IDENTIFICATION AND CHARACTERIZATION OF STUDENTS’ MISCONCEPTIONS IN BASIC ELECTRICITY FOR GRADE 10 IN HETO SECONDARY SCHOOL

MSC THESIS

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NOVEMBER, 2017

ARBA MINCH ETHIOPIA
IDENTIFICATION AND CHARACTERIZATION OF STUDENTS’ MISCONCEPTIONS IN BASIC ELECTRICITY FOR GRADE 10 IN HETO SECONDARY SCHOOL

By

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A THESIS SUBMITTED TO THE DEPARTMENT OF PHYSICS, COLLEGE OF NATURAL SCIENCES, SCHOOL OF GRADUATE STUDIES ARBA MINCH A UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN PHYSICS,

NOVEMBER, 2017

ARBA MINCH ETHIOPIA
STUDENT’S DECLARATION

I hereby declare that this MSc thesis is my original work and has not been presented for a degree in any other university, and all sources of material used for this thesis have been duly acknowledged.

Name: _________________________________________

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ADVISORS’ DECLARATION

This is to certify that the thesis entitled “Identification and characterization of Students’ Misconceptions in Basic Electricity for Grade 10 in Heto Secondary School” submitted in partial fulfillment of the requirements for the degree of Master’s in physics, the Graduate Program of the School of graduate studies, Department of physics and has been carried out by Haile Ashamo, under my/our supervision. Therefore, we recommend that the student has fulfilled the requirements and hence hereby can submit the thesis to the department for defense.

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Name of Principal advisor  Signature  Date

____________________  ___________  ___________
Name of co-advisor  Signature  Date
DEDICATION

I dedicate this MSc thesis work to my lovely Mother Askale Wokle whom I never and never forgot.
EXAMINERS’ THESIS APPROVAL SHEET

We, the undersigned, members of the Board of Examiners of the final open defense by Haile Ashamo, have read and evaluated his/her thesis entitled “Identification and characterization of Students’ Misconceptions in Basic Electricity for Grade 10 in Heto Secondary School” and examined the candidate’s oral presentation. This is, therefore, to certify that the thesis has been accepted in partial fulfillment of the requirements for the degree of master in physics.

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Stamp of Department  Date:___________
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Sincerely my special thanks go to Heto Secondary High School Administration and stuff members for giving relevant information for my study and their encouragement.
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<thead>
<tr>
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<th>Description</th>
</tr>
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<tbody>
<tr>
<td>CAT</td>
<td>Conceptual Understanding test on electric circuit</td>
</tr>
<tr>
<td>CQ1, CQ2, CQ3</td>
<td>Conceptual understanding test for student 1, 2, 3</td>
</tr>
<tr>
<td>CR</td>
<td>Correct Response</td>
</tr>
<tr>
<td>IQS</td>
<td>Interview Question for Student</td>
</tr>
<tr>
<td>#S1, #S2, #S3</td>
<td>Student-1, Student-2, Student-3</td>
</tr>
<tr>
<td>WR</td>
<td>Wrong Response</td>
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ABSTRACT

The main purpose of this study was to identify and characterize students’ misconceptions about basic electricity (simple electric circuit). The study was carried out in Heto Secondary School in Hadya Zone with special reference to grade 10 students. Case study was employed to address the problem. To conduct this study, 60 students were selected through random sampling technique from total population of 360 students. In order to achieve the objectives, the study employed conceptual understanding test and semi structured interview about simple electric circuit. Each question in the conceptual understanding test and interview was designed to probe students’ knowledge and understanding about electric circuit. All data collected using different tools were analyzed quantitatively and qualitatively.

The study identified some students’ misconceptions in electric circuit. These were: I) some students believed that the total resistance of the circuit increased when two or more resistors were connected in parallel, II) the power supply provided constant current regardless of how the circuit is changed, III) only one wire connected to a battery was needed for the circuit to work, IV) each device consumes some of current passing through it and others. The study also described the causes for these misconceptions. These were students’ personal experience, inappropriate use of laboratory, and unevaluated text books. Thus, to improve the situation, it is recommended that every educator should be aware students back ground, their daily life experience, and their pre conceptions before providing the lessons on electric circuit, teachers should also spent more time to produce more conceptual talk about the topic to bring conceptual understanding, different instructional methods should be applied to support conceptual understanding of students about simple electric circuit. Replacing those misconceptions by scientifically accepted conceptual views were necessary and efforts should be made to create awareness continuously for students, teachers, school principals and educational experts. Conducting trainings and different workshops with those concerned bodies was more advisable to increase the understanding and to avoid misconceptions in basic electricity.

Key words: Misconception, Heto high school, Basic electricity
CHAPTER ONE

INTRODUCTION

1.1. Background of the Study

Education helps human being to improve, change as well as develop and conserve his environment for the purpose of an all rounded development by diffusing science and technology into the society. This cannot be achieved without science. So, it is necessary to our students from the very beginning of their study to be on the right track of scientific conceptions. There are so many different sources for students to build up their scientific conceptions such as student's personal experience, Peer interaction, media, language, symbolic representation (e.g. equations, graphs), text books, and laboratory works. Many research studies have shown that, these sources sometimes produce wrong representation of the scientific concepts.

Children do not come to school as a “tabula rasa” (Pine et al., 2001) or they do not come into class as blank slates, but rather with knowledge gained from different sources and through daily life. This students’ prior knowledge can help or hinder learning. This knowledge consists of an amalgam of facts, concepts, models, perceptions, beliefs, values, and attitudes, some of which are accurate, complete, and appropriate for the context, some of which are inaccurate, insufficient, or simply inappropriate for the context. As students bring this knowledge to bear in our classrooms, it influences how they filter and interpret incoming information. Ideally, students build on a foundation of robust and accurate prior knowledge, forging links between previously acquired and new knowledge that help them construct increasingly complex and robust knowledge structures. However, students may not make connections to relevant prior knowledge spontaneously. If they do not draw on relevant prior knowledge in other words, if that knowledge is inactive it may not facilitate the integration of new knowledge. Moreover, if students’ prior knowledge is insufficient for a task or learning situation, it may fail to support new knowledge, whereas if it is inappropriate for the context or inaccurate, it may actively distort or impede new learning.

According to constructivist models of learning, the process of learning involve the “building up” knowledge structures (Smith, J. P, et al., 1993). Constructivist models of learning assume that existing knowledge and understanding are the basis for deeper and lasting learning. Theories of memory processing suggest that long term retention of
knowledge involves the consolidation of knowledge, through changes that which increase the levels of integration of recent learning with well-established knowledge.

The role of students’ pre-instructional conceptions that are not in accordance with scientific concepts has proven to be important in learning. If students do not understand concepts as scientists do, this situation is described as misconceptions by different researchers.

Students’ conceptions are surprisingly similar in different student age groups and similar conceptions are held by adults and some teachers (Driver, R. and Easley, J.1993) also educators need to worry about misconceptions for meaningful learning.

Learners start constructing knowledge with prior knowledge that they have before they enter the classroom. And also when they are introduced to an analogy, they already create an idea of how it relates to the real situation. “We found that the reason the students had difficulty understanding some concepts, such as the concept of electricity was because of their ontological presupposition of the concept. They use their existing knowledge of what they understand about the situation and make sense of concepts based on this understanding and find it difficult to reassign that concept to another set of ideas. Therefore, if they have a particular understanding of how something works, they interpret any new knowledge in accordance with their pre-existing idea. However, it is important to find a link between the previous knowledge and the expected target. Student’s preconceptions in science have aroused science educators’ interest because of the principle idea of constructivist learning theory, which was stated as “students come to the learning environment with the preconceptions, which were formed during their interactions within physical and social environment and those preconceptions affect learning” (Pfundt and Duit, 2006).

For about 20 years, the role of misconceptions in learning science has been investigated extensively. Numerous interviews with students at various levels have been conducted and it was found that misconceptions were frequent, the roots of misconceptions, how they affect learning of disciplinary knowledge and how they can be remedied have been investigated by many researchers (Chambers & Andre, 1997; Ship stone, 1988 and Cohen et al., 1983). The term misconception refers to the ideas that students have about any phenomena that are inconsistent with scientific conceptions. The goal of effective science instruction is to encourage the student to construct an understanding that is generally
consistent with accepted scientific theory. It is known that students use preexisting conceptions constructed from previous experiences to reason about newly presented science concepts (Driver & Easley, 1973). Such preconceptions are often incorrect from a scientific viewpoint and can interfere with students learning of science (Fredette & Clement, 1981). Studies have been done in many parts of world about students misconceptions on basic electricity. One active area of research on physics misconceptions is topic of simple electric circuits, but studies regarding misconceptions on electric circuit have not been reported in local research.

1.2. Statement of the Problem

There have been many studies world wide of students’ understanding of basic electrical concepts so that there is now quite a clear picture of many of their difficulty. By contrasts, work on remediation is in its infancy. Studies should be conducted concerning students’ difficulties with the concepts of circuits, current and electrical energy and should discuss some possible approach to instruction which arises in the light of these findings. Much of the research cried out has been within the paradigm of constructivist psychology which views all human being as prototypical scientists, constructing hypothesis and testing these against experience as their way of understanding the world around them. In seeking to understand electrical phenomena, student constructs a variety of explanatory conceptual models, some of which they then hold very tenaciously.

This study was focused on tenth grade students’ misconceptions on basic electricity especially in electric circuit. From researcher’s observation in his day to day instructional activities, there were a number of misconceptions such as: some students were believed that the total resistance of the circuit increased when two or more resistors were connected in parallel, the power supply provided constant current regardless of how the circuit is changed, only one wire connected to a battery was needed for the circuit to work, each device consumes some of current passing through it and others. Wrong perception leads wrong understanding and it was go out of scientific knowledge’s and truth.
1.3. Objectives of the Study

1.3.1. General Objective

The general objective of this study is to investigate the students’ misconceptions and their sources in basic electricity especially in electric circuit.

1.3.2. Specific Objectives

The specific objectives of this study are:

- Identifying student’s misconceptions about series and parallel circuits
- Searching other misconceptions on electric circuit concepts with in selected students
- Differentiating the causes or sources of these misconceptions

1.4. Research Questions

The research questions raised in this study are;

- What are 10th grade students misconceptions about series and parallel circuits?
- What are other misconceptions on electric circuit concepts with in selected students?
- What are the causes of these misconceptions?

1.5. Significance of the Study

The purpose of this study is describing the existence and causes of misconceptions about electric circuit concepts and recommending the impact of misconception in instructional process in order to support students on their conceptual understanding of electric circuit.

The findings of this study are important for different concerned educational professionals that are found at various levels: For, school administrators, teachers and students, the study also could be used as an additional source of information for further studies.

1.6. Theoretical Framework

The theoretical framework of this research is anchored in Ausubel et al., 1978) theory of meaningful learning. From Ausubel we took into account the role of previous knowledge, progressive differentiation, integrative reconciliation, and conditions for the occurrence of meaningful learning. Ausubel’s theory is a constructivist cognitive theory directed to learning the way it happens in the classroom, every day in most schools. To Ausubel et al., 1978), “The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly”. New concepts may be learned and retained as relevant and inclusive concepts are adequately clear and available in the
cognitive structure of the individual serving as anchorage to new ideas and concepts. Progressive differentiation and integrative reconciliation are two programmatic principles that refer to classroom dynamics. Progressive differentiation is the principle according to which the most generic and inclusive ideas of the teaching topic should be presented at the beginning of teaching and then they can be progressively differentiated in their details and specificities. There are two conditions for meaningful learning to happen: i) the material must be potentially meaningful, that is, the content to be studied must be relatable to the students’ cognitive structure in a non-arbitrary and non-verbatim way; ii) the students must have willingness to relate the new potentially meaningful material in a substantive and no arbitrary way to their cognitive structure.

1.7. Delimitation the Study
This study focused on only grade 10 Physics students of Heto Secondary School out of ten high schools under Hadya Zone Hossana town. But the problems of misconception were nationwide case. The study also delimited to identify and characterize students’ misconceptions on electric circuit. More specifically, the study focused on sixty grade ten students.

1.8. Limitation
The potential problem faced in the research process was unwillingness of a few respondents to fill in the questionnaire (test) and return back on time; and the shortage of time to collect the data were the constraints which encountered the researcher. However, the researcher appoints the respondents frequently and showing the commitment to complete this study successfully.

1.9. Definition of terms
Concept: An abstract or general idea inferred or derived from specific instances.
Conception: A general term used to describe beliefs, knowledge, preferences, mental images and other similar aspects of a mental structure.

- Concept of physics: general understanding of physics.
- Conceptual understanding: In many articles it seems to refer one’s ability to answer Qualitative questions addressing different aspects of physics concepts
- Misconceptions: different Version of students’ conceptions that are not in agreement with the conceptions held by the scientific community.
- **Problem:** A gap or barrier between a goal state and one’s present state

- **Problem Solving:** mental process and is part of the larger problem process that includes problem finding and problem shaping.
CHAPTER TWO
LITERATURE REVIEW

2.1. Introduction

Concepts can be regarded as “ideas, objects or events” that help us to understand the world around us (Eggen and Kauchak, 2004). Misconceptions can be described as incorrect ideas, mental models or understandings that are based on personal experience (Martin et al., 2002). These incorrect ideas are as a result of predictions that disagree with observations. Misconceptions have also been described as preconceived notions, on scientific beliefs, native theories, mixed conceptions or conceptual misunderstandings (Hanuscin, 2001).

Literatures show that children have differences in understanding science and it is often in consistent with what the teachers intended to achieve during instruction. Many possible sources are responsible for creating misconceptions. Experiences do not always lead to the correct conclusions or learners do not always see all possible outcomes in terms of why and how certain occurrences take place. Parents and family members may not always give the correct answer when confronted with questions from their children. Others sources of misconceptions include analogies, the media, teacher explanations and textbooks.

Studies show misconceptions amongst learners about electrical circuit (Driver and Easly, 1973). These researchers may have used different terms or names to describe the misconceptions, but a common thread was found. A South African study done by Kriek,& Kapartzianis, 2011) shows that learners have preconceptions, for example, the pre-existing knowledge that they may have from different cultures, experiences, teaching and misconceptions which are created based on poorly understand pre-existing knowledge. A number of studies were conducted to find common misconceptions in circuits by learners A comparison between common misconceptions and the scientific model is summarized in Table 2.1. the table shows the original researcher and how the misconception compares to scientific view.
<table>
<thead>
<tr>
<th>Misconception/Model</th>
<th>Scientific Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>The unipolar model or sink model: Learners believe that only one wire connected to a battery is needed for the circuit to work. (Chambers &amp; Andre, 1997)</td>
<td>There needs to be two wires to connect the two poles of the battery to the two sides of the resistor. In one wire current flows from the battery to the resistor and in the second wire, current flows from the resistor back to the battery.</td>
</tr>
<tr>
<td>The attenuation model: Learners believe that less current returns to the battery. They think each device consumes some of the current passing through it (Shipstone, 1988).</td>
<td>Current is not consumed by the electric devices: all current returns to the battery. It is energy, not current, that is transferred to the device that causes it to work.</td>
</tr>
<tr>
<td>The sharing current model: Learners believe that the current is shared by the devices in the circuit, and that less current return to the battery (Shipstone, 1988).</td>
<td>Current in a series circuit is the same throughout the circuit, whereas in parallel circuits, current branches and rejoin again such that all current is conserved.</td>
</tr>
<tr>
<td>The sequential model: Learners believe that a change in the circuit will affect current in parts of the circuit that are located ‘ahead’ the change, but not in parts located behind’ the change (Dupin&amp;Joshua, 1987).</td>
<td>Any change made in a circuit affects the circuit as a whole. For example, if a resistor is added, the current will decrease throughout the entire circuit.</td>
</tr>
<tr>
<td>The clashing current model: Learners believe that current flows from both poles of the battery in opposite directions to the resistor. These currents are seen as a positive and a negative current which clash in the resistor such that the clash creates</td>
<td>Current in a circuit flows in one direction. Conventionally, current flows from the positive terminal of a cell, around the circuit to the negative terminal. The current is made up of moving charges carrying</td>
</tr>
</tbody>
</table>
energy in the resistor (Chambers & Andre, 1997). The empirical rule model: Learners believe that if a light bulb is far away from a battery it will glow dimmer.

<table>
<thead>
<tr>
<th>The short circuit model: Learners believe that wires in a circuit with no electrical devices can be ignored when analyzing the circuit (Fredette &amp; Clement, 1981).</th>
</tr>
</thead>
<tbody>
<tr>
<td>A short circuit is a path without resistance that bypasses resistors. If a battery is shorted, other devices will receive no current while the current in the wire and battery will become very large because current takes the way of least resistance. The wires will become very hot and may melt, and the battery will overheat and become exhausted.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>The power supply misconception: Learners believe that the power supply provides constant current regardless of how the circuit is changed (Dupin &amp; Joshua, 1987).</th>
</tr>
</thead>
<tbody>
<tr>
<td>An ideal battery supplies a constant voltage, not a constant current. The current is the result of the combined effect of the voltage and the effective resistance of the circuit. This means that changing a device in a circuit changes the current while the...</td>
</tr>
<tr>
<td>The parallel circuit misconception: Learners believe that if the numbers of resistors in parallel are increased, the total resistance will also increase (Cohen et al., 1983).</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>The local reasoning model: Learners believe that current splits in equal parts at junctions regardless of the resistance of the branches. (Cohen, 1988). Learners believe if there is a change in a part of the circuit, it affects that part as opposed to the circuit as a whole. Although these two interpretations may overlap one another they are not identical.</td>
</tr>
<tr>
<td>The superposition model: Learners believe the physical arrangement of the cells does not affect the voltage across the circuit (Sebastia, 1993).</td>
</tr>
</tbody>
</table>

### 2.2. Origins of Misconceptions in Physics

Modern life is filled with electricity, from simply lighting our homes to using sophisticated computers. It goes without saying that as learners enter science classrooms;
they have a wide range of ideas and beliefs about electricity that they have developed from everyday experience. These ideas, beliefs or preconceptions, that they have shape the understanding and construction knowledge as they are taught. Learners use these internal representations, which are known as models, to predict the behavior of electricity and to explain electric circuits (Gentner & Gentner, 1983). Unfortunately, many learners’ intuitive ideas that constitute their mental models are incomplete and conflict with scientific explanations of electrical circuits (Lee & Law, 2001). Misconceptions may arise in a variety of ways. They may, for instance, stem from misinformation, inattentiveness, selective attention, misinterpretation, a lack of aural or visual acuity or be generated by ambiguous information. The application of an inappropriate analogy may also generate misconceptions about regularities in the world (as, perhaps, when a child uses a common inflection as an analogy and announces that something is ‘deeded’). Some particularly problematic misconceptions are probably acquired through direct but limited experience with the world.

2.3. Factors Related to Misconceptions

There are many factors that contribute to the formation of misconceptions amongst learners. Each factor that was found to be common in literature is discussed below.

2.3.1. Gender and Background

Sencar (2001) explain in great detail a number of factors that could influence misconceptions in girls rather than in boys. The ins and outs of the school experiences of learners play a strong role in their attitude towards science. A student is not enthusiastic and about science, the possibility of constructing meaning and understanding from electricity lessons is minimal. Girls usually tend to take interest in subjects other than science and this may influence the number of misconceptions in girls since girls may be treated differently at home, their background and interest in electricity differs from that of boys. This inevitably will affect the way in which they develop and the knowledge that they may construct and will therefore impact on their knowledge in certain sections of electricity.

“Alternative conceptions are held by individuals because of their diverse set of personal experiences including direct observation and perception, peer culture and language, teacher’s explanations and instructional materials.” Learners’ experiences outside of school will influence his or her performance inside school. External, social factors are
known to have an effect on learner performance amongst all learning areas. It is therefore argued that the different experiences of girls influence their understanding and performance in science. Who strongly agrees that boys have fewer misconceptions than girls as it was evident in his study where he compared the understanding of direct current resistive electrical circuits through samples of males and females at school and also at university level? However, they are contradicted by Anamuh-Mensah *et al.*, 2001) who found that gender does not play a major role in misconceptions in electric circuits. It is, in fact, common amongst both genders. There is no empirical evidence of why boys may perform better in science than girls.

2.3.2. Cognitive Perspective

Sencar (2001) argue that age also plays a role in the creation of misconceptions. He views learners as being of different ages and different mental and physical stages. He also sees them as being at different maturity levels so the knowledge that they should construct when they are at a certain stage is not guaranteed and could be hindered by the phase that learners are in within their lives.

Piaget’s theory of cognitive development explains the ability of learners as their “thinking processes change radically, though slowly, from birth to maturity because we constantly strive to make sense of the world. Piaget identified four factors; biological maturation, activity, social experience and equilibration that interact to influence changes in thinking” (woolfolk, 2010, p.32). Piaget argues that children develop in stages, at the concrete operational stage (7-11 years) learners are not able to construct and make logical deductions. They cannot transfer their knowledge well at this stage, cognitive development, as described by woolfolk (2010,p.26), is “gradual orderly changes by which mental processes become more complex and sophisticated”; the difference in cognitive development is possibly responsible for differences in understanding because learner’s perceptions and ability to grasp concepts will differ due to learners developing at different times, not all learners are able to construct and find understanding in certain sections of electricity. An example of this can be seen in Shipstones study (1984, p.33) where he explains various understandings of the water pipe analogy by a group of learners in the same grade.
2.3.3. Lack of Knowledge

The lack of knowledge amongst learners was mistaken for a misconception in many studies. A learner that actually does not have knowledge is thought of as having a misconception regarding the topic. Different learners are being taught by different teachers using different teaching methods at a primary level, and the learners already have a certain amount of prior knowledge.

Chang et al., (1998) suggest that there are three different problems; “discrepancy”, “uncertainty”, and “incompleteness”. “Discrepancy” is the difference of what the learners understand and the teacher thinks the learner understands. “Uncertainty” is when the learner is in doubt his or her understanding of a concept. “Incompleteness” is when the learner has some knowledge and understanding but does not completely grasp the concept. Chang et al., (1998) suggest methods to solve these problems; “discrepancy” which can be solved by revising the concept. “Uncertainty” which can correct by assessing if the learner understands the concept correctly and “incompleteness”-which can be corrected through remedial instruction using methods that are suitable for the learner to grasp the concepts.

2.4. Factors Related to Teaching Electricity

Teaching science is influenced a multitude of factors. In the section below, factors that may relate to the teaching of electricity are discussed.

2.4.1. Teachers and their Beliefs

The Experiences (Liegeois et al., 2003) of teachers and their beliefs play an intricate part in the way they teach. This impacts the understanding and interpretation of learners. Many teachers are resistant to change (Kucukozer & Kocakulah, 2007). They do not adopt their teaching methods to accommodate the type of learners that they have interns of background, language, cognitive ability and so forth. Cohen et al., (1983) found that misconceptions. Mellados (1997, p. 208) explanation for teachers not advancing their studies is “Science education is theoretical, impersonal and static with little relationship to the practical knowledge on the classroom required when giving the science lesson.”

2.4.2. Conceptual understanding

Teaching learners to understand how an electric circuit functions on a qualitative level is difficult pedagogical challenge (Hart, 2008; Mc Dermott & Shaffer, 1992). Concepts such as potential difference, current and resistance, which are the central concepts in
electricity, are very abstract by nature. Consequently, there is great difficulty in providing learners with accurate information about electric circuits in a comprehensible format (Finkelstein et al., 2005). Alternatively, learners are provided with an algebraic equation (Frederikson et al., 1999; McDermott & Shaffer, 1992) as a method to teach the model of electric circuits. Students find it difficult to link the quantitative circuit theory to a conceptual “casual model of what is happening in the circuit” Dowker, (2005) explains that learners may do well in calculation because of their skills in mathematics but show limited conceptual understanding of it. Mathematical manipulation may conceal the cause-effect relation of voltage and current. Therefore we can assume that learners do not view the circuit as a system, but view each component individually. It is also possible that teachers share this poor conceptual understanding, and avoid teaching conceptually. The concept of potential difference can form misconceptions. The debate of whether it should be taught before or after current is argumentative. Studies done by McDermott and Shaffer show those learners that are “able to analyze a circuit quantitatively were often unable to analyze that same circuit qualitatively. It has also been found that “the ability to solve a circuit problem numerically does not necessarily indicate a corresponding level of qualitative understanding. The learners lack conceptual understanding and are so focused on collecting numerical answers that they do not pay attention to why and how they get these values. For simple calculations at Grade 9 level, learners may find difficulty in mathematical manipulation. As learners start learning more complex calculations in electricity, they will need to integrate the concepts with their numerical understanding in order to answer more complex circuit questions. Less emphasis is put on practical work and conceptual understanding but is rather focused on calculations. This results in poor conceptual understanding and a possibility of misconceptions. Learning is a rational activity.” Therefore, it is important to not only identify misconceptions, but also to understand “some reasons for their persistence,” and “how a student’s current ideas interact with new, incompatible ideas”. In order for a learner to learn, there needs to be some form of dissatisfaction about the existing concept within the learner. The learner needs to find the new concept plausible, which is usually difficult for learners. If the new concept is plausible it must be intelligible. This requires, “an understanding of the component terms and symbols used and the syntax of the mode of expression” (Posner et al., 1982). The learner needs to find the new concept to be fruitful in a way that will “lead to new insights and discoveries” (Posner et al., 1982). These are the four criteria needed
for conceptual change and may be used by teachers to address their learners’ misconceptions.

2.4.3. Analogies

In electricity, it is a mental model of how abstract electrical concepts can be viewed in order to create an understanding of the functioning circuit. “For the past two decades, a growing amount of research has shown that the use of analogies in science teaching and learning promotes meaningful understanding” (Chiu and Lin, 2005, p.429).

Analogies are a method of learning and constructing knowledge about concepts that are difficult to understand. This method of teaching has been used for years and allows learners to create a picture in their mind of what may be occurring and the process that may be taking place it allows for a visual perspective on a topic to allow for clearer and more in-depth understanding. Analogies are very popular in science teaching. The water-pipe analogy described by Shipstone (1988) is a well-documented analogy to explain the flow of charge. Learners start constructing knowledge with prior knowledge that they have before they enter the classroom. When they are introduced to an analogy, they already create an idea of how it relates to the real situation. “We found that the reason the students had difficulty understanding the concept of electricity was because of their ontological presupposition of the concept” (Chiu and Lin 2005, p.429). They use their existing knowledge of what they understand about the situation and make sense of concepts based on this understanding and find it difficult to reassign that concept to another set of ideas. Therefore, if they have a particular understanding of how something works, they interpret any new knowledge in accordance with their pre-existing idea. However, it is important to find a link between the previous knowledge and the expected target. Gentner and Gentner (1983) proposed the structure mapping theory which opened a whole new field of how man can solve and confront problems. The theory indicates the relationship between the familiar and unfamiliar domain and how analogies can help in the construction of knowledge, “through the analogical relationship between the domains” (Chui and Lin 2005, p.430). He uses the example of “the flow of electricity is similar to the flow of water”, so the familiar domain is the flow of water and the unfamiliar domain is electricity. These mental images or mental representation are known as “mental simulations” of the real situation (Gentner & Gentner, 1983). Johnson-Laird (1983) describes this phenomenon as analogical representations of reality or a working model. This theory has played a key role in science because it understood that it is used...
by novices and experts for different reasons but allows for creative thinking. In fact, famous philosophers and scientists such as Plato, Aristotle, Maxwell and Franklin have found that analogies play a crucial role in theory development itself. Teachers who are unaware of analogies themselves struggle to find analogies that are “the same as the real thing” (Mulhall et al., 2001, p.578). Yet, analogies should not be seen as a simplistic solution. Dagher (1994) and Chi (1992) argue that analogies are not effective because they do not bring about conceptual change. Instead, using analogies allows for “assimilating new knowledge” (p. 431) and “served as references for initial explanations or conjectures” (p. 431). Therefore, the use of an analogy will only be effective if the learner is able to construct new knowledge or other assimilated knowledge. Furthermore, there are studies that have found that analogies may cause a great amount of confusion. Yerrick et al. (2003) claims that the teachers’ role in using analogies is a crucial one. He believes that if the teacher does not scaffold the lesson so that learners move towards the knowledge they are meant to construct, it may cause many misconceptions...

The success of analogies can be understood in terms of Greeno’s theory of multiple representations which explains that by using different types of analogies to explain a concept, learners understand and find meaning easier (Greeno & Hall, 1997). Learners understand the content better due to the use of analogies which in essence is a formation of an idea or picture in their minds.

It is characteristic of the physicist to want to strive to condense information and reduce it to the essentials, which can be achieved by observing the essentials of the analogy.

2.4.4. Simulations

A simulation as a new method of teaching is found to be beneficial but require instructional support. Jaakkola et al., 2011) found that simulations do not provide an additional gain of understanding as compared to real life circuits. In fact, it slows down the learning process. Computer simulations merely provide support with regard to the conceptual understanding of electric circuits that learners already have, and should be used as a tool for additional support, not as the only form of teaching. Jaakkola et al., (2011) claims that “an interactive computer-simulation that models electric circuits has the potential to help learners overcome their misconceptions and learn the scientific model of electric circuits. Simulations allow students to engage actively instead of merely watching a demonstration because they are able to set up virtual circuits and change circuit Domain of observables (objects, materials and phenomena) Domain of ideas
variables to observe the outcome De Jong, (2006). Some simulations are useful because they present different quantities such as electric current, potential difference, energy, and resistance in different colors so that learners can see how they work together in the circuit. However, many schools are not resourced with interactive technology such as smart boards where learners can play around with the different quantities, change the circuits, add new components, and see how it impacts on the circuit. The debate about computer simulations and hands-on practical work has been investigated in many studies. Hands-on practical work is regarded as important authentic experience. Learners need to engage with real material and not distorted reality. Recent research shows that a combination of virtual (computer simulations) and real (hands-on practical work) is most beneficial (Zacharia, 2007; Ronen & Eliahu, 2000). Even though demonstrations are a form of practical work, demonstrations are done by the teacher only, where as practical work is done by the learners.
CHAPTER THREE
RESEARCH METHODOLOGY

3.1. Introduction

This chapter presents design of the study, description of the study area, sample and sampling techniques, data gathering instruments, data collection procedure. A design, description of the population, the instrument used and analysis were included. It also contains the validity and the reliability of the instruments used in the study.

3.2. Research Method

For this study, the research design employed was case study. A study can employ either the qualitative or the quantitative approach or some combination. This choice is entirely based on the assumption that both of pure qualitative and pure quantitative approaches have their own weaknesses. To fill the gap, philosophers and educators have currently adopted this third paradigm. The mixed methods approach becomes the third paradigm in addition to the pure qualitative and pure quantitative approaches. It is currently advocated by educators. In this research work Problems related to behavioral variables were analyzed quantitatively through conceptual understanding test on electric circuit, problems related to motivational variables were also analyzed qualitatively through open ended questioner video recording at the time of interviewing or think-aloud method. Based on the type of data, the research is primary research because data were collected from primary sources and both qualitative and quantitative (mixed) approach were used for data analysis and interpretation.

The reason for selection of this method than others was because the focus of this study is on extensively exploring and understanding rather than confirming and quantifying. It provides an overview and in depth understanding of misconceptions with in sample students.

3.3. Source of Data

Having a real source of data in the process of the study is unquestionable to address the basic questions. To have thick and valuable data, primary sources of data were used in this study. Primary source help the researcher to get firsthand information about the issue under study. Primary source was grade 10 students in Heto secondary school.
3.4. Research Site and Target Population

The study was conducted in Heto Secondary School (grade 10), which is found in Hadya Zone of SNNPR, Ethiopia. The school was intentionally chosen for this study because the researcher works as a physics teacher of the target school and the existing situation would enable him to conduct research on the topic and come up with reliable inquiry. The Target population of the study included 360 grade 10 students of Heto High School in 4 sections. Out of these the researcher selected 60 students by employing simple random sampling method.

3.5. Sample and Sampling Technique

The subjects of the study were grade ten students. There were 200 male and 160 female totally 360 grade ten students from four sections in the school. Of these, the researcher intended to take 60 students as sample populations of the study. However, the number of students within each class was decreased. This is, because in case study managing the data needs more time. The reason why students were chosen randomly from the four sections was to give every student an equal chance of being selected.

To attain the purposes of the research, the researcher used simple random sampling technique. In simple random sampling, the selection of each object of the study from the population has an equal chance and the probability of a subject of the other subjects of the population. Simple random sampling technique involves selecting of random from the population the required number of participants or cases for the sample.

Table 3.1 Personal data of sample students

<table>
<thead>
<tr>
<th>Sex</th>
<th>Number of students</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>36</td>
<td>60</td>
</tr>
<tr>
<td>Female</td>
<td>24</td>
<td>40</td>
</tr>
<tr>
<td>Total</td>
<td>60</td>
<td>100</td>
</tr>
</tbody>
</table>

As mentioned above table, 60% of the sample was males and 40% of the sample was females.

3.6. Research Instruments

Two different instruments were developed and used. These instruments were conceptual understanding test and interview about basic electricity.
3.6.1. Conceptual Understanding Test (CAT)

The designed conceptual understanding test (CAT) consists of 12 questions, 6 of which are selected and partially modified from the studies investigating students’ ideas about simple electric circuits. In the pilot phase of the study, CAT was administered to 60 students and interviews were conducted with randomly selected 30 students who responded to CAT beforehand. Thereafter, content validity of CAT was checked by two experienced high school physics teachers. According to analysis results of pilot study some changes in the questions, which were difficult to respond, were made. All the questions were in open-ended form in the pilot study. According to the analysis of the data obtained, the most frequent responses given to each of the questions were used as alternatives to multiple-choice items in CAT. Students were asked to select only one alternative for each question.

3.6.2. Interviews

Semi-structured interview technique was used in the study. Interviews were conducted to examine deeply the ideas obtained from CAT. Firstly, the reasons beneath the explanations made to CAT and the questions from the interview schedule were asked. According to the progress made during the interviews, additional questions were also asked in some instances. Students were interviewed between 40 and 60 minutes time period. Maximum attention was paid not to lead the students but to strive to develop to interaction in a natural and comfortable atmosphere. All the interviews were recorded with the consent of students and transcribed. Some of the interview data that support the data obtained from each CAT question was presented in the findings section.

3.7. Pre-test/Piloting Study

After the development of conceptual understanding test the first activity was assessing test reliability and validity. A pilot test has several functions, principally to increase the reliability, validity and practicability of the instrument. Thus, pilot testing was designed for the purpose of determining the significance and clarity of the instrument that helps to create appropriate ground for the main study and to make necessary corrections based on the feedback obtained. The pilot study was conducted on the students who did not take part in the actual research. The number of students participated were 10 which were 6 males and 4 female students.
3.7.1. Validity

Validity is the extent to which an instrument measures what it is supposed to measure. The instruments were given to two experienced high school teachers and my Adviser, Co-Advisor and two experienced high school teachers to obtain their views in regarding to the appropriateness of objective, language leveled. Moreover, pilot test was conducted for calculating difficulty index. Based on their feedback, corrections and changes were made before the test was used for data generation.

3.7.2. Reliability

The reliability coefficient is a measure of the error associated to the students’ scores. Its values can range from 0 to 1. A reliability coefficient of zero would indicate the instrument does not consistently measure anything while coefficient of 1 would indicate the instrument has no measurement error. The reliability coefficient of conceptual understanding test was obtained from SPSS software by using conceptual understanding test data. Reliability alpha coefficient of conceptual understanding test on this research work was 0.75.

If the reliability of alpha coefficient is 0.90 and above it is excellent for classroom test, 0.80-0.90 is very good for classroom test, 0.70-0.80 is good for classroom test, and 0.60-0.70 is somewhat low, 0.50-0.60 suggest need for revision and 0.50 or below is questionable reliability.

Based on this criterion, the reliability of the pilot test and conceptual understanding test lied within good range for classroom test.

3.8. Item Difficulty Index

This is a measure of the difficulty of a particular question denoted by P. It is the ratio of the number of students, who answered the question correctly to the total number of students, taking the test.

\[ P_{\text{value}} = \frac{n}{N} \]

Where, P: is difficulty index value
n: is number of students responding correctly
N: is number of students taking the test
A difficulty index value in the range of 0.2-0.8 is conventionally considered adequate, a value less than 0.2 indicate that the questions are too difficult for discriminating and a value more than 0.8 indicates that the question is too easy.

3.9. Data Collection Techniques

Before collection of data detailed literature review about students’ misconception on simple electric circuit was done. Some available journals and articles were obtained and examined to find the related research studies. While making this literature review, some misconception models were determined and the questions were examined. In order to conduct the study, the researcher asked permission from the school principal. Data was collected using interview and conceptual understanding test. The conceptual understanding test consists of multiple choice theoretical questions with 12 items. The questions of the test were distributed to 60 grade 10 students in the presence of the researcher and they are told that scores of this test would not affect their classroom results. In the test each student wrote down his/her gender and age. The subjects were given 40-60 minute class hours for completing the test. After getting the data the test of each subject was scored and data table consisting of age and gender was prepared.

3.10. Data Analysis Techniques

The quantitative data analysis techniques were used for data collected by conceptual understanding test, and a qualitative data analysis techniques were used for data collected by interview. Finally, based on the analysis of the data, the researcher tried to summarize the research findings, draw conclusions from the findings and suggest a few recommendations.

3.11. Threats to internal and external validity

3.11.1. Threats to internal design validity

History: Events which occurred between observations of measurements; during data gathering students had not enough confidence in giving responses.

Maturation: Students who were selected to answer questions gave response according to their interest rather than the actual facts and classroom researchers took themselves…

Instrumentation: The data gathering tools were understood in different ways.
Diffusion of treatments: The sample group might get biased information from population. This might lead them to give the response to the questions according to the gathered information from the environmental influence.

3.11.2. Threats to external validity
Interaction of personal variables and treat mental effect this means the way to approaching to treat the same group to treat the selection or collecting data systematically. He or she did not get the correct answer, so he or she asked indirect questions to get the correct answer the treatments effect of the research could be changed the real situation of gathering information.

3.12. Ethical consideration
The data collected from two instruments was well proved by school principals by the stamped seal and also kept its privacy. Ethics of research here referred to the morals of search or intervention with regard to minimal abuse or disregard of the social and mental well-being of persons participate in the research work. Therefore, the research needed to include a statement of ethical reflection and obtained ethical clearance. Here, the benefits and any harm to the study participants should be clearly presented. The issue of confidentiality (keeping the information only for intended purpose without using any personal identifiers) should be indicated.
CHAPTER FOUR

RESULTS AND DISCUSSIONS

This chapter deals with analysis and interpretation of the data collected through conceptual understanding tests and interview from students. The chapter also presents misconceptions reflected by students and discusses them thematically to answer the research questions raised in chapter one. The analysis of the data from two instruments has been carried out in an integrative way based on the major themes and sub themes of the study. The presentation falls into three main sections. The first section deals with students’ misconceptions about series and parallel circuits. The second section discusses other misconceptions on electric circuit concepts with in selected students and the third and the last section focuses on the causes of misconceptions on electric circuit concepts.

4.1. Data Analysis and Interpretation of Conceptual Understanding Tests

In order to identify and characterize misconceptions, conceptual understanding test was used. Conceptual understanding test provide academic opportunity for comparing the status of particular conception in different individuals. It may therefore possible to identify the status of each conceptions not by isolation, but rather by studying each of related conceptions and the reasoning statements which link them and indicate the range of conditions under which each conceptions is to be used. Conceptual understanding test was administered to the target groups. The result scores on each item of students obtained was recorded and analyzed as follows (see Appendix B)

4.2. Characteristics of the respondents

As mentioned earlier in methodology section, Heto secondary school grade 10 students were the samples of this study. Conceptual understanding test was administered to 60 students and data was collected properly. Regarding the prepared interview guide was presented to 30 students and responded to the interview questions.
4.3. Quantitative Components of the Study

The data collected from Conceptual understanding test were treated using descriptive statistics. The descriptive part of the study summarizes the data observed on the variables by using percentage, mean and standard deviations.

4.3.1. Conceptual Understanding Test Results

Conceptual understanding test was designed from the topic of basic electricity (simple electric circuit), (see Appendix B). Conceptual understanding test was administered to the target groups. The result scores on each item of students obtained is in the following table below.

Table 2.1 Summary of Conceptual Understanding test results for 60 sample respondents

<table>
<thead>
<tr>
<th>Items</th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
<th>Q5</th>
<th>Q6</th>
<th>Q7</th>
<th>Q8</th>
<th>Q9</th>
<th>Q10</th>
<th>Q11</th>
<th>Q12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct answer</td>
<td>20</td>
<td>25</td>
<td>35</td>
<td>25</td>
<td>20</td>
<td>25</td>
<td>20</td>
<td>40</td>
<td>20</td>
<td>30</td>
<td>35</td>
<td>45</td>
</tr>
<tr>
<td>Correct answer in (%)</td>
<td>33.3</td>
<td>41.6</td>
<td>58.3</td>
<td>41.6</td>
<td>33.3</td>
<td>41.6</td>
<td>33.3</td>
<td>66.6</td>
<td>33.3</td>
<td>50</td>
<td>58.3</td>
<td>75</td>
</tr>
</tbody>
</table>

Table 4.1 shows that the scores of students in question items (Q1, Q2, Q4, Q5, Q6, Q7 & Q9) is less result i.e. below the average value (50%). This indicates that they had high misconception in basic electricity (simple electric circuit).
Figure: 4.5 Graphical illustration of number of students and test results

The graph above expresses the conceptual understanding of student’s result.

Table 4.2 Conceptual understanding of student’s test result out of 12 test items and its percentage

<table>
<thead>
<tr>
<th>No.</th>
<th>value</th>
<th>percentage</th>
<th>No.</th>
<th>Value</th>
<th>percentage</th>
<th>No.</th>
<th>value</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>33.33</td>
<td>21</td>
<td>5</td>
<td>41.66</td>
<td>41</td>
<td>4</td>
<td>33.33</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>41.66</td>
<td>22</td>
<td>4</td>
<td>33.33</td>
<td>42</td>
<td>4</td>
<td>33.33</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>33.33</td>
<td>23</td>
<td>4</td>
<td>33.33</td>
<td>43</td>
<td>4</td>
<td>33.33</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>33.33</td>
<td>24</td>
<td>5</td>
<td>41.66</td>
<td>44</td>
<td>5</td>
<td>41.66</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>33.33</td>
<td>25</td>
<td>6</td>
<td>50</td>
<td>45</td>
<td>4</td>
<td>33.33</td>
</tr>
<tr>
<td>6</td>
<td>5</td>
<td>41.66</td>
<td>26</td>
<td>4</td>
<td>33.33</td>
<td>46</td>
<td>4</td>
<td>33.33</td>
</tr>
<tr>
<td>7</td>
<td>4</td>
<td>33.33</td>
<td>27</td>
<td>4</td>
<td>33.33</td>
<td>47</td>
<td>5</td>
<td>41.66</td>
</tr>
<tr>
<td>8</td>
<td>4</td>
<td>33.33</td>
<td>28</td>
<td>4</td>
<td>33.33</td>
<td>48</td>
<td>4</td>
<td>33.33</td>
</tr>
<tr>
<td>9</td>
<td>5</td>
<td>41.66</td>
<td>29</td>
<td>4</td>
<td>33.33</td>
<td>49</td>
<td>5</td>
<td>41.66</td>
</tr>
<tr>
<td></td>
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<td></td>
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<td>---</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>4</td>
<td>33.33</td>
<td>30</td>
<td>4</td>
<td>33.33</td>
<td>50</td>
<td>4</td>
<td>33.33</td>
</tr>
<tr>
<td>11</td>
<td>4</td>
<td>33.33</td>
<td>31</td>
<td>5</td>
<td>41.66</td>
<td>51</td>
<td>5</td>
<td>41.66</td>
</tr>
<tr>
<td>12</td>
<td>4</td>
<td>33.33</td>
<td>32</td>
<td>4</td>
<td>33.33</td>
<td>52</td>
<td>5</td>
<td>41.66</td>
</tr>
<tr>
<td>13</td>
<td>4</td>
<td>33.33</td>
<td>33</td>
<td>4</td>
<td>33.33</td>
<td>53</td>
<td>4</td>
<td>33.33</td>
</tr>
<tr>
<td>14</td>
<td>4</td>
<td>33.33</td>
<td>34</td>
<td>4</td>
<td>33.33</td>
<td>54</td>
<td>6</td>
<td>50</td>
</tr>
<tr>
<td>15</td>
<td>4</td>
<td>33.33</td>
<td>35</td>
<td>5</td>
<td>41.66</td>
<td>55</td>
<td>4</td>
<td>33.33</td>
</tr>
<tr>
<td>16</td>
<td>4</td>
<td>33.33</td>
<td>36</td>
<td>4</td>
<td>33.33</td>
<td>56</td>
<td>4</td>
<td>33.33</td>
</tr>
<tr>
<td>17</td>
<td>5</td>
<td>41.66</td>
<td>37</td>
<td>4</td>
<td>33.33</td>
<td>57</td>
<td>4</td>
<td>33.33</td>
</tr>
<tr>
<td>18</td>
<td>4</td>
<td>33.33</td>
<td>38</td>
<td>4</td>
<td>33.33</td>
<td>58</td>
<td>5</td>
<td>41.66</td>
</tr>
<tr>
<td>19</td>
<td>4</td>
<td>33.33</td>
<td>39</td>
<td>4</td>
<td>33.33</td>
<td>59</td>
<td>6</td>
<td>50</td>
</tr>
<tr>
<td>20</td>
<td>4</td>
<td>33.33</td>
<td>40</td>
<td>4</td>
<td>33.33</td>
<td>60</td>
<td>4</td>
<td>33.33</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2,166.43</td>
</tr>
</tbody>
</table>

Mean = 260/720=36.11% or 2,166.43/6,000 = 36.11%

Table 4.2 shows that the mean scores of all the respondents is 36.11%. This mean value for test scores also indicates that the students had high misconception in basic electricity (simple electric circuit).
Figure 4.6a Conceptual Understanding test results out of 12 for the first 30 students
Figure 4.7b Conceptual Understanding test results out of 12 for the remaining 30 students.
4.3.2. Analysis and Interpretations

The Conceptual understanding test is designed to find out the levels of students misconception in basic electricity (simple electric circuit) by using scoring criteria. Scores could range from 0 to 100. Scores that are greater than 75 were classified to show performance of low misconception in basic electricity, scores 50-74 were classified to indicate normally moderate misconception in basic electricity and scores less than 50 were classified to show high misconception in basic electricity. The data that shows the level of students’ misconception in basic electricity were summarized in the following table.

Table 4.3 frequency distribution for Conceptual Understanding test results of respondents

<table>
<thead>
<tr>
<th>Scores</th>
<th>N</th>
<th>%</th>
<th>Mean %</th>
</tr>
</thead>
<tbody>
<tr>
<td>75-100</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>50-74</td>
<td>3</td>
<td>5</td>
<td>36.11</td>
</tr>
<tr>
<td>&lt;50</td>
<td>57</td>
<td>95</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>60</td>
<td>100</td>
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</tr>
</tbody>
</table>

Figure 8.3 graphical illustration of frequency distribution for Conceptual Understanding of respondents
Table 4.3 and its graphical representation above shows that the frequency of misconception was found to be 95% and this finding indicates that there is high degree of misconception in students.

**Item Difficulty Index**

This is a measure of the difficulty of a particular question denoted by P. It is the ratio of the number of students, who answered the question correctly to the total number of students, taking the test.

\[
\text{Item difficulty index} = \frac{\text{the number of students responding correctly}}{\text{the number of students taking the test}}
\]

In symbolic representation, \( P = \frac{n}{N} \)

Where, P: is difficulty index
\( n: \) is number of students responding correctly
\( N: \) is number of students taking the test

A difficulty index value in the range of 0.2-0.8 is conventionally considered adequate, a value less than 0.2 indicate that the questions are too difficult for discriminating and a value more than 0.8 indicates that the question is too easy.

**Table 4.4 Item difficulty data for Conceptual Understanding test**

<table>
<thead>
<tr>
<th>Question No.</th>
<th>CR</th>
<th>CR/T</th>
<th>WR</th>
<th>WR/T</th>
<th>Question No.</th>
<th>CR</th>
<th>CR/T</th>
<th>WR</th>
<th>WR/T</th>
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<td><strong>Total of CR</strong></td>
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</tr>
</tbody>
</table>

Where CR – Correct response (series 1)

WR – Wrong response (series 2)

T – Total number of responses
From table 4.4 and figure 4.4 shown above, the calculation performed on the value of item difficulty index \((P)\) on the data described in the table indicates that the value lies between 0.2-0.8. Therefore, it is possible to conclude that the difficulty index of the test items prepared for the respondents is conventionally adequate.
4.4. Data Analysis and Interpretation of interview

The interview was conducted for 30 students, out of these 10 students were female & 20 students were male. The researcher selected and organized the interviews. The whole interview was analyzed as follows:

For IQ 1: The interview result showed that 10 students or 33.3% explained that electricity is used for lighting, heating etc. in our daily life, but 20 students or 66.7% of them had difficulty in explaining its use. This information of respondents interview show most of the students possess misconception in electricity.

For IQ 2: The interview results show 9 students or 30% explained the difference between series and parallel circuit correctly, but 21 students 70% explained wrongly. They said when two or more resistors are connected in parallel the total resistance increases, but, according to the scientific fact since connecting more resistors in parallel reduces the total resistance because it creates more pathways for current to flow in the circuit, this result shows that most of the students had misconception in electricity.

For IQ 3: From the interview 18 students or 60% suggested that for the circuit to work there needs to be two wires to connect the two poles of battery to the two sides of the resistor, but 12 students or 40% suggest that for the circuit to work one wire is connected to a battery. Since as for a circuit to work one wire is connected to a battery, is the scientific fact, the above result of the interview shows that most of the students had misconception.

IQ 4: The interview responses of students showed that 6 students or 20% say electricity concepts are too easy to understand and grasp, but 24 students 80% responses showed that grasping basic electricity concepts are too abstract to understand easily. Therefore, from the response most students had misconception about basic electricity.

For IQ 5. From the interview 11 students or 36.6% said there is no dependence between length of wire and current, the bulb glow equally bright and dim in parallel and in series, but 19 students or 63.4% believe that when a light bulb is far away from a battery it will glow dimmer and if it is near a battery it will glow brighter. As most of the students responded that when a light bulb is far away from a battery it will glow dimmer and if it is near a battery it will glow brighter which
contrtionadicts scientific truth, this showed that most of students had misconception about basic electricity.

For IQ 6: Interviews response of 10 students or 33.3% showed if the number of resistors are increased the total resistance of the circuit will also decrease, but 20 students or 66.4% believe that connecting more resistors in parallel increases the total resistance of the system. The correct scientific truth implies that when the number of resistors are increased the total resistance of the circuit will decrease. According to this, since the response of most students is against this principle, this indicated that most of the students had misconception in basic electricity.

For IQ 7: From the interview 11 students or 36.6% said an ideal battery supply constant voltage, not constant current because the current is the combined effect of the voltage and effective resistance of the circuit, but 19 students or 63.3% showed that a constant voltage supplied by ideal battery provide constant current. This result indicated that as most of the respondents answered that a constant voltage supplied by ideal battery provide constant current which is incorrect according to the existing scientific fact there was a misconception.

For IQ 8: From the interview 12 students or 40% said when they used identical bulbs, batteries and long wires, there was no dependence between length of wire and current, but 18 students 60% believe that when a light bulb is far away from a battery it will glow dimmer and if it is near a battery it will glow brighter. The result indicated that since most of the respondents replied there was a dependence between length of wire and current, this shows most of the respondents had misconception.

For IQ 9: from the interview all (30) students or 100% said background or prior knowledge affects their understanding of basic electricity concepts. This result shows that prior knowledge was one of the key factor for students misconception.

For IQ 10: From the interview all (30) students or 100% believe that personal experience, text books, media, etc are factors which contribute to the formation of misconception.
4.5. Discussion on Research Questions

4.5.1 Research Question 1: What are 10th grade students’ misconceptions about series and parallel circuits?

The analysis of students’ response for question number IQ 2, 18 students from a total of 30 students or 60% explained wrongly by saying the total resistance is the sum of individual resistances for both series and parallel circuits but the scientific fact is that for series circuit total resistance increases and for parallel circuit it reduces. And for question number IQ 6, 21 students or 70% of them explain wrongly by saying when the numbers of resistors in parallel are increased, the total resistance will also increase but connecting more resistors in parallel reduces the total resistance because it creates more pathways for current to flow in the circuit. This shows that most of the students gave incorrect answers (misconception in electric circuit).

4.5.2 Research Question 2: What are other misconceptions on electric circuit concepts with in selected students?

The responses of Questions 3, 5, 7 and 8 were analyzed as follows.

For Question 3 twelve (12) students or 40% gave correct answer, but eighteen students or 60% of them gave wrong answer by saying the power supply provided constant current regardless of how the circuit is changed. This shows most of the respondents possess misconception.

For Question 5 ten (10) students or 33.33% gave correct answer, but twenty (20) students or 66.67% of them gave wrong answer by saying only one wire connected to a battery was needed for the circuit to work, but there needs to be two wires to connect the two poles of the battery to the two sides of the resistor. This indicates that most of the respondents possess misconception.

For Question 7 thirteen (13) students or 43.34% gave correct answer, but seventeen students or 56.66% of them gave wrong answer by saying each device consumes some of current passing through it, but current is not consumed by the electric devices: all current returns to the battery. This shows most of the respondents possess misconception.

For Question 8 eleven (11) students or 36.67% gave correct answer, but nineteen students or 63.33% of them gave wrong answer by saying wires in a circuit with no electrical devices can
be ignored when analyzing the circuit. This indicates that most of the respondents possess misconception.

4.5.3 Research Question 3: What are the causes of these misconceptions?

From the interview IQ 10 (Appendix B) response and CAT-Q12 (Appendix A) answer it is shown that students personal experience, text books, laboratory activities, media, everyday language, prior teachings, etc were sources for students misconceptions.
CHAPTER FIVE
CONCLUSION AND RECOMMENDATION

5.1. Introduction
Under this chapter the overall conclusion and the recommendation were presented by the researcher consecutively.

5.2. Discussion of the result
Identifying and characterizing students’ misconceptions before providing instruction benefits for the targeted learners in terms of developing better conceptual understanding, offering a better opportunity for supporting the students’ future career. As mentioned earlier, the main purpose of the study was to assess students’ misconceptions on electric circuit with reference to grade 10 students at Heto Secondary School in Hadya Zone of SNNPR. The study focused on assessing major problems that students face when they were learning physics, identifying causes for students’ problems in understanding electric circuit concepts and exploring how physics teachers attempt to help students in overcoming the problems.

For this study, descriptive research design was employed, and in trying to address these issues, qualitative research method was used. In this study 60 grade 10 students were chosen as a sample through random sampling technique. In order to achieve the objectives two data gathering tools were used. These were conceptual understanding test on electric circuit and interview. The study indicated that the students had a lot of problems in understanding electric circuit concepts from CAT and Interview results.

In comparing the results of this research with those of the previous studies, this research supports most of the findings of the previous studies. For instance, as can be seen from the basic descriptive statistics of achievement scores, most of the students have misconceptions related to electric circuit concepts. Moreover, the percentages of students’ misconceptions are relatively similar to the results of previous studies (Cohen, et al., 1983). The findings of this research is in agreement with that of (Cohen, et al., 1983) studies, that learners believe that if the numbers of resistors in parallel are increased, the total resistance will also increase. Moreover, in this study different categories of misconceptions were identified in detail in electric circuit concepts, which supports the findings of the previous studies or in agreement with that of (Chambers & Andre,
studies, that learners believe that only one wire connected to a battery is needed for the circuit to work.

There are other misconceptions which agree with this study where learners believe that wires in a circuit with no electrical devices can be ignored when analyzing the circuit (Shipstone, 1988). Learners believe that the current is shared by the devices in the circuit, and that less current return to the battery. And other misconceptions were shown. The students’ problems in misconceptions were mainly attributed to students’ related factors like misinformation, inattentiveness, selective attention, misinterpretation or be generated by ambiguous information. Some of the identified reasons for student confusion and misconceptions were students personal experience, text books, laboratory activities, media, everyday language, prior teachings, etc.

5.3. Conclusion

It was realized that, students have considerable degree of misconceptions about simple electric circuits.

1. There are some problems that Heto Secondary School grade 10 students face problem of understanding electric circuit (series and parallel) concepts.

2. Prior knowledge and everyday language are main sources of misconceptions. Prior knowledge of students obtained from previous grades, from their peers, from different sources. Every day language which were commonly spoken ideas.

Existing memories and information influence the selection of stimuli, the attention given to stimuli and subsequent meaning generated from stimuli. More briefly, existing concepts play an important role in determining learning outcomes because they provide the foundation for the construction of new information.
Table 5.1 Identified characterized misconceptions in this study Vs Scientific Truth

<table>
<thead>
<tr>
<th>Identified Misconceptions</th>
<th>Scientific Truth</th>
</tr>
</thead>
<tbody>
<tr>
<td>I) Learners believe that the total resistance of the circuit increased when two or more resistors were connected in parallel. (The parallel circuit misconception).</td>
<td>Connecting more resistors in parallel reduces the total resistance because it creates more pathways for current to flow in the circuit.</td>
</tr>
<tr>
<td>II) Learners believe that the power supply provided constant current regardless of how the circuit is changed (The power supply misconceptions).</td>
<td>An ideal battery supplies a constant voltage, not a constant current. The current is the result of the combined effect of the voltage and the effective resistance of the circuit.</td>
</tr>
<tr>
<td>III) Learners believe that only one wire connected to a battery was needed for the circuit to work (The unipolar model or sink model misconceptions).</td>
<td>There needs to be two wires to connect the two poles of the battery to the two sides of the resistor.</td>
</tr>
<tr>
<td>IV) Learners believe that each device consumes some of current passing through it (The attenuation model misconception).</td>
<td>Current is not consumed by the electric devices: all current returns to the battery.</td>
</tr>
</tbody>
</table>

5.4. Implications of the Study

According to the results of the study, the following suggestions can be offered:

1. The results of the study showed that students have misconceptions and these misconceptions resist to change and obstructing the learning process. The more teachers know about their students’ misconceptions, the more they will be able to provide them to learn.

2. In this study, it was found that students who had higher scores on the test have as many misconceptions as the students who had lower scores.

3. Teachers should emphasize on the conceptual understanding of the students.
4. Teachers should use formative evaluation to assess the misconceptions of students about electric circuit. Therefore, it can be needed for them to use different methods or instruments in the lecture to make the concepts more clear and understandable.

5. Identifying the students’ misconceptions in electric circuit by the think allowed interview method can give some feedback to the textbook editors. They can use more examples and simple questions dealing with the misconceptions instead of complex situations and questions.

5.5. **Recommendation**

It is the concern of teachers and/or researchers to create conceptual understanding of basic electricity concept in students. This study states, identification and characterization of misconception of students in Heto secondary school. Taking the findings of this study into account, the researcher has forwarded the following recommendations to the stakeholders:

1. For aiding students' conceptual understanding through instruction every educator should be aware of students' background, daily life experiences and differences in type of activities that has an important role on their preconceptions.

2. For promoting students’ performance and positive attitudes in physics, teachers should encourage them to set meaningful learning goals and help students understand their attributions by creating both female and male oriented teaching instruction.

3. Teachers should spend more time to produce more conceptual talk about conceptually challenging topics that students describe their own views and ideas about a variety of phenomena.

4. The physics lessons should be organized to enable students' conceptual learning instead of rote learning and supplied with experiments and activities that student can perform and learn concepts by doing themselves.

5. Different instructional techniques are needed to apply by taking into consideration of students' misconceptions for gaining comprehension learning in physics.
This study also suggested different issues for future studies. These are briefly as follows:

1. Future research could perform a replication of this study using different physics topics.

2. For different grade levels, students' misconceptions can be investigated and detected using similar design of this study.

3. Future research could not only be interested in only identifying and characterizing misconceptions but also how to bring conceptual change on students, learning style, quality of teacher.

4. Teachers need opportunities to learn about children’s cognitive development and children’s development of thought (children’s epistemologies) in order to know how teaching practices build on learners’ prior knowledge.
6. REFERENCES


Conceptual understanding test about basic electricity

The objective of this Conceptual understanding test is to collect information about students’ misconceptions in basic electricity. Since the reliability of the information depends on the objectivity of your responses, you are kindly requested to be as frank and honest as possible.

I. Personal Data

Sex ............... Male..........female....... Age .................

Instructions

The test consist 12 questions; please provide your responses by circling the letter that contains the correct concept, if you come across with vague questions ask for clarification. Do not write your name finally, your answer remains strictly confidential and will not affect your class room results of physics.

I. Instruction: for the following questions choose the letter of correct answer

1. If the number of resistors in parallel circuit is increased, the total resistance will.........
   A. Increase   B. Decrease
   C. Remains the same   D. no answer

2. A change in the circuit will not affect the..................
   A. current   B. voltage
   C. resistance   D. none
3. Which one of the following is incorrect about the potential difference across the battery?
A. When cells are connected in series the potential difference increases.
B. When cells are connected in parallel the potential difference remains constant.
C. The physical arrangement of cells does not affect the voltage across the circuit.
D. For series connection of cells the potential difference of cells added up.

4. For the short circuit, which circuit element does not affected
A. the cell  
B. the battery
C. the connecting wire  
D. all are affected

5. For the circuit to work how many wires are connected to the battery and resistor?
A. one wire  
B. two wires
C. three wires  
D. four wires

6. A current of 5A is passed through 60W bulb. What happen the amount of current if it is returned back to battery?
A. increase  
B. decrease
C. remains the same  
D. no answer.

7. One of the following is consumed by the electric devices.
A. energy  
B. current
C. voltage  
D. resistance

8. If the number of resistors increase in parallel circuit, the total resistance of the circuit
A. increase  
B. decrease
C. remains the same  
D. not determined

9. The sum of currents approaching the junction.............the sum of the current leaving it.
A. equal  
B. greater than
C. less than  
D. none

10. What single resistor could be placed in the box to replace the two shown in fig- 2
A. 16  
B. 8
C. 48  
D. 3
11. Which one of the following is correct about circuit?
A. The equivalent resistance is always less than the smallest of the individual resistance in parallel.
B. The equivalent resistance is always larger than the biggest of the individual resistance in series.
C. The equivalent resistance is always larger than the biggest of the individual resistance in parallel.
D. no answer.

12. Which one of the following is source for you to build up your scientific conception
A. peer interaction
B. media
C. text book
D. all
The objective of this interview and discussion is to collect information about students’ misconceptions in basic electricity. Since the reliability of the information depends on the objectivity of your responses, you are kindly requested to be as frank and honest as possible.

Thank you in advance.

Personal Data

Sex  male _____ female______

Instruction

Please read all the questions well and write down what you feel on the space provided if it is necessary.

1. What is the use of electricity in our daily life? List and explain some?

2. What basic differences do you understand between series and parallel circuit?
3. Some students believe that only one wire connected to a battery is needed for the circuit to work. What about you? Explain.

4. What are your difficulties in grasping basic electricity concepts?

5. If a light bulb is far away from a battery, then will it glow brighter or dimmer?

6. What happens to the total resistance in parallel circuit, if the number of resistors is increased?

7. An ideal battery supplies a constant voltage. Do you believe that this constant voltage provides constant current? Why?

8. When we use identical bulbs, batteries and long wires, in which connection the bulb is brighter and in which it is dimmer? Why?

9. Do you believe that your background or prior knowledge has impact on understanding the basic concepts of electricity? Explain your answer.

10. What are factors that contribute to the formation of misconception in basic electricity? List and explain.
APPENDIX C

Interview questions and responses

Question-1:-What is the use of electricity in our daily life?

Students responses

#s-1. for lighting our homes
   - for cooking our food
   - for using electric devices, etc.

#s-2. for heating our homes
   - for lighting our homes
   - for using computers, etc.

#s-3. for cooking our food
   - for using electronics
   - for lighting our homes etc.

#s-4. for using computers
   - for lighting our home
   - for cooking our food etc.

Question-2:-What basic differences do you understand between series and parallel circuit?

#s-1. In series there is only one path, but in parallel there are more than one path
   - In series total current is equal to individual currents, but in parallel current differs
   - In series total voltage is the sum of individual voltages, but in parallel voltage is similar

#s-2. In series total current is equal to individual currents, but in parallel current differs
   - In series total voltage is the sum of individual voltages, but in parallel voltage is similar
   - In series there is only one path, but in parallel there are more than one path

#s-3. In series total voltage is the sum of individual voltages, but in parallel voltage is similar
- In series there is only one path, but in parallel there are more than one path.

- In series total current is equal to individual currents, but in parallel current differs.

Question 3: Some students believe that only one wire connected to a battery is needed for the circuit to work. What about you? Explain.

- For the circuit to work one wire is needed.
- Their needs to be two wires to connect the poles of battery to resistor.
- For the circuit to work one wire is needed.
- For the circuit to work one wire is needed.

Question 4: What are your difficulties in grasping basic electric concepts?

- The concepts are too abstract
- Difficult to understand easily
- The concepts are very difficult
- The concepts are too abstract

Question 5: If a light bulb is far away from a battery then, will it glow brighter or dimmer?

- It will glow dimmer, because a light bulb is far away from battery.
- The current is affected by the length of the wire.
- It will glow brighter because a light bulb is far away from the battery.
- It will glow dimmer, because a light bulb is far away from battery.
Question 6: What happens to the total resistance in parallel circuit, if the number of resistors are increased?

- Reduces total resistance
- Increase the total resistance
- Increase the total resistance
- Increase the total resistance

Question 7: An ideal battery supplies a constant voltage. Do you believe that this constant voltage provides constant current? Why?

- Yes, it provides constant current regardless of how the circuit is changed.
- No, the current is combined effect of the voltage and resistance of the circuit.
- Yes, it provides constant current regardless of how the circuit is changed.
- Yes, it provides constant current regardless of how the circuit is changed.

Question 8: When we use identical bulbs, batteries and long wires, in which connection the bulb is brighter and in which it is dimmer? Why?

- In series the bulb is brighter and in parallel it is dimmer
- In parallel the bulb is dimmer and In series the bulb is brighter
- In series the bulb is brighter and in parallel it is dimmer
- In parallel the bulb is dimmer and In series the bulb is brighter

Question 9: Do you believe that your background or prior knowledge has impact on understanding the basic concepts of electricity? Explain your answer.

- Yes, I believe
- Yes, I believe
- Yes, I believe
- Yes, I believe
Question 10: What are factors that contribute to the formation of misconception in basic electricity? List and explain.

#s-1. Personal experience, media, language, symbolic, text books, laboratory works, etc.

#s-2. Text books, laboratory works, media

#s-3. Personal experience, media, language, symbolic, text books, laboratory work

#s-4. Text books, laboratory works, media etc.
### APPENDIX D

Data analysis from multiple choice items

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Data analysis from multiple choice items
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APPENDIX F

Class Room Activities on
Identification and Characterization of Grade 10 students’ misconception
On Electric Circuit