the status of a conception is marked by the extent to which it is intelligible, plausible and fruitful. These conditions were fulfilled through the hands-on activities, the group discussions and general class discussions on basic concepts of electricity.

The 5Es lesson planning model contributed to the conceptual understanding of the basic concepts of electricity which were under study. The model is often associated with constructivist learning design. According to Bransford, Brown and Cocking (2000), the five phases of the 5Es model are: engagement, exploration, explanation, elaboration and evaluation. The processes involved in the five phases have been outlined below. First, there was the assessment of the learners' previous knowledge to help them engage in the new concept through the use of short activities that promote curiosity. The second phase involved the provision of a common base of activities within which the misconceptions and difficulties in learning were identified and conceptual change facilitated through practical activities. The third phase involved focusing pupils' attention on particular aspects of the concept and providing the learner the opportunities to demonstrate their conceptual understanding and process skills. The fourth phase involved pupils' application of their understanding of the concepts by conducting additional activities. The final phase involved the assessment of learners understanding which provides opportunities to evaluate their progress toward the instructional objectives.

The improvement in performance of the pupils as depicted in the post-test result was not due to chance but rather could be attributed to the well planned cooperative learning strategies incorporated in the intervention process together with the constructivist model of teaching electricity (science). The researcher observed that there was cordial interpersonal relationship created between the researcher and the pupils and between the pupils and their peers, especially those in the same group. There were opportunities for the pupils to manipulate the teaching learning materials on electricity to have a better chance of understanding and retaining concepts that were taught. There were also opportunities for group discussions during which the pupils discussed their observations and felt safe in sharing their view points on some basic concepts of electricity. That was in line with the research work of Driver (1989), that a cooperative learning environment is necessary for successful conceptual change instruction and that there must be opportunities for discussions. Pupils must feel safe in sharing their view points as they consider and evaluate other perspectives (Scott, Asoko, & Driver, 1991). The cooperative learning approach according to Scott, Asoko and Driver (1999) can contribute to an overall increase in motivation and promotion of cognitive development. In the view of Cooper, Robinson and Mckinney (1994), cooperative learning tasks in which pupils assist other peers to learn through explaining concepts to each other, i.e. elaborated help, have been correlated with academic achievement.

Finally the analysis of the science teachers' questionnaires showed that the study on using conceptual change approach to science instruction to improve the understanding of JHS two pupils' understanding of electricity was successful.

CHAPTER FIVE

SUMMARY, CONCLUSIONS, RECOMMENDATIONS AND SUGGESTIONS

Overview

This chapter presents the summary, conclusions, recommendations and suggestions for further studies. Furthermore, the implication of the study to science education has also been included.

Summary

The purpose of this study was to use conceptual change model of science instruction to improve junior high two pupils' understanding of some basic concepts of electricity. The researcher employed action research design in the study with the aim of finding answers to the proposed research questions. The samples were drawn from the accessible population of the junior high schools in Eastern region of Ghana. The target population was junior high schools at Kibi. There are six JHS in the town from which two JHS namely KPCE Demonstration JHS and Kibi State JHS were selected and used for the study. The two selected JHS had a population of 240 pupils of which 115 pupils are in form two classes. KPCE Demonstration JHS has a population of 30 boys and 27 girls while Kibi State JHS has 35 boys and 23 girls. There were 20 teachers on the staff of both schools including six science teachers. The two JHS for the study were randomly selected and to help each pupil benefit from the good effects of the study intact classes were used.

The researcher used two sets of questionnaires and tests as the research instruments to obtain information for the study. With regards to questionnaires, 115 questionnaires were administered to all the JHS two pupils and six to the science teachers involved in the study. All the questionnaires were successfully retrieved, representing 100% return rate from the respondents. The data from the tests and questionnaires were presented in the form of tables and graphs and were analysed using simple percentage and descriptive statistics. The findings obtained from the study revealed the pupils' major difficulties in learning basic concepts of electricity and the effective intervention strategy led to the pupils' deeper understanding of concepts of electricity, hence a conceptual change in learning about electricity.

The analysis of the pupils' questionnaires revealed that they had misconceptions and difficulties in learning the following basic concepts of electricity: electric circuits, electric current, conductors, voltage and resistance. Based on the pupils' misconceptions, the researcher taught three lessons on electricity using the constructivist model and the 5Es lesson model.

The pre-test results of the study showed low performance of the pupils but the post-test results showed a great significant improvement in the performance of the pupils. All the science teachers who observed the lessons strongly agreed with the questionnaire items that the intervention strategy really led to a conceptual understanding of the basic concepts of electricity under study. The use of cooperative learning approach involving hands-on activities on manipulation of teaching learning materials on electricity together with group discussions promoted a sense of togetherness in the pupils and that enhanced exchange of views among them. The teamwork encouraged the pupils to engage in hands-on activities, discussed their findings, answered questions, drew conclusions and applied their findings. Those processes made the pupils understand the basic concepts of electricity. The results can therefore be generalized to the accessible population used in the study.

Conclusions

The following conclusions can be drawn from the results of the study. The conceptual change model of science instruction involving hands-on activities, demonstrations in small groups and group discussions was an effective tool in limiting the pupils' alternative conceptions and misunderstandings and therefore in improving their conceptual understanding of the following basic concepts of electricity: electric circuits, electric current, conductors, voltage and resistance.

The analysis of the results of the post-test showed that the pupils' sound understanding of the basic concepts of electricity increased significantly. Well-designed conceptual change approach to teaching the concepts of electricity represents an alternative approach which may assist pupils to improve their misunderstandings of these concepts.

The findings of this study have also shown that the constructivist model of teaching electricity had positive effects in fostering conceptual understanding of basic concepts in electricity. In addition to its effectiveness in promoting understanding of concepts, the approach enabled pupils to take ownership of their learning and to experience science as an active process of inquiry rather than as an established body of stagnant knowledge which is imparted to pupils.

Implications of the Study

In light of the significance of the findings of the study and related previous work about electricity and conceptual change approach in science instruction, the researcher offered the implications below.

Science teachers should be encouraged to acknowledge and reconsider the role of pupils' misconceptions in the learning process. These misconceptions are the basic building blocks for understanding, but at the same time are barriers and obstacles for learning as they are very persistent and may survive formal instruction.

Teaching for conceptual change primarily involves uncovering pupils' misconceptions about a particular topic or phenomena in science and using various techniques to help pupils change their conceptual framework. Conceptual change instruction can help pupils overcome misconceptions and learn difficult concepts in all areas of science.

There is no one methodology that can be used for all topics on electricity. However, well designed conceptual change approach based instruction in science represents an alternative instructional approach to encourage pupils to modify their misconceptions on electricity. Conceptual change approach based instruction is a powerful methodology for science classes. Some science teachers are faced with the challenge of changing pupils' misconceptions about science topics to scientifically accurate understandings. They can consider the pupils' existing misconceptions in science topics in order to select and organize pupils' intended learning outcomes. If pupils' misconceptions are known before hand, the teacher can prepare a teaching scheme to remove those kinds of misconceptions with his/her class (Griffiths & Grant, 1985; Adeniyi, 1985; O-Saki & Samiroden, 1990; Boujaoude, 1992).

Science teachers in a school need time to plan and collaborate with one another to develop materials and to try new instructional methods. Later, they need to meet to reflect upon their teaching processes.

Teachers can develops and apply the conceptual change approach to teaching various classes. First, they should think carefully of how to improve pupils learning about a science topic with the new method. Additionally, teachers should learn how to teach science topics using hands-on activities.

The nature of the conceptual change approach can enable pupils to progress at their own pace and to encourage pupils to use their thinking ability. The conceptual change approach of science instruction offers a set of guidelines to help pupils gain experience in grasping the concepts under study. These guidelines provide special learning environments such as identifying common misconceptions about electricity, presenting descriptive evidence in class that the misconceptions are incorrect, providing a scientifically correct explanation of the situation and giving pupils the opportunity to practise the correct explanation by asking questions.

For successful implementation of the conceptual change instructional strategy, the teacher and pupils should have some experience with constructivist learning and cooperative learning groups. Pupils who are accustomed to a transmission style of teaching (i.e. direct instruction) may be less motivated to participate in discussion-based activities (Scott, Asoko, & Driver, 1999). The teacher must be adept in managing class groups and also be able to assume a facilitative role.

Recommendations

The researcher has offered the following recommendations in light of the findings of the study.

a. Conceptual change approach to science instruction should be introduced into the science programme in Colleges of Education and made part of the course on methods of teaching science. The introduction into the course will help prospective teachers to learn how to teach for conceptual change.

b. Conceptual change should not be viewed as a process involving only cognitive factors but must be integrated with motivational factors because they play an equally important role as moderators of conceptual change. If pupils are not motivated enough to engage in reconstruction of their ideas then no conceptual change can occur. It is generally accepted that intrinsic motivation can promote learning and achievement to a greater extent. (Pintrich & Schunk, 1996).

c. Instructional strategies have to be designed such that pupils would be guided to learn science through direct observations, hands-on activities and collaborative participation in lessons because the individual has to be convinced that the scientifically sound concepts learnt in a class are more useful than the existing misconceptions. Conceptual change oriented instruction explicitly deals with pupils misconceptions while the traditional instruction does not.

d. The Ghana Education Service and the government should organize workshops and in-service training courses for teachers in effective teaching through the use of conceptual change model of science instruction. This is necessary because in order to facilitate pupils' learning of science at JHS, the science teachers need to learn different science teaching methods, to learn how to use different methods and develop different hands-on activities for science topics of their classes.

e. Ghana Education Service and the government of Ghana should provide the needed basic materials for science practical activities in school.

f. Teachers, curriculum developers and textbook writers must be aware of pupils' misconceptions in concepts of electricity and must try to prevent them from occurring.

Limitations

It is assumed that any research work would not be free from limitations. In the course of the study the most challenging limitations that the researcher encountered had been outlined below.

a. Few pupils were absent from classes during the periods of the intervention so the researcher had to spend time to review the previous lessons before the new lessons were started to help the pupils who were absent have the relevant previous knowledge to learn the new lessons.

b. The large class size cost the researcher so much money in buying the teaching learning materials and in the printing of work sheets, questionnaires and hand-outs.

c. There was the problem of time constraint. The researcher had limited time to carry out the study, write the reports and undertake his teaching activities at his place of work because the researcher was pursuing a distance programme,

d. Some of the pupils had poor communication skills in English. They found it difficult to read their hand-outs so they could not revise lessons that had been treated in class. They also found it difficult to read the test items with understanding and this affected their performance in the tests.

e. There was a limitation about generalization of the results of the study to other pupils of other schools. However, according to Hamilton (1981), action research produces results which are not generalisable but someone else's ideas or conclusions can always be tried out by other persons in their own practice to see if they work for them.

Suggestions for Further Research

The researcher suggests that further studies be undertaken to investigate the effects of gender, motivational and affective factors in fostering conceptual change in learning of electricity in Junior High Schools.

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APPENDIX A1.

LESSON PLAN 1. ELECTRIC CURRENT AND CONDUCTORS

Schools: KPCE Demonstration JHS
: Kibi State JHS
Class: JHS 2
Average age: 14 years
No. on roll: KPCE: 57; State JHS: 58

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Day/Date/ Duration	Topic / Subtopic	RPK / Objectives	TLMs / Teaching-Learning Activities	Misconceptions/ Core Points / Application	Evaluation / Exercise / Remarks
Monday 3rd Oct. 2011 70 min.	Topic: Electricity Sub-Topic Electric current and conductors	R.P.K Students are familiar with the two cables that bring the mains electricity supply	TLMS: Five improvised electric circuit boards, 10 dry cells, five (1.5V) flashlight bulbs, aluminum strips (conductors), improvised bulb holders, five pieces of flexible wire, five small nails, 50 Gp coins, 100 Gp coins, five copper rings, five office pins, five pen covers, five pieces of paper, five carbon rods, five pieces of wood, five glass rods, five pieces of brass, five pieces of thick copper wire, worksheets on: a. Components of electric circuit. b. A switch and a fuse in a circuit. c. Conductors and non-conductors of electricity d. Short circuits. INTRODUCTION • Review students' RPK by asking the following questions. Q1. Name the two cables that bring electricity from the main lines into your house.	Misconceptions: • Current is consumed by circuit components e.g. bulbs (Brain, 1988). • Current comes out from both poles of the dry cell and clashes in the bulb to light it (Brain, 1988). • Current comes from the positive pole of cell and enter the bulb where it is consumed to light the bulb which is not affected by the second wire connected between the negative pole and itself Brain, 1988). • Copper wire is the only conductor of electricity (Brain, 1988). • One copper wire between a bulb and a cell is all that is needed to light a bulb (Karrqvist, 1985) • Electric current is the flow of energy (Brain, 1988).	

Day/Date/ Duration	Topic / Subtopic	RPK / Objectives	TLMs / Teaching-Learning Activities	Misconceptions/ Core Points / Application	Evaluation / Exercise / Remarks
		into their houses. OBJECTIVES By the end of the lesson the student will be able to: 1. make predictions on the given misconceptions on electricity.	Expected answer: Live and Neutral wires. Q2. How many electric cables form a complete path of electricity? Expected answer: Two • Organize students into 5 groups. Select group leaders and distribute the TLMs through the group leaders. Activity 1. Prediction. In groups, let students make their predictions on the misconceptions that have been outlined above. Let them explain their predictions among themselves.		
		2. Determine the components of an electric circuit.	Activity 2. Parts of a circuit a. In groups, let students read the procedures for the activity and also study the circuit diagram on the worksheet entitled: components of and electric circuit. b. With the use of the circuit diagram and an improvised electric circuit boards guide students to construct a simple electric circuit. c. Let them close the switch and observe what happens. d. Let students discuss these questions among themselves. i. Name the parts of the electric circuit you have constructed.	2. The three main components of an electric circuit are: - A source which provide the electric energy (voltage) -A conducting path along which the current can flow (conductor). -A component in which the electrical energy is converted into another form of energy (load/) • An electric circuit is the complete path taken by an electric current. • A closed circuit is one in which there is an unbroken conducting path around which electric current flows continuously. • An open circuit is one in which there is no	2. How will you determine the components of an electric circuit?

Day/Date/ Duration	Topic / Subtopic	RPK / Objectives	TLMs / Teaching-Learning Activities	Misconceptions/ Core Points / Application	Evaluation / Exercise / Remarks
			ii. What is an electric circuit? iii. What are the 3 main components of an electric circuit? iv. Which of the 3 components of an electric circuit serve as the main source of energy?	current anywhere in the circuit.	
		3. Demonstrate at least one function each of a switch and a fuse in an electric circuit.	Activity 3. Fuse and Switch a. In groups, let students read the procedures and then study the circuit diagram on the work sheet: the use of a switch and a fuse in an electric circuit. b. With the use of the electric circuit that had been constructed in Activity 2, let students open and close the switch and observe what happens? c. With use of a closed circuit, let students cut and open any one of the aluminum strips as conductors and observe what happens. Next, let them close the gap with a single thin flexible wire. Let them observe the bulb. d. Let students discuss the questions below among themselves. i. What is a switch? ii. What is the function of a switch? iii. Explain the following concepts: closed circuit and open circuit. v. What scientific name is given to the thin flexible which helped to close the circuit?	A switch - 3. A switch is a device which helps to complete and break the circuit conveniently. - In an electric circuit all switches and fuses are placed in the live wire. A fuse: - A fuse is a short thin piece of copper wire with fairly low melting point, which becomes hot and melts when the current through it exceeds a safe value. - A fuse wire should be weaker than the rest of the circuit. - If a fuse is too strong it will not melt when there is short circuit. If the fuse is too weak it might melt even without a short circuit.	3. You have been given an improvised electric circuit board, two dry cells, a piece of flexible wire, a bulb and aluminum strips. Demonstrate the functions of switch and a fuse in an electric circuit.

Day/Date/ Duration	Topic / Subtopic	RPK / Objectives	TLMs / Teaching-Learning Activities	Misconceptions/ Core Points / Application	Evaluation / Exercise / Remarks
			vi. What do you think will happen to the thin flexible wire in the circuit when it becomes too hot? vii. What is the function of a fuse? viii. Do you think any ordinary thick wire can be used as a fuse? Give your reason.		
		4. Outline two factors that will cause a fuse to melt.	Activity 4. Melting of fuse Discuss the factors that can cause a fuse to melt with students.	4. Factors that cause fuses to blow are: - A fuse may melt because the wire is very old and has become weakened by oxidation. - A fuse can melt from the heat in an over loaded cable of the circuit. - Frequently, a fuse may melt through a short circuit which causes the fuse to become too hot.	4. Outline two factors that may cause a fuse to melt.
		5. Outline two ways of replacing a melted fuse.	Activity 5. Replacing melted fuse Discuss with students the various ways by which a melted fuse can be replaced.	5. Replacing melted fuse wire: - A new fuse wire which is chosen to replace the melted one should have the correct current capacity. The fuse wire must not be over-tightened so as to stretch and weaken it. - Avoid using pieces of any kind of wire or paper clip to replace melted fuse wire. This can cause serious electrical troubles. • Rating a fuse. $\text{Current (I)} = \frac{\text{Power (P)}}{\text{Voltage (V)}}$ • Fuses are fitted in plugs to protect the	5. Outline two ways by which a melted fuse can be replaced.

Day/Date/ Duration	Topic / Subtopic	RPK / Objectives	TLMs / Teaching-Learning Activities	Misconceptions/ Core Points / Application	Evaluation / Exercise / Remarks
				appliances.	
		6. Determine five conductors and non-conductors each of electricity.	Activity 6. Conductors and Non-conductors a. With the use of the improvised electric circuit boards, let students construct a complete closed electric circuit. b. Let students open the switch on the circuit board which is made up of two pieces of aluminum strips. c. Let students close the switch with each of these materials: a piece of copper wire, office pin, piece of paper, pen cover, carbon rod, piece of wood, a small nail, 5Gp coin, 10Gp coin, 20Gp coin, 50Gp coin and 100Gp coin, stone, bone, cotton wool, cloth, glass, candle and silk, a piece of brass. d. Let them observe what happens to the bulb (in terms of brightness) when different materials are used to close the switch and then group the materials as conductors and non-conductors of electricity. e. Let students discuss the following questions among themselves. i) What are conductors and non-conductors of electricity? ii) Give three examples each of conductors and non-conductors of electricity. iii) Mention one importance each	6. Conductors are substances which allow electric charges to flow through them. • A conductor is a material which contains movable electric charges. • Examples of good conductors of electricity are: copper, silver, aluminum, carbon. • In metallic conductors such as copper or aluminum, the movable charged particles are electrons. They alone can carry electric current. • All metals are good conductors of electricity allowing large current through them • Electricity travels more easily through thick wires than through thin wires. Some materials conduct electricity but rather less well than metals. These include graphite and some special metal alloys e.g. constantan and manganin. • Non-conductors: - Non conductors (insulators) are substance which does not allow electric charges to flow through them. - In non-conductors the electrons cannot move about. - Examples of non-conductors: Nylon, plastics, wood, glass, cloth, wool, bone, silk, hair, paper, candle wax.	6. How will you determine five conductors and five non-conductors of electricity through experiments?

Day/Date/ Duration	Topic / Subtopic	RPK / Objectives	TLMs / Teaching-Learning Activities	Misconceptions/ Core Points / Application	Evaluation / Exercise / Remarks
			iv) of conductors and non-conductors of electricity. v) Using your knowledge on conductors and non-conductors of electricity mention two things that you must do about electricity and two that you must not do.		
		7. Outline one importance each of conductors and non-conductors	Activity7. Importance of conductors and non-conductors Discuss with students the importance of conductors and non-conductors of electricity.	7. Importance of conductors / Non-conductors - Conductors are used in making electric wires. - Proper design of an electrical conductor takes into account the temperature that the conductor needs to be able to endure without damage, as well as the value of electric current. - Electrical connecting wires are covered with non-conductors (insulators) to prevent the current from taking a short cut (short circuit) when two bare wires accidently touch together. It also prevents electric shocks from touching live wires.	7. Outline one importance each of conductors and non-conductors of electricity.
		8. Demonstrate to show a short circuit and its effect.	Activity 8. Short circuits a. In group, let students read the worksheet on short circuit and then study the circuit diagram. b. With the use of a closed electric circuit of the improvised electric circuit board, let students use a	8. Short circuits A short circuit is a low resistance connection established by accident or intention between two points in an electric circuit at different voltages. - The current tends to flow through the area of low resistance, by passing the rest of the	8. You have been given the Following materials: an improvised electric circuit board, a bulb,

Day/Date/ Duration	Topic / Subtopic	RPK / Objectives	TLMs / Teaching-Learning Activities	Misconceptions/ Core Points / Application	Evaluation / Exercise /
			thick insulated copper wire to join any part of the negative and positive sides of the circuit an observe what happen to the bulb. c. Let students repeat the activity with bare copper wire. Let them touch the wire and discuss their feelings. d. Let students discuss the questions below among themselves. i. What is meant by the concept short circuit of electricity? ii. Mention one problem that can arise through short circuit of electricity. iii. What is electric current? iv. What is electricity?	circuit. - When the resistance drops, the electric current in the circuit becomes very high and can cause damage to the circuit and start fires. A common type of short circuit occurs when the positive and negative terminals of a battery are connected together with a low resistance conductor, like a wire. - A short circuit acts as a by pass for electric current by providing an easier or shorter path for the current to flow round.	two dry cells, aluminium strips and a thick piece of copper wire. Demonstrate to show a short circuit and its effect in an electric circuit.
		9. Discuss the simple concepts about electricity.	Activity 9. General discussion Take the class through a general class discussion of the activities that they had carried out namely: a. Components of electric circuits. b. Demonstrations on functions of switch and fuse. c. Determination of conductors and conductors. d. Short circuits.		
		10. Determine the relationship between electric	Activity 10. Relation between current and voltage Discuss with student the relationship	10. Electric current is the flow of electric charges through a substance. - To channel wandering electrons (charges) into	10. Distinguish between electric current

Day/Date/ Duration	**Topic / Subtopic**	**RPK / Objectives**	**TLMs / Teaching-Learning Activities**	**Misconceptions/ Core Points / Application**	**Evaluation / Exercise /**
		current and voltage	between electric and voltage.	a steady one way, a source of energy is required. The energy is the voltage which can be supplied by a battery / generation	and voltage.
		11. Outline two do's and don'ts of electricity	Activity 11. Do's and don'ts of electricity Let students outline the do's and don'ts of electricity. Closure Summarize the lesson through oral questions and answers. Assignment Let students draw and label the circuit diagrams.	11. Do's and Don'ts of electricity: • Do fit the correct value fuse in 13A plug to suit the appliance. • Do replace fuse wire with the correct rating wire, never with ordinary wire or things like paper clips. • Do not replace a fuse until the fault in the circuit or appliances has been found and removed or repaired.	11. Outline two do's and 2 don'ts of electricity. Remarks

APPENDIX A 2.

LESSON PLAN 2. ELECTRIC CIRCUITS

Schools: KPCE Demonstration JHS
: Kibi State JHS
Class: JHS Two
Average age: 14 years
No. on roll: KPCE: 57; State JHS: 58

References

1. Ghana Education Service. (2007). *Teaching syllabus for integrated science: Junior high school*. Accra: GES. Page 36.
2. Abbot, A. F. (1987). *Ordinary level Physics* (4th edition). London: Macmillan Press. Page 411.

Day/ Date/ Duration	Topic / Subtopic	RPK / Objectives	TLMS/Teaching-learning Activities	Misconceptions/ Core Points / Application	Evaluation / Exercise / Remarks
Tuesday 4th Oct. 2011 70 min.	Topic: Electricit y Sub-Topic Electric circuits	R.P.K Students have learnt about components of a simple circuit.	TLMS: Five improvised electric circuit boards, 10 dry cells, aluminum strips, five (1.5V), flashlight bulbs, five ammeters and worksheets: 2a. Demonstrating the use of ammeter in a circuit. 2b. Determining the characteristic of series connection. 2c. Determining the characteristics of cells connected in parallel. 2d. Determining the characteristics of bulbs connected in parallel INTRODUCTION • Review' pupils' RPK by asking the following questions. Q1. Name the components of a simple electric circuit. Expected answer:	Misconceptions: • One wire between a bulb and a cell is enough to light the bulb (Karrqvist, 1985). • Current leaves from the positive terminal and negative current leaves from the negative terminal of the cell and they meet and produce energy in the bulb (Karrqvist, 1985). • Electric current flows in a given direction around a circuit, each device in the circuit uses up some of the current so that current weakens (Karrqvist, 1985). • Current travels around the circuit in one direction and the devices in the circuit share the current equally (Karrqvist, 1985). • The current supplied by the cells is always the same regardless of the circuit features (Karrqvist, 1985) • Electric current does flow through closed circuits (Karrqvist, 1985).	

Day/ Date/ Duration	Topic / Subtopic	RPK / Objectives	TLMS/Teaching-learning Activities	Misconceptions/ Core Points / Application	Evaluation / Exercise / Remarks
		OBJECTIVES By the end of the lesson the student will be able to:	- A source which provide the electric energy. - A conducting path along which the current can flow. - A component in which the electrical energy is converted to another form of energy. Q2. What is an electric circuit? Expected answer: An electric circuit is the complete path taken by an electric current. • Organize students into five groups. Select group leaders and distribute the TLMs through the group leaders. Predictions: Let pupils make their predictions on the misconceptions that have been outlined above. Let them discuss their reasons for making the predictions among themselves.		
		1. demonstrate how to use the ammeter to measure current in a circuit.	Activity 1. Use of Ammeter. a. In groups, lets students read the procedures for the activity and then study the circuit diagram on the worksheet entitled: Demonstrating the use of an ammeter in a circuit. b. With the use of the improvised electric circuit board guide students to connect an ammeter in series with the circuit. c. Let students close the switch and observe the ammeter carefully. d. Guide students to read the ammeter. e. Let students discuss the questions below	• 1. An ammeter is connected in series in the circuit. • An ammeter has a very low resistance so it introduces very little extra resistance into the circuit. • The positive end of an ammeter is connected to the positive end of the circuit. • An ammeter is used to measure the current through an electric circuit. The S.1 Unit for current is the ampere (A). • 1A is quite a large current for class experiments, so mA (milliamp) is often	1.You have been given an ammeter, two dry cell, a bulb and an improvised electric circuit board with aluminium strips. Demonstrate how an ammeter is

Day/ Date/ Duration	Topic / Subtopic	RPK / Objectives	TLMS/Teaching-learning Activities	Misconceptions/ Core Points / Application	Evaluation / Exercise / Remarks
			among themselves. i. What does an ammeter measure? ii. What is the S.I unit of measurement of electric current? iii. How is an ammeter connected in a circuit? iv. What scientific name is given to the type of ammeter that measures the electricity that we use in our homes?	used. 1mA = 0.001A or 1000mA = 1A	used to measure electric current in a circuit.
		2. Outline two characteristics of electric current.	Activity 2.Characteristics of electric current. Discuss the characteristics of electric current with students.	• 2. Current is the rate of flow of charge. • We say current through a component. • Current is not used up, what flows into a component must flow out.	2. Outline two characteristics of electric current.
		3. Determine two characteristics of series connection.	Activity 3. Series of Connection a. In groups, le students read the procedures for the activity and also study the circuit diagram on the worksheet: Determining the characteristics of series connection. b. With the use of the improvised electric circuit board let students connect two bulbs and two dry cells in series. Let them close the circuit and observe the brightness of each bulb. c. Let students remove one bulb from the holder when the circuit is complete and observe what happen. d. Let students discuss the questions below.	3. Current is the same through all components connected in series. • Bulbs connected in series are equally bright and have the same current through them. • When bulbs are connected in series, if any one bulb fails to light or becomes loose in its holder, the whole circuit is broken and all the bulbs go off. • Voltages add up for components connected in series.	3. How will you determine two characteristics of series connection?

Day/ Date/ Duration	Topic / Subtopic	RPK / Objectives	TLMS/Teaching-learning Activities	Misconceptions/ Core Points / Application	Evaluation / Exercise / Remarks
			among themselves i) What happened when a bulb was removed from the complete electric circuit? ii) Explain why the other bulb could not light even though the switch was closed. iii) If one cell has a voltage of 1.5V, what was the total voltage of the circuit? iv) Mention two characteristics of series connection of bulbs and dry cell. v) What electrical factor in the dry cell caused the bulb to light? vi) Distinguish between current and voltage.		
		4. Determine two characteristics of cells connected in parallel.	Activity 4: Cells in parallel a. Let students study the circuit diagram on the worksheet: Determining the characteristics of cells connected in parallel. b. With the use of the improvised electric circuit board and the circuit diagram, let students connect two dry cells in parallel with a bulb. c. Let them close the circuit and observe what happens. d. Let students remove one of the dry cells in the circuit and observe what happens to the bulb. e. Let students discuss these questions among themselves:	• 4. Less current flow in a parallel circuit. • Voltage is the same across all components connected in parallel. • When cells of equal voltage (electromotive force) are connected in parallel, the resultant voltage is the same as that of one cell only. • Cells should never be left connected in parallel when not in use because if the voltage of one is slightly greater than the other, current will circulate in that cells and the cells will become exhausted.	4. How will you determine two characteristics of cells connected in parallel?

Day/ Date/ Duration	Topic / Subtopic	RPK / Objectives	TLMS/Teaching-learning Activities	Misconceptions/ Core Points / Application	Evaluation / Exercise / Remarks
			i) What is the voltage through the circuit? ii) Explain why the bulb continued to light when one of the two dry cells was removed from the circuit. iii) Mention two characteristics of parallel connection of cells. iv) Mention one importance of parallel connection of cells.		
		5. Determine two characteristics of bulbs connected in parallel.	Activity 5: Two bulbs in parallel a. In groups, let students study the procedure and circuit diagram of the worksheet: Determining the characteristics of bulbs connected in parallel. b. With the use of the circuit diagram and the improvised electric circuit board, let students connect two bulbs in parallel with a dry cell. c. Let students close the circuit and observe what happens to the bulbs. d. Let students remove one of the bulbs from the circuit and observe what happens to the other bulb. e. Let students discuss these questions among themselves. i) What do you think will happen in a parallel connection of two bulbs when one bulb fails to light or is removed from a closed circuit?	• 5. When bulbs are connected in parallel, if one bulb fails to light, it does not affect the other bulbs. • In a parallel connection of bulbs, the current in a circuit divides up and only part of it flows in each bulbs (resistor/ load).	5. How will you determine two characteristics of two bulbs connected in parallel?

Day/ Date/ Duration	Topic / Subtopic	RPK / Objectives	TLMS/Teaching-learning Activities	Misconceptions/ Core Points / Application	Evaluation / Exercise / Remarks
			ii) Mention two advantages of parallel circuit over series circuit. iii) Mention two disadvantages of parallel connection over series connection.		
		6. Discuss concepts about series and parallel connections.	Activity 6: General class discussion Take the class through a general class discussion of the activities that they had carried out namely: a. Demonstrating the use of an ammeter in a circuit. b. Determining the characteristics of series connection c. Determining the characteristics of sells in parallel. d. Determining the characteristics of bulbs connected in parallel.		
		7. Distinguish between current and voltage.	Activity 7. Distinction between current and voltage Guide students through questions to distinguish between current and voltage.	7. Voltage is a measure of the energy carried by the charge. It is the energy per unit charge whereas Current is the rate of flow of charge.	7. Distinguish between current and voltage.
		8. Outline two advantages and disadvantages each of parallel connection.	8. Let students outline the advantages and disadvantages of parallel connection.	8. Advantages of parallel circuits: • The cells last longer. • A fault in one bulb does not affect another. • A fault in one cell does not put off the light (bulbs). Disadvantage of parallel circuit. • The bulbs are not bright. • Less voltage is produced.	8. Outline two advantages and disadvantages each of parallel connection of electricity.

Day/ Date/ Duration	Topic / Subtopic	RPK / Objectives	TLMS/Teaching-learning Activities	Misconceptions/ Core Points / Application	Evaluation / Exercise / Remarks
		9. Outline one importance of parallel connection.	Activity 9 Let students outline the everyday uses of parallel connection. Closure Summarize the lesson through oral questions and answers. Assignment Let students draw the 4 electric circuit diagrams into their exercise books.	9. Application At home we connect all the light and electrical equipment in parallel so that they can be switched on and off separately.	9. Outline the importance of parallel connection. Remarks

APPENDIX A 3.

LESSON PLAN 3. **VOLTAGE AND RESISTANCE**

Schools: KPCE Demonstration JHS
: Kibi State JHS
Class: JHS 2
Average age: 14 years
No. on roll: KPCE: 57; State JHS: 58

References

1. Ghana Education Service. (2007). *Teaching syllabus for integrated science: Junior high school.* Accra: GES. Page 35.
2. Abbot, A. F. (1987). *Ordinary Level Physics* (4th edition). London: Macmillan Press. Page 406.

Day/ Date/ Duration	Topic / Subtopic	RPK / Objectives	TLMS/Teaching-learning Activities	Misconceptions/ Core Points / Application	Evaluation / Exercise / Remarks
Tuesday 4th Oct. 2011 70 min.	Topic: Electricity Sub-Topic Voltage and Resistance	 R.P.K Students have learnt about conductors and non-conductors of electricity.	TLMS: Five improvised electric circuit boards, 10 dry cells, aluminium strips, five voltmeter, five (1.5)v, flashlight bulbs, 10 pieces of copper wire, five improvised jockeys, five pieces of resistance wire, worksheets on: a. Demonstrating the use of a voltmeter in a circuit. b. Determining the effects of resistance in an electric circuit. INTRODUCTION Review students' RPK by asking the following questions. Q1. What is a conductor of electricity? Expected answer: A conductor is any substance which allows electric	Misconceptions: • Charges slow down as they pass through a thin piece of wire (Brain, 1988). • High resistance bulbs are brighter than low resistance ones (Brain, 1988). • A conductor has no resistance (Brain, 1988). • Current is the same thing as voltage (Brain, 1988). • Resistors consume charge (Brain, 1988). • No current no resistance (Brain, 1988).	

Day/ Date/ Duration	Topic / Subtopic	RPK / Objectives	TLMS/Teaching-learning Activities	Misconceptions/ Core Points / Application	Evaluation / Exercise / Remarks
		OBJECTIVES By the end of the lesson the student will be able to: 1. make predictions on the given misconceptions on electricity. 2. demonstrate the use of a voltmeter in a circuit.	charge to flow through it. Q2. Name two good conductors of electricity. Expected answer: Good conductors of electricity: silver, copper, aluminium. Activity 1. Prediction In groups, let students make predictions on the misconceptions that have been outlined above. Let them explain their predictions among themselves. Activity 2. Use of a voltmeter. a. In groups, let students study the procedure and circuit diagram on the worksheet: Demonstrating the use of a voltmeter in an electric circuit. b. With the use of the improvised electric circuit board and the circuit diagram let students connect the voltmeter in parallel with the bulb. c. Let students close the switch and read the voltmeter. Let students discuss the following questions among themselves. a. What is a voltmeter?	• 2. A voltmeter is placed in parallel with the voltage of the resistor to be measured.	2. You have been given an improvised electric circuit board, a bulb, aluminium strips, two dry cells and a voltmeter. Demonstrate to show how a voltmeter is used to measure voltage across a resistor (appliance)

Day/ Date/ Duration	Topic / Subtopic	RPK / Objectives	TLMS/Teaching-learning Activities	Misconceptions/ Core Points / Application	Evaluation / Exercise / Remarks
			b. How is a voltmeter connected in an electric circuit? c. What is the unit of measurement of voltage? d. Name the instrument that is used to measure electric current in a circuit.		
		3. Outline two characteristics of a voltmeter	Activity 3. Characteristics of voltmeter Discuss the characteristics of voltmeters with students.	• 3. A voltmeter has a high resistance and the current they take is usually negligible. • A voltmeter is an instrument which is used to measure the potential difference (voltage) between the ends of a resistor. • Potential difference (voltage) is measured in volts (V). • 1mV = 0.001 V or 1000mV = IV. • A voltmeter measures the electrical push (force) driving the current around a circuit.	3. Outline two characteristics of a voltmeter.
		4. Determine two effect of resistance in an electric circuit.	Activity 4: Resistance. a. In groups, let students study the procedures and circuit diagram on the worksheet: Determining the effects of resistance in an electric circuit. b. With use of the improvised electric circuit board and the circuit diagram, let students connect the resistance wire and the jockey to the circuit board form a complete circuit with an	• 4. In terms of current electricity, the resistance of a substance is the ability to resist the flow of electricity through it. - A good conductor has a low resistance and a poor conductor has a high resistance.	4. How will you determine two effects of resistance in an electric circuit?

Day/ Date/ Duration	Topic / Subtopic	RPK / Objectives	TLMS/Teaching-learning Activities	Misconceptions/ Core Points / Application	Evaluation / Exercise / Remarks
			improvised variable resistor. c. Let students place the improvised jockey at the junction of the aluminum strip and the resistance wire and close the circuit. Let them observe the brightness of the bulb and describe it as "very bright". d. Let students place the jockey at the extreme end of the resistance wire and observe the brightness of the bulb. Let them describe it as "very dim". e. Let students place the jockey at point which is 5cm from the junction of the aluminium strip of the circuit and the resistance wire. Let students observe the brightness of the bulb and record their observations. f. Let students repeat the activity 3 times with an increasing distance of 5 cm on the resistance wire towards the extreme end. g. Let them observe the brightness of the length of the resistance wire and the degree of brightness of the bulb. h. Let students discuss the following questions among themselves. Q1. What effect did the length of the		

Day/ Date/ Duration	Topic / Subtopic	RPK / Objectives	TLMS/Teaching-learning Activities	Misconceptions/ Core Points / Application	Evaluation / Exercise / Remarks
			resistance wire have on the brightness of the bulb? Q2. What are the three factors in the circuit which were affecting the brightness of the bulb? Q3. The resistance of a wire depends on its dimensions and the materials from which it is made. (True / False). Q4. A poor conductor of electricity has a high resistance and a good conductor has a low resistance (True/False) Q5. The resistance of a wire is proportional to its length. (True / False). Q6. What is the relationship among resistance, current and voltage?		
		5. Outline two factors that affect resistance of a wire.	5. Discuss with students the factors that affect the resistance of a wire at constant temperature.	• 5. The resistance of a wire depends on its dimensions namely the length and cross sectional area, and the materials from which it is made. • When resistors are being made, short lengths of thick wires are used for the low resistance, and long lengths of thin wire for the high resistance. • For a wire of given dimensions, silver offers least resistance to the current followed next by copper. • The resistance of a conductor is the ratio of the potential difference (voltage) across it to the	5. Outline two factors that affect resistance of a wire.

Day/ Date/ Duration	Topic / Subtopic	RPK / Objectives	TLMS/Teaching-learning Activities	Misconceptions/ Core Points / Application	Evaluation / Exercise / Remarks
				current flowing through it. Resistance = $\frac{\text{voltage}}{\text{Current.}}$ • For a given potential difference a high resistance will pass a small current and a low resistance a large current. • The S.1 unit of resistance is the ohm. • The resistance of a conductor is measured by the use of a rheostat. • Gold, silver and copper have low resistance, which means that current can flow easily through these materials. Glass, plastics and wood have very high resistance which means that current cannot pass through these materials easily.	
		6. Discuss their findings in the 2 activities.	Activity 6. Take the class through a general class discussion of the activities that they had carried out namely: a. Demonstrating the use of a voltmeter in a circuit. b. Determining the effects of resistance in an electric circuit.		
		7. Explain the concept of voltage.	Activity 7. Concept of voltage Discuss the concept of voltage with students by means of analogy.	7. Voltage: • Voltage is a measure of the energy carried by electric charge. It is the energy per unit charge. • The proper name of voltage is potential difference.	7. Explain the concept of the voltage.

Day/ Date/ Duration	Topic / Subtopic	RPK / Objectives	TLMS/Teaching-learning Activities	Misconceptions/ Core Points / Application	Evaluation / Exercise / Remarks
				• Voltage is a potential difference between two points in a circuit. • The voltage or the potential difference between the ends of a conductor is equal to the energy converted from electrical to other forms per unit electric charge flowing through it.	
		8. Explain the concept of current.	Activity 8. Explanation of current. Discuss the concept of electric current with students.	8. Current. Current is the rate of flow of electric charge. Current is not used up, what flows into a component must flow out.	8. Explain the concept of current.
		9. Outline two do's and don'ts each of electricity.	Activity 9. Do's and don'ts of electricity. Let students outline the do's and don'ts of electricity.	9. Do's and Don'ts of Electricity. • Do switch off and disconnect appliances when not in use. • Do not overload a circuit and sockets with too many appliance plugged into multiway adaptors. • Do not leave long cables trailing across a room.	9. Outline two do's and two don'ts of electricity.
		10. Outline two importance of resistance in a circuit.	Activity 10. Importance of resistance Let students outline the importance of resistance in a circuit Closure Summarize the lesson through oral questions and answers. Let students write the chalkboard summary into their notebooks.	Application. 10. Importance of a resistance. • It is resistance that allows us to use electricity for heat and light. • Resistances are sometimes added into an electrical circuit to restrict the flow of electricity and protect the components in the circuit. • Resistance helps to shield ourselves from the harmful energy of electricity.	10. Outline two importance of resistance in a circuit.

Day/ Date/ Duration	Topic / Subtopic	RPK / Objectives	TLMS/Teaching-learning Activities	Misconceptions/ Core Points / Application	Evaluation / Exercise / Remarks
			Assignment Let students answer the evaluation questions on voltage, current and resistance.		Remarks

APPENDIX B 1

WORKSHEET ON LESSON 1. ELECTRIC CURRENT AND CONDUCTORS

Activity 1 A. Components of an Electric Circuit.

Materials. Improvised electric circuit board, two dry cells, torchlight bulb (1.5V), aluminum strips (conductors), a bulb holder.

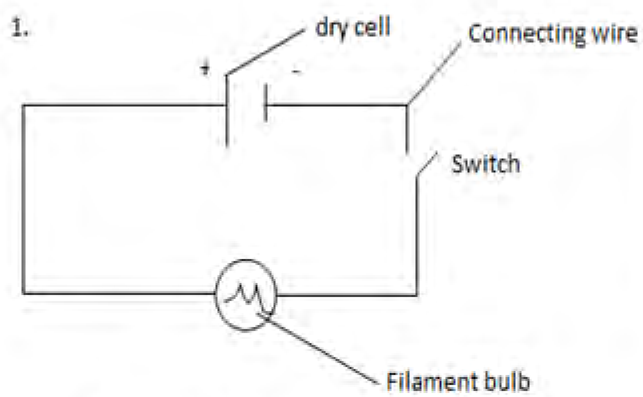


Fig. 1. Circuit diagram.

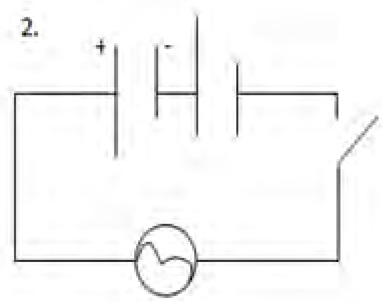


Fig. 2 A simple electric circuit.

Procedure.

1. Study the electrical circuit diagrams above and make similar connections using your improvised electric circuit board.

Questions.

a) Name the parts of the electric circuit you have constructed.

b) What is an electrical circuit?

c) What are the three main components of an electric circuit?

d) Which of the components serve as the main source of energy?

Activity 1B. The Use of a Switch and a Fuse in an Electric Circuit.

Procedure.

1. Using the electrical circuit you have constructed on the improvised electric circuit board, open and close the switch. Observe the bulb and discuss your observation.

2. Use a single thin flexible wire to close the switch on your electric circuit board. Observe what happens to the bulb and discuss your observations.

Questions.

a. What is a switch?

b. Explain the following terms: i) Closed circuit ii) open circuit

c. What name is given to the thin wire in the circuit that closed the switch?

d. What do you think will happen to the flexible wire when it becomes too hot?

e. State one function of a fuse.

f. Do you think any ordinary wire can be used as a fuse? Give your reasons.

Activity 1 C. Determination of Conductors and Non-conductors of Electricity.

Materials. Small nails, 10Gp coin, 100Gp coin, 20Gp coin, 5Gp coin, office pins, pen covers, pieces of paper, carbon rods.

Procedure.

1. Construct a simple circuit using the improvised electric circuit board.
2. Switch the circuit on and off and observe the bulb.
3. Open the switch of the electric circuit board and use each of the above listed substances to close the switch. Observe what happens to the bulb as you close the switch.
4. Group the given substances in terms of their ability to light the bulb or not.

Questions.

a. What are conductors and non-conductors of electricity?

b. Give three examples each of conductors and three of non-conductors of electricity.

c. Mention one importance each of conductors and non-conductors of electricity.

d. Mention two things in relation to electricity that you must do and two things that you must not do when working with electricity.

Activity 1D. Short Circuit

Materials. Improvised electric circuit board, a thick piece of copper wire or aluminum strips.

Procedure.

1. Connect your improvised electric circuit board to light the bulb.
2. Use a thick piece of copper wire or aluminum strip to connect the right hand side of the circuit to the left hand side of the circuit. Observe what happens to the bulb and discuss your observation.

Questions.

a. What is meant by the concept of short circuit of electricity?

b. State one problem that can arise through short circuit of electricity.

c. What is electric current?

APPENDIX B 2

WORK SHEET ON LESSON 2. ELECTRIC CIRCUITS

Activity 2A. **The Use of Ammeters**

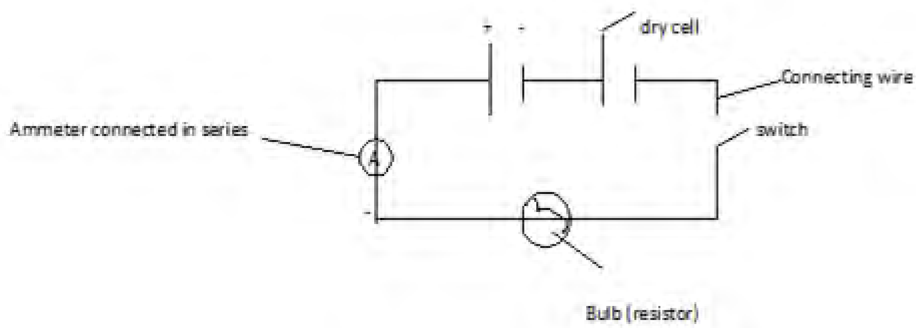


Figure 1. A Diagram of an Ammeter Connected in Series in a Circuit.

Procedure.

1. Study the circuit diagram above.
2. With the use of your improvised electric circuit board, connect the ammeter in series in the circuit.
3. Close the circuit and read the ammeter.

Questions.

a. What does an ammeter measure?

b. What is the unit of measurement of electric current?

c. How is an ammeter connected in a circuit?

Activity 2B. Characteristics of Series Connection

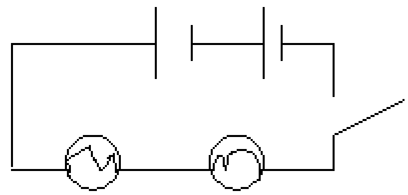


Figure 1. A Circuit Diagram Showing Cells in Series, Bulbs in Series.

Procedure.

1. Study the circuit diagram showing cells and bulbs in series.
2. With the use of the improvised electric circuit board connect two bulbs and two cells in series.
3. Close the circuit and observe the brightness of each of the bulb.

   Discuss your observation.

4. Remove one of the bulbs from the holders and discuss you observation.

Questions.

a. What happened when a bulb was removed from the complete electric circuit?

b. Explain why the other bulb could not light even though the switch for the circuit was closed?

c. If one cell has a voltage of 1.5V, what was the total voltage of the circuit?

d. What is the total voltage across the cells?

e. What factor in the dry cell caused the bulb to light?

f. Distinguish between current and voltage.

g. Mention two characteristics of series connection of cells and two of bulbs.

Activity 2C. Characteristics of Parallel Connection

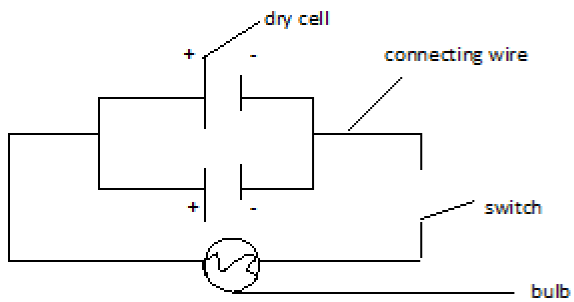


Figure 1. A Diagram Showing Cells Connected in Parallel.

Procedure.

1. Study the circuit diagram of two cells connected in parallel.
2. With the use of the improvised electric circuit board and the circuit diagram connect two cells in parallel with a bulb. Close the circuit and discuss your observation.
3. Remove one of the dry cells in the circuit and observe what happens to the bulb. Discuss your observation.

Questions.

a. What is the voltage through the circuit?

b. Explain why the bulb continued to light when one of the dry cells was removed?

c. Mention two characteristics of parallel connection of cells.

d. Mention one importance of parallel connection of cells.

Activity 2D. Characteristics of Bulbs Connected in Parallel

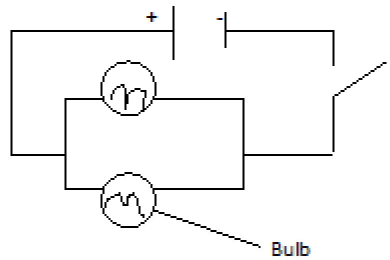


Figure 2. A Circuit Diagram Showing Two Bulbs Connected in Parallels.

Procedure

1. Study the electric circuit diagram of bulbs connected in parallel with a dry cell.
2. With the use of the electric circuit board connect 2 bulbs in parallel with a dry cell and close the circuit. Discuss your observation.
3. Remove one of the bulbs from the circuit and discuss your observation.

Questions.

a. What do you think will happen in a parallel connection of 2 bulbs when one bulb fails to light or is removed?

b. State 2 advantages of parallel circuit over series circuits.

c. State 2 disadvantages of parallel connection over series connection.

APPENDIX B 3

WORK SHEET ON LESSON 3. VOLTAGE AND RESISTANCE

Activity 3 A. Connecting and Reading of Voltmeters.

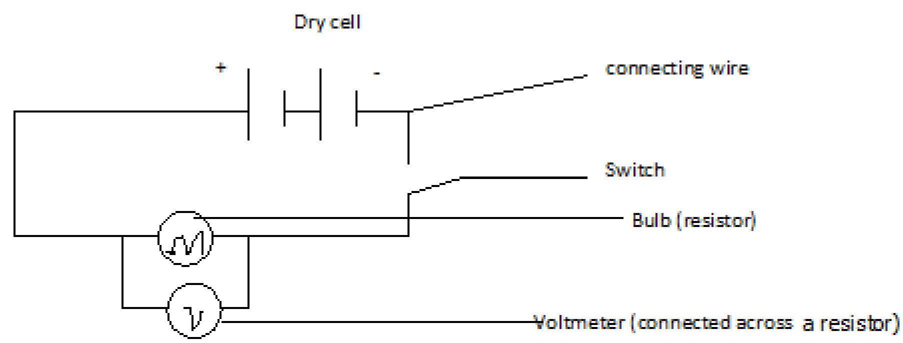


Figure1. A Diagram Showing a Voltmeter Connected in Parallel in a Circuit.

Procedure.

1. Study the electric diagram above.
2. With the use of your electric circuit board construct the circuit to light the bulb.
3. Connect the voltmeter across (in parallel) with the bulb / resistor.
4. Read the voltmeter and record your findings.

Questions.

a. What is a voltmeter?

b. How is a voltmeter connected in an electric circuit?

c. What is the unit of measurement of voltage?

d. Name the instrument that is used to measure electric current in a circuit.

Activity 3B. To Study the Effects of Resistance in an Electric Circuit.

Materials. Improvise electric circuit board, two dry cells, two pieces of copper wire (each about 30cm long) an improvised jockey made from a copper wire fixed to a strip of aluminum plate, resistance wire of length 20cm (from the element of an electric store),a metre rule, 1.5V torchlight bulb.

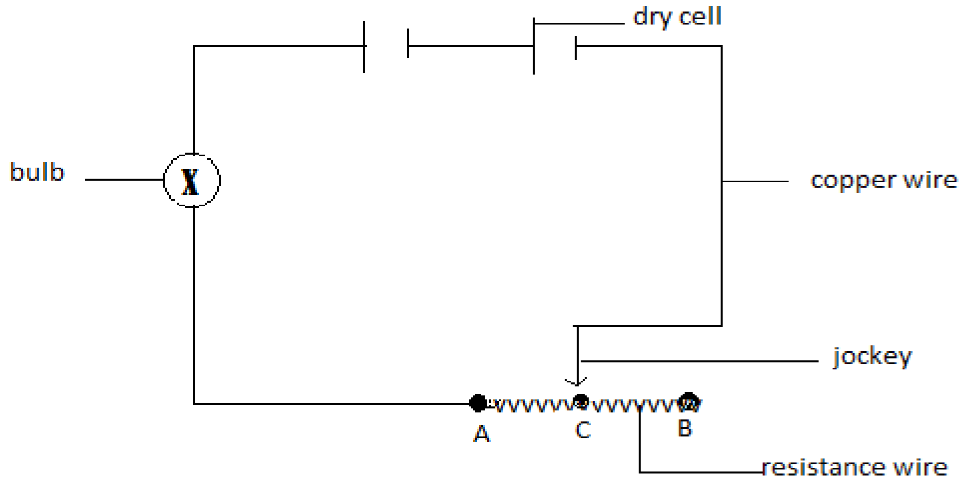


Figure 1. Circuit Diagram on Resistance

Procedure.

1. Connect the two dry cells, a bulb, resistance wire, a jockey and copper wires (aluminum strips) as shown in the diagram above.
2. Place the jockey at point A. Observe the brightness of the bulb. Describe it as very bright.
3. Place the jockey at point B. Observe the brightness of the bulb. Describe it as very dim.
4. Now place the jockey at point C, a distance of 5cm from point A. observe the brightness of the bulb. Make your judgment of how bright it is.

5. Repeat the experiment two times more, each time increasing the distance of C from A by the same amount.
6. Record your observations in the table below.

Length of resistance wire (cm)	Degree of brightness of the bulb
0	Very bright
5	
10	
15	
20	Very dim

Questions

1. What effect did the length of the resistance wire have on the brightness of the bulb?
2. What are the three factors that were affecting the brightness of the bulb?

- Point to note: the resistance of a wire depends on its dimensions and the materials from which it is made. A good conductor has a low resistance and a poor conductor has a high resistance. The resistance of a wire is proportional to its length.
- Short lengths of thick wires give low resistance; long lengths of thin wire give high resistance.
- The resistance of a conductor is the ratio of the potential difference (voltage) across it to the current flowing through it.

$$\text{Resistance} = \frac{\text{voltage}}{\text{current}}$$

APPENDIX B 4.

METHODOLOGY OF THE LESSONS

The researcher used the 5Es model of lesson presentation to teach the three lessons of the study. The activities for the various stages of each lesson have been described in relation to the 5Es model.

Introduction. Review of pupils' previous knowledge through oral questions.

Engagement phase: This was the first teacher-learner activity. The researcher assessed the learners' prior knowledge and helped them become engaged in the new concepts to be learnt through the use of short activities that promoted curiosity and elicited prior knowledge. The activities were to make connections between past and present learning experiences, expose prior conceptions, and organize pupils' thinking toward the learning outcomes of current activities. The pupils were helped to make their prediction and hypothesis on five given misconceptions on concepts of electricity.

Exploration phase. This was the second activity. The exploration experiences provided the pupils with a common base of activities. The pupils carried out hands- on activities on basic concepts of electricity, guided by worksheets with circuit diagrams and series of questions. (Appendices B1, B2 & B3). There were group activities and discussions that led to knowledge construction and understanding of concepts about electricity. The practical activities helped the pupils use their prior knowledge to generate new ideas, explored questions and possibilities and designed and conducted a preliminary investigation.

Explanation phase. This was the phase for general class discussions on the activities that had been done and the development of core ideas on the concepts of electricity. The explanation phase focused the pupils' attention on particular aspects of their engagement and exploration experiences and provided them with opportunities to demonstrate their conceptual understanding and process skills on electricity. The phase also provided opportunities for the researcher to directly introduce the concepts and process skills to be studied. The learners explained their understanding of the basic concepts of electricity. An explanation from the researcher also guided the pupils toward a deeper understanding of the basic concepts of electricity, which was a critical part of that phase and to clarify misconceptions on basic concepts of electricity.

Elaboration phase. This phase was the application of the concepts learnt in real life situations. The researcher challenged and extended pupils' conceptual understanding and skills on basic electricity to help them develop deeper and broader understanding and acquired adequate skills and knowledge. The learners expanded on their knowledge, connected it to similar concepts and applied it to other situations.

Evaluation phase. This was the closure of the lesson which was made up of the summary of the lesson and assessment of the pupils through oral and written exercises. The evaluation phase encouraged pupils to assess their understanding and abilities and provided opportunities for the researcher to evaluate pupil progress toward achieving the instructional objectives. The pupils were assigned home work on the lesson.

During each lesson, the researcher acted as the facilitator and a co–learner. He motivated the pupils to work by giving praises and encouragement. The researcher moved round the groups to supervise and guide the pupils in their activities. The researcher asked pupils probing questions to help them generate new activities. The pupils were made to discuss their results among themselves. Each lesson ended with a general class discussion during which pupils' misconceptions on some concepts of electricity were made clear by use of conceptual change text. During the interventional stage the researcher took photographs to capture various situations in the activity based–lessons during the lesson presentations (Figure 1A-1E).

Figure 1A. A Photograph of a Group of Pupils Determining the Components of an Electric Circuit

Figure 1B. A Photograph of a Group of Pupils Determining a Short Circuit of Electricity

Figure 1C. A Photograph of a Group of Pupils Determining the Characteristics of Series Connection of Electricity

Figure 1D. A Photograph of a Group of Pupils Determining the Characteristics of Parallel Connection of Electricity

Figure 1E. A Photograph of a Group of Pupils Determining the Characteristics of a Resistor of Electricity

APPENDIX C 1

PRE-TEST QUESTIONS ON ELECTRICITY

Name:

School

Class.

Instructions

Answer all the questions. Select the right answer to each question.

1. Electric ……………….is the flow of electric charges
   a. Current b. resistance c. series d. circuit
2. An electric circuit consists of a source of energy, a load or resistance and a (an)……
   a. Electric circuits b. switch c. volt d. fuse
3. What is created when charges flow through a wire or another material?
   a. Short circuit b. static electricity c. electric current d. lightning
4. Fuses, circuit breakers, and ground prongs are all:
   a. Electric circuits b. parallel circuits c. short circuits d. safety mechanisms
5. Electric current does not flow through this type of electric circuit:
   a. Open circuit b. series circuit c. parallel circuit d. closed circuit
6. Fuses shut off electric current when the current gets too:
   a. Fast b. long c. hot d. short
7. In order to make electric charges move, you need a device that produces energy, such as a battery or a (an): a. Appliance b. cell c. outlet d. ground prong.

8. In a parallel circuit, different parts of the circuit are on:

   a. Third prong b. electric current c. fuses d. separate branches.

9. This is an unintended path that allows current to bypass the loads in a circuit:

   a. Long circuit b. series circuit c. short circuit d. parallel circuit

10. The greater the potential difference, the greater the:………

    a. Circuit breaker b. short circuit c. electric circuit d. voltage

11. What part of a plug protects against short circuits?

    a. Fuse b. neutral pin c. electric current d. static plug

12. A switch must be…………………..to create a complete circuit.

    a. Opened b. closed c. fixed d. short

13. The two main kinds of circuits are

    a. Short and long circuit's b. short and series circuits c. short and parallel circuits d. series and parallel circuits.

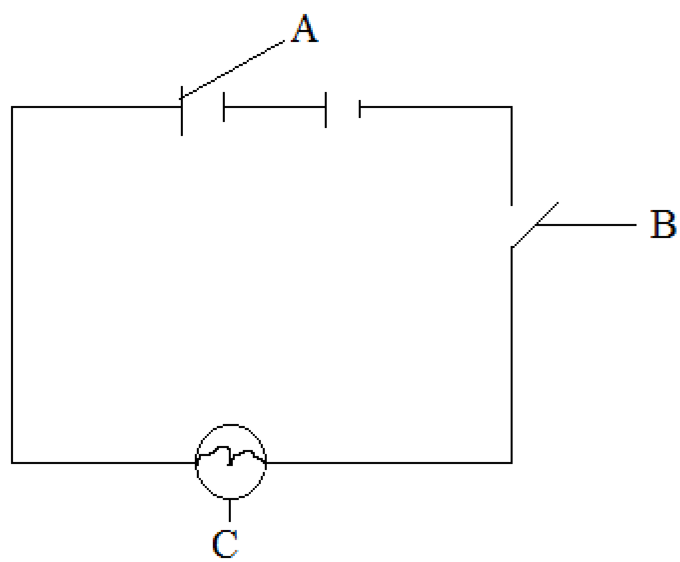
14. Conductors are materials through which no current can easily flow.

    a. True b. false c. no idea d. none

15. Insulators are materials that do not prevent or reduce the flow of electric current

    a. True b. false c. no idea d. none

Use the diagram of the figure below to answer questions 16 to 18.



16. The part of the circuit diagram labelled A.

a. Current b. dry cell c. switch d. open

17. The part of the circuit diagram labelled B.

a. Open b. switch c. dry cell d. resistor

18. The part of the circuit diagram labelled C.

a. Resistor b. closed c. current d. ammeter

Questions 19 and 20 are on do's and don'ts of electricity.

19. Do replace a fuse wire with any ordinary wire or things like paper clips and office pins that can conduct electricity. a. True b. False c. No idea d. None

20. If you have only one electric socket in your room you can over load the socket with too many appliances plugged into multiway adaptors.

a. True b. False c. No idea d. None

APPENDIX C2

ANSWERS TO THE PRE-TEST QUESTIONS

1 A. current

2 A. switch

3 C. electric current

4 D. safety mechanisms

5 A. open

6 C. hot

7 B. cell

8 D. separate branches

9 C. short circuit

10 D. voltage

11 A. fuse

12 B. closed

13 D. series and parallel circuits

14 B. false

15 B. false

16 B. dry cell

17 B. switch

18 A. resistor

19 B. false

20 B. false

APPENDIX D1

POST-TEST ON ELECTRICITY

Name:

School

Class.

Instructions

Answer all the questions. Select the right answer to each question.

1. What is created when charges flow through a wire or another material?

   a. Short circuit b. static electricity c. Electric current d. Lightning.

2. Electric current does not flow through this type of electric circuit.

   a. Open circuit b. series circuit c. Parallel circuit d. Closed circuit.

3. In order to make electric charges move, you need a device that produces energy, such a battery or a (an): a. Appliance b. cell c. outlet d. ground prong

4. This is an unintended path that allow current to bypass the loads in a circuit.

   a. long circuit b. series circuit c. short circuit d. parallel circuit

5. Fuses, circuit breakers and ground prongs are all: a. Electric circuits b. ground prong c. electric current d. Safety mechanisms.

6. Fuses shut off electric current when the current gets too: a. Fast b. long c. hot d. short

7. What part of a plug protects against short circuits?

   a. Fuse b. neutral pin e. electric current d. static plug.

8. In a parallel circuit, different parts of the circuit are on:

a. Third b. Electric current c. fuses d. separate branches.

9. The greater the potential difference, the greater the:

a. Circuit breaker b. short circuit c. electric circuit d. voltage

10. An electric circuit consists of a source of energy, a load or resistance and a (an)

a. Electric circuit b. switch c. volt d. fuse

11. An electric ………………………….is the flow of electric charges

a. Current b. resistance c. series d. circuit.

12. The two main kinds of circuits are:

a. Short and long circuits b. series and parallel circuits c. short and parallel circuits d. Short and series circuits

13. A switch must be …………………………….to create a complete circuit.

a. Opened b. closed c. fixed d. short

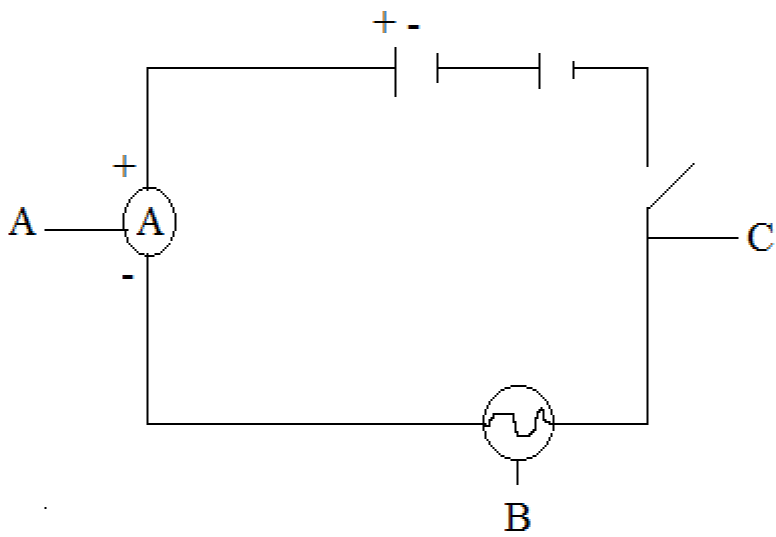
14. Conductors are materials through which no electric current can easily flow.

a. True b. False c. no idea d. none

15. Insulators are material that prevent or reduce the flow of electric current.

a. True b. false c. no idea d. none

Use the diagram below to answer questions 16 to 18.



16. The part of the circuit diagram labelled A:

a. Ammeter b. voltmeter c. dry cell d. amp

17. The part of the circuit diagram labeled B

a. Resistor /load b. switch c. connect wire d. fuse

18. The part of the circuit diagram labelled C:

a. Ammeter b. voltmeter c. connecting wire d. switch

Questions 19 and 20 are on do's and don'ts of electricity.

19. Do replace a fuse wire with any ordinary wire or things like paper clips and office pins that can conduct electricity.

a. True b. false c. no idea d. none

20. If you have only one electric socket in your room you can over load the socket with too many appliances plugged into multiway adaptors.

a. True b. false c. no idea d. none

APPENDIX D2

ANSWERS TO POST-TEST QUESTIONS

1. C. electric current
2. A. open
3. B. cell
4. C. short circuit
5. D. safety mechanisms
6. C. hot
7. B. fuse
8. D. separate branches
9. D. voltage
10. B. switch
11. A. current
12. B. series and parallel circuits
13. B. closed
14. B. false
15. A. true
16. A. ammeter
17. A. resistor
18. C. connecting wire
19. B. false
20. B. false

APPENDIX E

QUESTIONNAIRE FOR PUPILS

This study is to improve JHS two pupils' understanding of concepts of electricity. Please, you are requested to provide an input which will help the researcher undertake the study successfully. You are assured that your identity will be kept secret and there may not be any harmful effect of the study on you.

Instruction

Name

Sex

School

State whether you: agree with or disagree with or have no idea on each of the statements below on the topic Electricity.

1. Electric current is the flow of energy. (a. agree b. disagree c. no idea).
2. Current is consumed by the components of an electric circuit. (a. agree b. disagree c. no idea).
3. The current which is supplied by a battery (cell) is not always the same with regard to the circuit features. (a. agree b. disagree c. no idea).
4. Current comes out from both poles of the dry cell and do not clash in the bulb to light it. (a. agree b. disagree c. no idea)
5. It is possible to have voltage without current, but current cannot flow without voltage. (a. agree .b disagree c. no idea).
6. Voltage is supplied by a battery (cell). (a. agree b. disagree c. no idea)
7. Voltage is not used up in components of an electric circuit. (a. agree b. disagree

c. no idea).

8. Current is the same thing as voltage. (a. agree b. disagree c. no idea)

9. A conductor has no resistance. (a. agree b. disagree c. no idea).

10. A resistor consumes electric charge (current). (a. agree b. disagree c. no idea).

11. Resistance is a feature of a material that determines the flow of electric charge. (a. agree b. disagree c. no idea).

12. The resistance of a component of an electric circuit depends only on its own properties. (a. agree b. disagree c. no idea).

13. One copper wire between a bulb and a cell is all that is needed to light a bulb. (a. agree b. disagree b. no idea).

14. Electric current does not flow through closed electric circuits. (a. agree b. disagree c. no idea).

15. An electric circuit has to form a closed loop for current to flow. (a. agree b. disagree c. no idea)

16. The two main types of electric circuits are series and parallel connections. (a. agree b. disagree c. no idea).

17. All electric wires are insulated. (a. agree b. disagree c. no idea).

18. Copper wire is not the only conductor of electricity. (a. agree b. disagree c. no idea).

19 A non-conductor is a material which does not contains movable electric charges. (a. agree b. disagree c. no idea).

20. Electric current cannot pass through a material which is made of aluminum because it is a non- conductor of electricity. (a. agree b. disagree c. no idea).

APPENDIX F. QUESTIONNAIRE FOR SCIENCE TEACHERS

This questionnaire is part of a study of using conceptual change model of science instruction to improve JHS two pupils' understanding of electricity. Kindly provide truthful answers to the items below. Any information you give will be treated as confidential. Thank you.

Instruction

Please, tick your appropriate response to each of the items.

1.1 Name

1.2 Gender Male [ ] Female [ ]

1.3 School

1.4 Highest academic achievement.

1.5 Have you been trained as a science teacher? a. Yes b. No

1.6 Have you ever taught the topic electricity in JHS two before?

2.0 The teaching and learning materials which the researcher used for the 3 activity based lessons were appropriate for the lesson.

a. Strong agree b. Agree c. Disagree d. Strong disagree

3. During the lesson delivery, the students were guide to carry out all the activities in groups through effective use of the worksheet with questions for group discussions.

a. Strongly agree b. Agree c. Disagree d. Strongly disagree

4. The teacher-learning activities were relevant and suitable to the class and they helped the learners to explain concepts on electricity as well as develop process skills.

a. Strongly agree b. Agree c. Disagree d. Strongly disagree

5. The practical activities together with the general class discussion helped the students to address all their misconception about electricity, if they had some misconceptions.

a. Strongly agree b. Agree c. Disagree d. Strongly disagree

6. The model that was used in the teaching about electricity to JHS 2 students was very effective to enhance students' understanding and must be adopted by science teachers.

APPENDIX G

Determination of the Test Reliability Coefficient

Using the Cronbach Alpha formula given as

$$r = \frac{n\,(\sigma_t^2 - \sum\sigma_i^2)}{(n-1)\,(\sigma t^2)}$$

Where: r is the reliability coefficient

n is the number of test items

σ_i^2 is the variance of the test scores of the i-th item

σ_t^2 is the variance of the score of the entire test.

$s_1^2 = 8.72969697$

$s_2^2 = 5.032727273$

$s_3^2 = 7.256161616$

$s_4^2 = 6.146944444$

$s_5^2 = 1.01260101$

$\sum s_1^2 = 28.17813131$

$s_t^2 = 77.33304716$

$n = 5$

$$r = \frac{n\,(s_t^2 - \sum s_i^2)}{(n-1)\,s_t^2}$$

$$= \frac{5}{4} \times \frac{(77.33304716 - 28.17813131}{77.33304716}$$

$$= \frac{5}{4} \times \frac{49.15491585}{77.33304716}$$

$$= \frac{5}{4} \times 0.635626264$$

$= 0.\ 79453283$

$= 0.80$ (approx)

Interpretation of Reliability Coefficients

Reliability	**Interpretation**
0.95 and above	Excellent
0.90 – 0.94	Very Good
0.85 – 0. 89	Good
0.80 – 0.84	Useful
0.75 -0.79	Exercise Caution
0.65 – 0.69	Large amount of measurement error
0. 60 – 0.64	May be useful in obtaining group means
0. 59 and below	Consider other alternatives

Mc. Daniel (1994)