DIFFICULTIES ENCOUNTERED BY THE GRADE TEN TOWNSHIP LEARNERS WITH RESPECT TO THE CONCEPT OF ELECTRICITY

by

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A mini-thesis submitted in partial fulfillment of the requirements for the degree of

Masters in Science Education

SUPERVISOR: PROF M. B. OGUNNIYI
DECLARATION

I declare that “Difficulties encountered by the grade ten township learners with respect to the concept of electricity” is my own work, that it has not been submitted for any degree or examination at any other university, and that all the sources I have used or quoted have been indicated and acknowledged by complete references.

GILBERT DOLO

Signed: ...........................................

Date: ............................................
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ABSTRACT

The purpose of this study was to investigate the difficulties encountered by the grade ten township learners with respect to the concept of electricity. More specifically, the study attempted to explore the learners’ scientific knowledge by investigating their conceptions or alternative conceptions about electricity; the influence of learners’ age, career interests and gender issues on their conceptions of electricity and; the effectiveness of concept mapping (a pedagogic tool designed by Novak in the 1970s) in facilitating the learners’ understanding of electricity. The study was premised on socio-cultural constructivism as well as meaningful learning as espoused by Ausubel (1968).

A Pre-Test-Post-Test Control Group Design was adopted in the study in which two comparable groups were used. The data was analyzed using both qualitative and quantitative research methods and the instruments that were used included a conception of electricity (COET) (originally adopted and administered in the Western Cape, Northern Cape provinces and in Norway in 1999 for the purpose of Science and Technology Literacy Project (STLP) with the hope that their reliability and validity was guaranteed); selected learner interviews and evaluation forms.

The summary of findings has suggested that the Grade ten learners held misconceptions about the concept of electricity even after they were exposed to intervention that included concept mapping. In terms of the gender issues, there was no significant difference in performance between the boys and girls though the females outperformed their male counterparts at both groups. The underachievement of the older learners compared to the younger ones has also surfaced and that is against expectation since a number of studies carried out earlier (see Ogunniyi (1999)) have already corroborated such findings. With respect to career interests, what the learners indicated as their future dreams, i.e. what they intend to do and become, seems to have been influenced their performance at the pre- and post-test stages.
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KEYWORDS

♦ Grade ten

♦ Electricity

♦ Concept mapping

♦ Learners' understanding

♦ Misconceptions

♦ Language difficulties

♦ Constructivism

♦ Process skills

♦ Conceptual change

♦ Township schools
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<table>
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<th>Description</th>
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<tr>
<td>HOD</td>
<td>Head of Department</td>
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<tr>
<td>STLP</td>
<td>Science and Technology Literacy Project</td>
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<tr>
<td>COET</td>
<td>Concept of Electricity Test</td>
</tr>
<tr>
<td>DOE</td>
<td>Department Of Education</td>
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<tr>
<td>CMEE</td>
<td>Concept Mapping Exercise on Electricity</td>
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<tr>
<td>SI</td>
<td>Student Interview</td>
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<td>LERF</td>
<td>Lesson Evaluation and Reflection Forms</td>
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<td>LO3</td>
<td>Leaning Outcome 3</td>
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<tr>
<td>C2005</td>
<td>Curriculum 2005</td>
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<td>ISLP</td>
<td>Integrated Service Land Project</td>
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CHAPTER ONE

INTRODUCTION TO THE STUDY

1.1 Introduction

Since World War II science has become an important subject in most curricula. It has now reached a stage where it is taken as a given that science should form part of every student’s subject offerings for a given number of years of their school life, yet it is often viewed as a difficult subject by students. Several reasons can be advanced for this and they include students’ attitudes towards science due to poor teaching methods, teachers mystifying science, elitism, lack of laboratories and/or resources, students’ prior learning; abstract concepts, as well students’ cognitive age (Tabor, de Trafford & Quail, 2006).

Difficult concepts for the students can be found in all the science disciplines in the syllabi. However, students lack an understanding and encounter great difficulty in understanding abstract concepts of science, particularly the concepts used in the topic of electricity as exemplified in the Natural Sciences of Curriculum 2005 where the topic on electricity is flagged as one of the topics that students find difficult. If they would learn anything meaningful from the topic of electricity, they would most probably tend to learn it by rote. Perhaps this is what Howe (1996:37) refers to when asserting that:

…children are more aware and knowledgeable of a concept as a concept that they have been taught in school than they are of the object or phenomenon represented by the concept.

Thus, students dichotomize their knowledge of such concepts and may not find school knowledge meaningful in their everyday experiences and this may give rise to the erroneous notions that they hold about the concepts germane to the topic and for the same lack of valid understanding of the concept and
consequently poor performance in science. As a result, they may develop a
negative attitude for the subject.
Responses to assessment items dealing with electricity from a large sample of
15-year olds in research, confirm the general picture of an area where
understanding is low and misconceptions are common (Arnold et al.1987).
Perhaps it is generally, if erroneously, assumed that students’ learning difficulties
may be as a result of the so-called cognitive internal difficulties internalized in the
students’ mind. A further assumption is that students coming to school have
sufficient technical knowledge and concepts although they are still vague and
unstructured, hence the understanding is low and misconceptions are common.
According to Driver (1986) in Gil-Perez, D. and Carrascosa, J. (1990:531)
misconceptions – at least those most deeply rooted – are associated with
intuitive ideas or preconceptions acquired prior to school learning, and for some
authors as Preece (1984) cited by Gil-Perez, D. and Carrascosa, J. (1990:531),
these ideas are not just learned from experience but “built into the hardware of
the brain.”
Unlike the other topics, the topic on electricity requires that learners possess
certain process skills such as observation, analogical thinking, understanding of
the interrelationships between the current and voltage in order to understand the
concept. Teaching electricity requires that it be done largely by hands-on
experiments than through chalk and talk and also by the direct observation of the
entities involved in the electricity. This can also be called a hands-on experiential
learning that according to Hodson (1996) permits teachers to internalize the
concepts that they can pass on to their students. Also, teaching this topic can be
improved by acting out, i.e. the use of drama to teach science or a role-play. This
approach can be regarded as an active and powerful learning strategy that can
develop an understanding in science in general and electricity in particular.
1.2 Background

Delft was established in 1989 and has had a rapidly expanding community. The community was established as an integrated service land project (ISLP) for “coloureds” and “blacks”. The area is subdivided into five sections namely, The Hague, Rosendal, Voorbrug, Eindhoven and Delft South. The first three sections are predominantly “coloured” while Eindhoven is partially inhabited by “coloureds” and “blacks” while Delft South is predominantly “black”. The predominant languages are Afrikaans and Xhosa. The major challenges faced in the area are the continuous vandalism of school property, drug abuse, poor attendance of classes by learners and the lack of cooperation from the parents and community at large.

However, the experimental school I would call ‘Ibhongo Secondary School’\(^1\) that was involved in the study was established nine years later in 1998 and serves a multicultural diverse community in the impoverished area of Delft South. A large number of learners accepted at the school have an Eastern Cape schooling background with a record that reflects average to poor results. The control school that would be called ‘Ithemba Secondary School’\(^2\) also participated in the study and is situated in the same area but a distance away from the experimental school, about 2,3 kilometers to the south of the experimental school.

Most science textbooks deal with so many abstract concepts, that many students find difficult to understand, particularly those students who have not been well prepared from the lower grades. These difficulties are picked up as they progress at the high school level where they are expected to work independently. It is at this level that learners expect their teacher to begin to teach the actual concepts, perform experiments, conduct demonstrations and write down chalkboard notes which they then copy and commit to memory. Carrying out experiments and demonstrations are worthwhile activities in a science class, but it is not always possible to have the time or resources to perform such activities.

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\(^1\)This is a pseudonym to protect the anonymity of the school.

\(^2\)This is a pseudonym to protect the anonymity of the school.
In a number of workshops attended, most science teachers raise their concerns about the difficulties they encounter in getting the learners understanding the topic of electricity. The challenge that the teachers are battling to overcome is to achieve conceptual change among the students in an effort to change some erroneous notions that they hold in relation to science concepts. The problem is that many students do not develop new meaningful relationships with the new contexts that they are introduced to within the educational environment (Linder, 1993).

It possibly takes a while for them to acquaint and make sense of what is going on around them when they are in a science class. It is obvious that whenever new knowledge is assimilated into the cognitive structure of the student, one can make a claim that meaningful learning has taken place. The only way this can be achieved is by introducing the prior knowledge of the student in the learning process and this can be easily accomplished by starting with the concept mapping strategy. This strategy will externalize the preconceptions of the students and lay a solid foundation for the new knowledge to be attached (Koopman, 2004:37). The concept mapping strategy has been found very useful by earlier researchers, (Symington & Novak, 1982) in (Novak, 1990) asserts that their new graduate students who joined their research found that concept maps were not only a useful tool to represent changes in the knowledge structure of students over time, but also helped students learn to learn meaningfully, and to help teachers become more effective teachers.

1.3 The Problem Statement

The topic of the study, electricity is a part of the prescribed curriculum for grade ten. Research has shown that the concept of electricity has evinced all kinds of misconceptions and alternative worldviews among learners (Ogunniyi, 1999). The concept is seen as a complex cluster of related ideas rather than separate entities. Students tend to use the commonsensical and intuitive notion of electricity rather than the uncommon way the concept is construed in science.
It is interesting to know whether the difficulties encountered by township learners with respect to the concept of electricity are influenced by various aspects such as the learners’ age, gender and/or career interests. It may not be easy to overlook or not to consider the aspects listed above, particularly the career interests that learners might have. The possibility is that, the career interests can be crucial to how learners can perform in any discipline. An example to this notion is that students choose certain careers based on the parents’ or siblings’ careers that they may be exposed to. That can be a source of motivation to them, (Nangu, 1996:37).

With respect to age, several investigations have been carried out to examine the difficulties that the 12-13 year olds experience in solving problems of electricity in the European context. It is more likely that similar investigation be carried out in a completely different context, i.e. South African township and to confirm if the results could be similar or not (Rozencwaig, 1992).

It is also important to investigate whether or not the gender can influence the concept development in learning electricity and to look at how the males perform compared to females. This can be done by means of achievement in a science class. Considering the aspects such as students’ age, gender and career interests could assist in terms of understanding how they can affect the way in which the students apply the process skills and acquire knowledge. Furthermore, when learners are exposed to concept mapping as an instructional strategy, the point of interest is to know whether their conceptions or alternative conceptions – also called misconceptions, preconceptions, children’s science etc. (e.g. see Driver and Erickson, 1983) can be addressed to sharpen their understanding of the concept of electricity. This could be monitored by means of difference in performance relative to the learners who are not so exposed to the concept mapping.
1.4 Purpose of the Study

The main purpose of this study was to investigate the difficulties encountered by the grade ten township learners with respect to the concept of electricity. More specifically, the study attempts to explore:

- the learners’ scientific knowledge by investigating their conceptions or alternative conceptions about electricity.
- the influence of learners’ age, career interests and gender issues on their conceptions of electricity.
- the effectiveness of concept mapping in facilitating the learners’ understanding of electricity.

1.5 Theoretical Framework

The study is underpinned and draws inspiration from the important theory for research and practice in science education called constructivism. Constructivism is a theory of learning that asserts that knowledge is personally and socially constructed, mainly through interaction and experience with phenomena. The underlying tenets of constructivism are:

Each learner constructs his/her learning based on his/her previous interaction with the environment; the learner uses his/her conceptual framework to explore and interpret natural phenomena; instruction should start where learners are before taking them forward. Driver and Erickson (1983) define a conceptual framework to be a mental organization imposed by an individual to interpret experience with natural phenomena. According to constructivists’ view, learners are active beings responsible for the generation and construction of their own knowledge. They believe that learners have their own pre-conceptions about phenomena that help them to make sense of the world they live in (see Ausubel, 1968; Osborne and Wittrock, 1985; Aikenhead and Jegede, 1999 and Ogunniyi, 1995).
However, there are many forms of constructivism such as personal, radical, social, critical and contextual (Good, 1993; Solomon, 1994). Social constructivism was the best practice to which the study was related and the treatment aspect of the experimental group was solely based on the facilitation of the learners’ understanding of the concept of electricity using the instructional strategy called concept mapping. In as much as constructivist’s view believes that meaning is not out there to be discovered rather it has to be constructed by the group of people, it also turns out that advocates of constructivism are of the view that teachers should not just stand by and watch children explore and discover ideas; but they should rather guide and encourage them to work in groups, think about issues and questions, and provide them with guidelines where and when necessary. Part of the reason why the concept mapping was used as an instructional teaching strategy was that the role of the teacher is to use the teaching methods that are powerful to make the lesson interesting, understandable and challenge the learners’ creativity and critical thinking.

The major problem of teaching electricity at any instructional level, and especially in elementary school, is the abstract nature of this knowledge and the fact that learners observe and try to explain the macroscopic phenomena resulting from some microscopic processes, which are not directly observed or perceived (Azaiza, Bar and Gallii, 2006). However, (Arnold et al. 1987: 554) argues that difficulties in grasping the abstract concepts of electricity often seem to stem directly from children’s failure to ‘visualize’ what is going on, or to construct a set of images to assist them in understanding and predicting.

The process referred to above involves a conceptual change where the students’ conceptual understandings prior to, during and after formal instruction are crucial. A constructivist view maintains that a learner’s prior knowledge is the most important ingredient in the process of meaningful learning (Ausubel, 1968). Novak (1990) further asserts in agreement with Ausubel (1968) that the most important single factor influencing learning is what the learner already knows.
In search for an effective instructional tool, the concept mapping as espoused by Novak and associates in the 1980’s has been adopted to deal and correct effectively the misconceptions that the learners hold. Andre and Ding (1991:303) define misconceptions as referring to ideas that learners have incorporated into their cognitive structures that they use to understand and make predictions about the world. This kind of knowledge is based upon the learners’ experience, but often incorrectly represents the natural world.

Feuerstein (1991) argues that a mediator, that is, the teacher has to mediate this learning as somebody who is between the learner and what is to be learned. He refers to that kind of learning as a mediated learning experience acquired by the learner. Kilpratric (cited by Rossouw & Smith, 1999) asserts that knowledge is acquired when the learner incorporates the new experiences into existing mental structures and reorganizes those structures to handle more problematic experiences. In a science class, the introduction of new concepts of electricity to learners is a major problem facing most educators in the disadvantaged township schools. That is a possible cause of a negative impact on the learners’ performance and could also enhance an unpleasant attitude towards the topic of electricity and science in particular. Research evidence, for example, Ogunniyi’s (1999) study on grade eight students performance on electricity reflected that a high percentage, i.e. over 65% of the subjects have a very poor knowledge of electricity. The difficulties experienced do not lie so much in the introduction of the concepts, but in establishing them (Swart, 1988).

In other words, if the concepts are wrongly established, then a situation whereby the learners get into cognitive difficulties in terms of the necessary process skills needed to assimilate and adapt them becomes created. This seems to be the problem facing the learners at schools like Ibhongo Secondary. Furthermore, the language of western science, as a third language introduced to second language learners (in addition to English), for whom it is a foreign language in the poor communities adds to their difficulties (see a further explanation provided in the section on language difficulties in the next chapter).
Indeed, the possible aspect that takes the challenge quite far in terms of difficulties in understanding the concepts in a science class is the use of English by teachers as an instructional language for a majority of students, particularly those who are bused in from the Eastern Cape. This carries with itself negative effects in so much that students would rather remain passive during the teaching and learning process since the use of language becomes a possible learning barrier. In other words, this simply means that if the medium of instruction (i.e. English in this case) is not understandable by the students, then very little can be learned as was asserted by Gagne (1985). Nevertheless, Ogunniyi (1988) made a remark that the language of science that the teacher uses in his/her classroom is foreign to the learners because the background from which the teacher presents or express it to the learners does not take the cultural background of the learners in to consideration.

1.6 Research Hypothesis

In view of the questions asked below the following null hypothesis were posited for investigation:

- Grade 10 learners hold serious alternative conceptions of the electricity.
- There is no relationship between the learners’ conceptions of electricity and their gender, career interests and/or age.
- There will be no difference in the performance of learners exposed to the instructional strategy called concept mapping on electricity and those not so exposed.

1.7 Research Questions

The study aims to answer the following research questions:

- What conceptions do grade 10 learners hold about the concept of electricity?
- What process skills do grade 10 learners (to perform cognitive tasks on the topic of electricity) use?
- Are the learners’ conceptions of electricity related to their gender, career interests and/or age?
- Is there any difference in terms of performance when learners are exposed to the instructional strategy called concept mapping on electricity and the learners that are not so exposed?

1.8 Limitations

The study was supposed to be carried out during the third term of the year i.e. the time of the year in which the topic on electricity is normally scheduled to be covered in the school syllabus. The process of administering the instruments was dealt with within eight weeks that was heavily loaded with challenges for both schools involved since the beginning of the school term. This was done so that the quality data was collected, captured and analyzed carefully.

Eight weeks was not long enough time to carry out the whole exercise because for a number of weeks since the beginning of the term, the period timetable was faulty with clashes and periods shortened on some days to allow the registration process of new learners to take place, if not registration then the preparation for practice of athletics. Within this period I had also to teach the experimental group how to develop and use concept maps.

Furthermore, the gatekeepers were obstacles in both schools such that before the preparation to administer the instruments, access to the photocopy room and the photocopy material needed to produce the number of manuscripts needed for the research was denied.
1.9 Delimitation

The research was pursued as a case study in two township high schools in Delft South. Involved in the research were initially one hundred and fifty four new Grade 10 learners who were taking Physical Science as their major subject. The two teachers who assisted were carefully trained to administer the instruments by the researcher and were well experienced in a subject with a number of years of teaching experience.

The researcher was directly involved with the experimental group with one science teacher who was an observer during the process. The main reason for the researcher's direct involvement with the experimental group was that the learners constituted a purposive and convenient sample because they were registered for the physical science as their major subject that he offered. A purposive and convenient sample is suitable when the subjects are willing and are within easy reach of the researcher (Ogunniyi et al., 1995).

1.10 Definition of Terms

**Alternative conception:** - Also referred to as children’s science, this is the learner’s explanation of scientific phenomena based on his/her interaction with the environment or his experience (Erickson and Driver, 1983:41).

**Conception:** - A mental idea or one’s perception about the nature of a given subject matter.

**Conceptual change:** - This refers to meaningful learning occurring when a learner accepts new conceptions on the grounds that they are intelligible, plausible and fruitful.
**Concept Mapping:** - It is a schematic device that represents a hierarchical set of concepts that are linked with propositions to create conceptual meaning. In other words, a concept map is a semantic network of concepts and related presupposition. Concepts are linked with words or phrases that show the relationship among them (Heinz-Fry and Novak, 1990:461).

**Language of Instruction:** - The language in which teaching and learning materials are presented in the classroom.

**Meaningful learning:** - It is the incorporation of a new concept into the existing cognitive structure of the learner. The existing concept acts as an anchor for the new idea (Odom and Kelly, 1998:33).

**Prior knowledge:** - This refers to the previous knowledge or experience that the learner has prior to new learning that are relevant to the new experience.

**Rote learning:** - This involves mainly memorization of concepts without a clear and in-depth understanding of that concept. It is related to the cognitive structure but only in a verbatim fashion that does not result in the acquisition of any meaning (Ausubel, 1968:41).
CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This study as indicated in chapter one seeks to investigate the difficulties encountered by the grade ten township learners with respect to the concept of electricity. The study further attempts to correct their incorrect conceptions or alternative conceptions about electricity through the concept mapping used as an instructional tool to facilitate the learners’ understanding of the concept of electricity. However, the influence of learners’ career interests, age and gender issues on their conceptions of electricity is also explored.

The literature review shows that the daily understanding and usage of the concepts by the learners may be the very barrier that blocks their way to the scientific understanding of the concept (Ogunniyi, 2002). It may appear that though they hold valid ideas about the concept of electricity, their overall understanding of the concept is completely inadequate.

It is believed by many educators that the type of problems encountered in everyday existence make good starting points for learning. Dewey (1901) in Preethlall (1996:14) made an argument that information is educative only in so far as it represents definite images and conceptions of materials placed in a context of social life.

2.2 Theoretical Consideration

As pointed out in chapter one, this study is underpinned by the constructivist’s epistemology as espoused by a number of scholars such as (e.g. Novak and Gowin, 1984; Ausubel, 1968; Vygotsky, 1978; Ogunniyi 1995, 2002; Aikenhead and Jegede, 1999; Driver and Erickson, 1983 etc.). Socio-cultural constructivism,
which is an offshoot of cognitivism, construes learning as a socio-cultural activity in which both the teacher and the learner play active roles. Socio-cultural constructivists contend that learners do not enter the science classroom _tabula rasa_ (with empty minds) but hold intuitive ideas derived from their cultural setting. Hence, their perceptions of reality are moderated by knowledge gained from experience (Ogunniyi, 1995, 2002; Driver and Erickson, 1983).

Most science textbooks emphasize experimental details and lack a history and philosophy of science perspective. That is an aspect, which creates uncertainties for the educators when they have to introduce new concepts in the lesson to be taught in a classroom. It is concluded that if we want our learners to understand scientific progress and practice, then it is important that we include the experimental details not as a “rhetoric of conclusions” (Schwab, 1962; Schwab, 1974) but as “heuristic principles” (Lakatos, 1970) which were based on arguments, controversies and interpretations of the scientists.

According to Newton, Driver and Osborne (1999) there seems to be the tension between observations, experiments and interpretations/explanations. To them observations and experiments are not the bedrock upon which science is built; rather they are handmaidens to the rational activity of constituting knowledge claims through argument” (p.555).

South Africa has adopted a new curriculum since ushered in a democracy in 1994. This curriculum introduced by the Department of Education was called Curriculum 2005 (C2005), piloted in 1997 and was first implemented in certain classes in 1998.

The methodology in the new Curriculum 2005 is termed Outcomes Based Education (OBE) and it draws heavily on the work of a North American educationist, William Spady (see Spady, 1998; Spady & Marshall, 1991). C2005 specifies certain desirable critical outcomes that are informed by various aspects of thinking (cognition).
According to Adams (2003) learners continuously develop and organize their ideas through observations and they often accept more than one explanation for the observed event. They may consequently perceive a science demonstration from a perspective that differs from the teacher and scientists and this brings about a constraint to the learners’ ability to relate other scientific understandings to the phenomena observed. The everyday understanding and usage of the concepts by the learners may be the very barrier that block their way to the scientific understanding of the concept Ogunniyi (2002). Very often, children and adults use the term “gas” loosely in their everyday lives to mean electricity and perhaps that is appropriate in the context at which they use the term. However, in the science classroom, the responsibility is that of the teacher to assist them make a clear distinction between the way in which the concepts are used outside the school and in the science lesson.

It is very important to begin each topic by highlighting the historical background that can arouse an interest to learners so that they become prepared to open their minds and begin to apply the science processes to their cognitive structure. There is an extensive body of literature available to support the premise that children have and do develop alternative concepts of science to that taught in school (Driver, 1988).

Other studies have shown that learners use everyday experiences and explanations to define electricity. This is a case, for example when learners refer to electricity as gas, power etc.

Learning is depicted as a process of conceptual change giving explicit recognition to the educational research that has clearly shown that students come to class with a set of well-established science-related conceptions. These conceptions are usually often deviant to those being taught and as such are typically labeled alternative conceptions, naive conceptions, preconceptions, misconceptions and so on (Linder, 1993). Learners tend to hold erroneous notions about the science concepts and when they are confronted with empirical evidence that contradicts their beliefs, some learn the more scientifically accepted view, but given the time they regress to their nonscientific ideas.
This is as a result of committing the new knowledge in their short-term memory and in the process, the learner hardly accept the new concept. On this regard, Heller and Finley (1992) assert that researchers agree that the first step in designing instruction that promotes such conceptual changes is to assess students’ prior knowledge. Since electricity is a complex field with tightly structured knowledge architecture, performance on this type of task is highly dependent upon the level of mastery Rozencwajg (1992:6).

The electricity part of the curriculum is generally taught in the form of problem statements, accompanied by diagrams. Understanding diagrams is another source of problems, which leads the learners into severe difficulties experienced. Rozencwajg (1992) in his conclusion argues that the difficulties the 12-13 years olds experience in solving electricity problems fall into three categories:
- Difficulties related to concepts taught in class;
- Conceptual difficulties;
- Difficulties of a more general sort.

The difficulties that the 12-13 years old experience are carried over to the higher levels where the teachers experience hardships in getting the learners acquainted to the manipulation of these science concepts and making sensible explanations of what the diagrams intend to mean. However, difficulties in grasping the abstract concepts of electricity often seem to stem directly from children’s failure to visualize what is going on, or to construct a set of images to assist them in understanding and predicting (Arnold and Millar, 1987).

Nevertheless, the teachers’ role is also crucial in ensuring a better understanding of the concepts in class. As much as the teachers’ role is said to be a crucial factor to monitor and facilitate learning towards understanding, if the nature of physics knowledge of the teacher is a matter of concern, then a huge challenge of learners’ difficulties to understand the concepts of electricity could be assumed. An example to flag the teachers’ challenges is asserted by (Gunstone et al., 2009) in his abstract summarized, that there was a wide range of views
among the teachers about the difficulties of both the concepts of DC electricity and the teaching of these concepts, and about the nature of physics knowledge. A number of the interviewees revealed levels of conceptual understanding that they see as of concern.

As a matter of intervention to overcome the problems of misconceptions and encouraging meaningful learning, the use of concept mapping as an instructional tool is essential, (see more details in section 2.6). According to (Novak et al., 1983) meaningful learning results when a person consciously and explicitly ties new knowledge to relevant concepts or propositions they already possess. Furthermore, concept mapping is found to be a useful research tool to facilitate knowledge in any discipline and helps in organizing and understanding new subject matter (Novak, 1990).

2.3 Socio-cultural and Psychological Issues in Science Education

For most learners, especially in African continent, everyday experiences and the scientific worlds are different thus requiring adjustment and reorientation as they move between their home contexts into the school context. Goa (1998) therefore argues that culture is a contextual lens through which people view and understand the world and which directly influences their cognitive processes and understanding of science. He further asserts that the teaching and learning of school science is context dependent. Therefore, learners construct their own knowledge and provide explanations about natural phenomena and according to Adams (1999) they also develop their own views of the natural world. Adams (1999) further argues that learners that come from a traditional background have an anthropomorphic view about nature as opposed to the mechanistic view of nature indicative of western science. Unlike the scientists, whose world is mechanistic and impersonal, the learner’s world is impersonal and anthromorphic (Ogunniyi, 1988).
Different cultural groups hold different worldview presuppositions that are distinctive from that of school science (Fakudze, 2002). According to Adams (1999) there is no doubt that a clear distinction exists between western and non-western cultures. Aikenhead, cited in Adams (1999) states that when school science is in total harmony with the learners’ worldview this will enhance the process of enculturation of science. Understanding something in one way does not preclude understanding it in other ways, hence interpretation of meaning reflects the culture’s authoritative ways of constructing reality. According to Ogunniyi (1998) nothing is culture free; neither are individuals simply mirrors of their culture.

The exclusion of culture from the science classroom has a fallacious effect on student achievements (Tharp, 1989) and Hurd (1998) asserts that ignoring the learners’ cultural worldviews could result in learners seeing science as nothing but a collection of “dead facts” for which they show no appreciation.

It makes more sense when Ogunniyi (cited by Adam, 1999) asserts that science should not be seen as a collocation of facts but as an attempt by human beings to organize their experiences as a meaningful system of description, explanation and prediction.

He further argues that when science is presented as a catalogue of facts to be committed to memory then students are tempted to regard it as such and consequently, all they do is to memorize what is given to them, regurgitate this in examinations and forget it as quickly as possible. This is a type of instruction that is said to be unfruitful which discredits education since it promotes passive learners that are capable of being recipients of other people’s ideas rather than becoming active generators of their own knowledge. Further results are that students may pass examinations but they may no be able to use a concept or know its relevance in their everyday experiences. The possible implication of this may be that they need to be exposed on how to use conceptual tools in authentic activities i.e. they may require more than abstract concepts and self-contained examples that turn them into “parrots” rather than creative thinkers.
2.4 Language Difficulties

The role of language is a crucial factor in determining a successful content delivery and the understanding during the process of concept development in science. The situation becomes more difficult and challenging if the teacher overlooks the necessity of ensuring a proper use of scientific language which itself is regarded as the third language to learners. This has been confirmed by Brookes and Brookes (1995) when he argued that learners have an extreme difficulty in coping with Scientific English without a basic fluency in ordinary English.

In a multicultural science classroom the issue of language becomes extremely complex. Nevertheless, this is evident to the situation of Ibhongo Secondary School when new learners at the beginning of the year experience difficulties when the use of English is emphasized. This, according to them is perceived as a subtractive situation since the mother-tongue is not acceptable to teach science at grade ten level. This could then have a potential to influence their performance in science as they find their language and the accompanying culture devalued. On the other hand, the use of mother-tongue for teaching can be seen as additive since it positively values the child’s mother-tongue and culture and that could lead to enhancement and increase power in the development of language skills needed.

As was pointed out in chapter one, this becomes evident for those learners who have the Eastern Cape schooling background as they find it extremely difficult to understand the instructional language other than their mother tongue for teaching. In a science class, this is a challenging concern in that, if a learner cannot express him or herself properly in the second language, how much of the science concepts taught in the third language to the same learner would be understood? The use of instructional language other than the learners’ mother tongue in a science class carries with itself negative effects in so much that students would rather remain passive during the teaching and learning process since the use of language becomes a possible learning barrier.
The passive nature that the learners portray brings across a strong message to the science teacher that the learners are not in their comfort zone in terms of language where they could freely express themselves when the discussion could be the need during the teaching and learning process and this could possibly result to a very negative performance.

Killfioi (1999) asserts that one of the causes of poor performance in science is due to learners’ poor language facility. He further contends that linguistically weak learners will perform poorly in science due to their low language skill. In other words, according to Gagne (1985) this simply means that if the medium of instruction (i.e. English in this case) is not understandable by the students, then very little can be learned.

However, the assertion in the paragraph above, directly relates to the sample size as shown in the following chapter three according to a language profile. The study shows that there is large number of learners (71%) who speaks Xhosa as their home language and (29%) learners who speaks Afrikaans. The large number of Xhosa speakers includes 35% of learners who have a schooling background from the Western Cape and 65% learners from the Eastern Cape.

The significance of the notion language of science as remarked by Ogunniyi (1988) is very clear when he asserts that the language of science which the teacher uses in his/her classroom is foreign to the learners. This is because the background from which the teacher presents or expresses it to the learners does not take the cultural background of the learners in to consideration. Ogunniyi (1986) further contends that learners who use their second language are likely to encounter language problems. This, according to Luthi (1969) would result into learners with a limited or poor vocabulary that could develop comprehension difficulties. Also, this normally results in insensible statements being made by the learners. An example of such insensible statements can be seen in the discussion of chapter four.
Therefore, linguistical development is also directly related to culture. The use of language constitutes the elaboration of culture. The cognitive attainment of knowledge (subject related or general) depends on verbal and other forms of symbolic languages (Ausubel, Hunesian and Novak, 1978). The symbolic meanings of language are socially constructed rather than genetically determined since children live in a cultural setting.

However, language acts as a potential barrier to learning because the classroom language is alien to the everyday language usage of children. Ogunniyi (1988) asserted that the gap between the everyday language and school science is rather broad and Vygotsky (1978) believes that the language of school science should not be different from the cultural everyday language of the learner because life is not demarcated and children should be allowed to communicate in their symbolic languages or cultural metaphors.

In support of the above argument, Rollnick and Rutherford (1996) contends that children develop a language for school and a language for home just like they have a uniform for school and a uniform for home.

This reveals that the meaning for everyday discourse is totally different from that of school science and the modern science has been developed in largely Western countries and hence, its thought forms, concepts and languages are consonant with the language of such societies.

The literature in the work of Patel Stevens et al. in Richardson and Gomez, (2009) reflects that the research groups whose focus is on linguistics and science learning for diverse populations, have the common goal of promoting science learning and scientific inquiry for students from various linguistic and socio-economic backgrounds. Students of diverse backgrounds are capable of learning science and engaging in scientific inquiry. Lee, (2002:56) concurs that teachers need to incorporate cultural and linguistic funds of knowledge that students of diverse backgrounds bring to science and also that teachers need to examine how students’ everyday knowledge and language intersect with scientific principles.
2.5 Alternative Conceptions

The extant literature is replete with research on learners’ misconceptions in science education and among other studies carried out by Nada Chatila Afra et al (2009) where they attempted to investigate the alternative conceptions that a group of 12 Lebanese students in a grade 9 class hold about electricity. It is interesting to note their findings which revealed that most of the common alternative conceptions reported in literature were found across the board i.e. from elementary to university and college, as well as by prospective physics teachers (e.g. Arons, 1997; Cohen, Eylon, & Ganielet, 1983; McDermott & Shaffer, 1992a; Shipstone, Rho¨neck, Jung, Dupin, Joshua, & Licht, 1988).

Nada Chatila Afra et. al (2009) citing (Shipstone et al., 1988) further asserts that it was also found that these alternative conceptions were not confined to one country or to one educational system, but were common to various countries with different educational systems.

Among different concepts related to electric circuit, the understanding of electric current has been the most investigated, and as one of the basic areas in physics, its applications encompass many aspects of our everyday life. Nevertheless, the concept of electricity is a very fertile area for alternative conceptions, in which students develop views and imagery that are very different from scientific ones (Nada et. al, 2009). All that could be done in this study is to briefly allude to the nature of these misconceptions and of the factors responsible for their emergence during the teaching – learning process.

2.5.1 Features of alternative conceptions

Research studies done in science concept of electricity has shown that a number of learners hold a lot of conceptions and alternative worldviews (Ogunniyi, 1999). These conceptions often contradict those taught by the teachers in class and they are mostly termed “misconceptions”. Most people who hold misconceptions
are not aware that their ideas are wrong and possessing them, could have serious negative impacts on the learning of science. A plethora of studies has revealed that a common feature of misconceptions or alternative conceptions is that they are not easily replaced by the valid conceptions presented to the learners in the science classroom but are inextricably linked to the commonsensical and intuitive knowledge about diverse natural phenomena. During the teaching and learning process, learners could be at variance with what the teacher expects them to hold due to misconceptions arising and as a result of that, the teaching and learning process becomes unsuccessful. This could be a huge challenge for a science teacher to address the misconceptions if he/she is not well equipped to do so from the teacher training. As is the case in South Africa, most science teachers at the junior secondary school level are under-qualified, thus exacerbating students’ problems. Added to this is the fact that these teachers are wrongly equipped from their teacher training to deal with learners’ alternative conceptions and pre-conceived knowledge they bring into the science class. The emphasis of the current curriculum, as underpinned by the constructivist epistemology, is on learners’ independent construction of knowledge while the teacher acts as a facilitator of learning. In view of the background leveled on the features of the alternative conceptions one may wonder, if the teacher is not capable to distinguish between the learners’ personal and psychological knowledge structures and knowledge as presented in the textbook. To enhance the learners to perform their task effectively (Taber, 1998), one wonders at the chances of producing a future and strong community of sciences?

2.5.2 Everyday versus Science Worldviews

According to Warren, et al. (2001) daily experiences and ways of talking and knowing are seen not only as discontinuous with those of science but also barriers to robust learning. However, when a learner comes to the science class, he/she comes with a lot of knowledge gained from home, peers and previous grades. It is only in the science class where the learner is torn between two
worlds, i.e. the scientific and the everyday world. Concepts in the scientific domain are defined based on rules, laws and theories, whilst the everyday domain is based on the students' experience gained while interacting with the environment. The learner then attempts to reconcile the two domains and establish his/her new equilibrium.

It is also important to take note of the fact that both teachers and learners bring to class their own beliefs, which may clash or differ depending on their backgrounds. It depends whether or not these beliefs may be compatible with the scientific worldviews, but most importantly, according to Phelan, et al. (1991) teachers need to know how learners negotiate boundaries successfully or how they are impeded by barriers that prevent their connection not only with institutional context, but also with their peers who are different from them.

2.6 Conceptual Difficulties and Conceptual Development

As much as learning is a complex social enterprise, this is a critical area where the actual mediation is imperative. Hudgins (1977:4) argued that what the learner is capable of learning and the way in which learning proceeds are governed by the intellectual schemata or structures that are available to the learner, and these become more numerous and more elaborate with the passage of time. This implies that learning depends upon the learner’s stage of development. There is a possibility of a false assumption to the notion that learning is guaranteed when the relevant materials, resources, physical environment, questioning and threat-free atmosphere are provided. An avenue for a successful learning may be achieved when mediation and development of creative and critical thinking skills are provided. The main purpose of mediation and development is to address some possible misconceptions that the learners may have during the learning process and this is what is known as the conceptual change.
The term conceptual change, like constructivism, is a concept with multiple meanings based on who offers the definition and the theoretical underpinning of such definition. Underlining this definition is the fact that conceptual change is said to have occurred when inappropriate conception is modified to an appropriate one. Taylor (2001) defined conceptual change as the restructuring of pre-existing conceptual structures that the learner has in order to promote understanding of desirable or intended knowledge. In this sense, learning is said to have occurred when new knowledge is formed. It is also imperative to acknowledge that without misconceptions, the individual is left with nothing to change, and it is the desire for change that sustains the curiosity to search for new knowledge.

An example to the above assertion is that, after the learners have gone through a learning process, whether meaningful or not, they are normally assessed by the educator so that the impact of the learning process on their cognitive structure can be evaluated. The main purpose for assessing them is to ascertain if they fully comprehend what was learned and whether the conceptions have changed from those previously held. The feedback that the educators often get is disappointing since they do not get the desired results instantly.

It is agreed to by different scholars (e.g. Arnold and Miller, 1988; Clark, 1998; Driver and Wood-Robinson, 1987; Cobern, 1994; Waldrip and Taylor, 1999) that learners’ conceptions do not undergo major transformations, even after science teaching.

The strong belief systems among some Africans (i.e. Black South Africans) that have been passed on from generation to generation have an influence on conceptual change. In a case of teaching static electricity, the difficulty could be to make them to acquire a scientific knowledge and understand the scientific processes that explain the concept of lightning. Spending some months teaching the concept does not guarantee a complete conceptual change since learners would still believe that witchdoctors are the cause of lightning. Certain rituals such as placing sticks above the door post in a rural hurt could still be followed by learners when a thunderstorm comes. This is to prevent the family from being struck by lightning and is driven by the faith they possess in their parents and the
elders in the communities where they live. They avoid to be seen as being in opposition to the elders.

Cobern (1994) quoting a story narrated by Gunstone whereby a learner did not believe what the educator told him about electricity and only believed in a theory given by his father who was an electrician. Osborne (1985) citing Osborne, Bell and Gilbert indicates that learners’ conceptions do not change because the scientists’ viewpoint appears to children to be less intelligible, plausible and fruitful than their own view. In my view, based on the story narrated, I would argue that when the educators want to introduce a new scientific knowledge, the first thing they need to explore is the content of the learner’s cognitive structure by using a concept map as an instructional tool. There may be some possible misconceptions that might hinder the meaningful learning of new scientific knowledge and they may be addressed so that an alignment of existing knowledge and the new knowledge can be made. This can possibly enhance a successful conceptual change only if the new knowledge is intelligible, plausible and fruitful enough to lower the status of the old existing knowledge.

Vygotsky (1978) asserted that children learn scientific concepts out of tension between their everyday notion and adult concepts. The possible reason for that could well be that, the explanation given to concepts may not be related to the social reality or the environment of the proponents. The teachers should be responsible to foster intellectual conflict through the process of border crossing (as outlined in Ogunniyi, 2002) and to provide the learners with the necessary cognitive tools to resolve the conflict and to accommodate the new concept.

As much as conceptual replacement cannot be an adequate strategy to foster intellectual growth surrounding the learners’ understanding of electricity, it can only be achieved if science educators can attempt to bring the science they teach in class more closely to the cultural and traditional worldview of the learner. This clearly shows the importance of respecting and making use of the learners’ prior belief to serve as a basis for their development of the scientific view of electricity and hence enhance the achievement of the objective.
The process of border crossing, as was mentioned above, considers a learner’s experience with school science in terms of crossing boarders from his traditional or cultural worldview to that of the sub cultures of school science (Aikenhead cited by Fakudze and Ogunniyi, 2002). Ogawa (1986), described this border crossing from one world view (e.g. traditional cultural) to the other (science) as normally resulting in cognitive conflict. He further asserts that the contact between traditional and scientific worldviews results in mental conflicts while Ogunniyi (1988, 2001) contends that, if such a conflict exists at all, it is only a temporary affair which is resolved by the individual through a process he called harmonious dualism.

It is well known today that learners enter the science classroom with all sorts of ideas which are distinctly different from the scientific worldview. However, science teachers somehow believe that they can teach western science in a non-western setting and also assume that by teaching western science, their students will simply throw away their traditional beliefs automatically. It is my belief that to assume the success of the prescribed approach for teaching science, could simply result to endless disappointments for science educators and as mentioned in this section above, the reality becomes more evident after an assessment and evaluation processes are carried out. Ogunniyi (1988) asserted that ways should be found to provide a meaningful point of contact between the two worldviews, i.e. science and traditional worldviews. If western science can be presented in a corresponding way to the African culture, then learners will be in a better vantage to accept the scientific point of view.

2.7 Factors influencing conceptual change

Various factors determine the learners’ ability to plan, execute and appraise their own learning. Some factors are related to the learner’s cognitive disposition while others are environmental. Prior knowledge as espoused by Barnett and Ceci (2002) is one of the crucial factors that influence the learners’ ability to plan, execute and appraise their own learning. How an individual responds to specific
situations is determined by the prior experience that, which is a function of the degree of consistency between one’s cognitive structures and the physical environment that the individual interacts with (Anyanwu, 2008:72).

To facilitate learning, it is essential that an instruction confronts learners with activities that challenge what they have seen or touched before. These activities will enable the learner to trace the relationship between what is being taught and what he/she had learned before the new experience. When there is no stimulation at all, then the difficulty for restructuring to take place will be experienced. More specifically, prior knowledge can be attributed to being an essential resource of intellectual growth.

The time is an important factor that needs to be set aside for learners to allow for reorganization and restructuring of existing cognitive structures as the whole process does not occur incidentally. With enough time available, learners can reflect and evaluate their own ideas and that could enhance the organization of new concepts and the daily use of them.

Another important factor that influences the restructuring of ideas is practice. It provides opportunities for learners to involve all their senses such as heads, minds and body in learning. For learners to work in teams and explore the real world problems, hands-on experience is essential. Insight is another variable that is essential in the restructuring of ideas. For better results, the instruction should aim at in-depth rather than fleeting coverage of numerous science topics and this will facilitate the development of insight. Four main perspectives of science teaching that impact on the development of insights as espoused by Eylon and Linn (1988) include conceptual teaching, developmental teaching, differential teaching and problem solving teaching.

It is not necessary to think that conceptual change is a mere substitution of one idea with another but rather the restructuring of the existing cognitive structures. However, it is essential that teachers are aware of the experience or knowledge that the learners have before the instruction in a science class. Teachers should also be aware that it takes time and a lot of practice for conceptual change to
occur and for the change to take place, the instruction should expose learners to multiple experiences that would enable for the development of new insights.

2.8 Concept Mapping

The growth of our psychological and pedagogical knowledge as well as technological capacities has an impact in the gradual changing role of instructional tools in education. Curriculum materials should be produced for the students and not for the teachers and according to Novak (1965) they should be presented to the learner without using the teacher as a filter through which the subject content reaches the pupils.

When effective instructional tools are used, they reach the learner more clearly and effectively but can also be delivered on an individualized, self-paceable basis. They should be the guidance of independent study, thinking and problem solving and the direction of discussion about issues that are far too controversial or speculative.

According to Ausubel (1968), the major role of instructional tools should be to produce learning outcomes that are either equally as good as, or slightly better than, conventional matters, or to the extent to which these materials facilitate meaningful learning (Ausubel, Hunesian and Novak, 1978).

The importance and impact of the instructional tool, e.g. concept mapping will be discussed for as long as it has counted very little to the goals of individualized instruction in this study.

Llewellyn (2004) defined concept maps:

Concept maps are schematic organizations that identify multiple concepts and their interrelations with each other. Concept maps usually have either a radical (or weblike) orientation, with the main idea in the center of the map, or a hierarchical orientation, with the main idea at the top of the map. Connecting words, cross-links, or short phrases are used to show the relationship between concept and subconcepts.
Llewellyn (2004) further asserts that as the student completes the concept map, the teacher can determine what the student knows about the topic. And as the unit progresses, the student can return to the map and make corrections that emanated from prior misconceptions and additions, citing newly acquired information.

Referring to a study that was carried out, the challenge faced by the science teachers (Novak, 1990:941) was primarily how to organize better instructional material and how to help students learn the material. The results they found reflected that concept maps were useful to represent knowledge in any discipline and aided in organizing and understanding new subject matter. However, the concept mapping is not only a useful tool to represent changes in the knowledge structure of students over time, but also helped them to “learn how to learn”.

Furthermore, Novak (1990) quoting the report on the continuing studies in Nigeria utilizing concept mapping, issued by Jegede, Alaiyemola and Okekubola in the same article, the researchers reported that students in a class using concept mapping, when compared with a group using conventional lecture/expository instruction, received significantly higher mean scores on an achievement test dealing with nutrition in green plants and respiration in cells. He further highlights the use of concept mapping in 49 various aspects of teaching and learning, e.g. for exploring changes in meaning framework; in instructional design; etc.

Emphasizing the significance and effects of concept mapping on learning, Novak (1990) cited Helen & Novak as well as West & Pine as asserting that a concept map helps students to elaborate their conceptual understanding and to modify the knowledge structures that contain misconceptions, alternative conceptions or frameworks. If concept mapping reflected the positive results as stated in the context above, then obviously, similar results could be expected in any context, hence concept mapping has been employed as an instructional strategy in the study.
2.9 Conclusion

Since most science curricula of today are based on concepts, laws and theories which do not take learners' worldviews into consideration, there may be possible evidence that learners might sometimes show no appreciation for the materials presented to them as their performance could drop due to the potential conflict of their worldviews. This means that teachers should take responsibility to play a leadership role that could engage the learners in a science class so that they can develop cognitively and be able to close the gap between the two worldviews. Ogunniyi, (1995), asserts that constructivists believe all learners enter the classroom with their own belief systems which are distinct from those of school science. Efforts should be made to include the learners’ prior knowledge into the teaching and learning process and make learners aware of the merits and demerits of science and the traditional worldview (Ogunniyi, 1988). This process will result in improving their overall understanding of the subject matter. This is then the main focus of this study, to expose the grade ten township learners to the content of electricity through the use of concept mapping as a learning tool.
CHAPTER THREE

METHODOLOGY

3.1 Introduction

This study was concerned with investigating the difficulties encountered by the grade ten township learners with respect to the concept of electricity. However, this chapter describes the step-by-step procedure of the overall research method and design employed in the study to find out the effectiveness of concept mapping in facilitating the learners’ understanding of electricity; to explore the learners’ scientific knowledge by investigating their conceptions or alternative conceptions; to determine the effect of language of instruction and; to explore the learners’ attitudes to science in relation to age and gender issues. Detailed account of the implementation of the instruments, the selection of sample and subjects for the interviews is provided in this chapter in order to achieve the purpose of the study. The process of data gathering, analysis and reporting is also described in the chapter. The study was carried out in a working class area dominated by high rate of illiteracy, poorly constructed and under-resourced schools and poorly trained teachers. There was no permission required from the Education Department as both principals were informed by the respective educators who were involved in the research. They were both supportive and willing to have the research conducted at their respective schools. It could also be noted that random sampling could not be done and for ethical reasons all the grade 10 mathematics and science learners were involved in the study. Lastly, the attempts made by the researcher to ensure ethical conduct will be discussed.
3.2 Sampling Procedure

A subset of measurements selected from a population is called a sample. A researcher uses a sample to make inferences about a population on the basis of characteristics of the sample or, equivalently, the information contained in a sample (Schaeffer, Mendenhall and Otto, 1986).

The total number of subjects who took part in the study initially was eighty-one and according to the criterion that was set for them to be part of the study, they were the new grade ten groups of learners at both high schools. As mentioned in the previous section, they were all registered to do mathematics and science subjects. As pointed out in chapter one, two township high schools in Delft South were involved in the research project with learners who were taking Physical Science as their major subject. Initially, during the pre-test stage the experimental group (E) consisted of a physical science class of 42 learners in total that the researcher found it convenient to be responsible for, and the control group (C) comprised of a class of 39 learners to whom an experienced science head of department (HOD) was responsible for teaching. During the post-test, 35 learners participated and wrote the test at the experimental school (E) while 31 learners wrote at the control group school (C). There was a significant drop in the number of participants from both groups during the post test stage and this was mainly due to absenteeism from school, lost opportunity to write a test due to late coming to class and some other reasons not known by the researcher. The post-test scripts of some learners did not tally with the pre-test scripts and this was an indication that they wrote for the first time since there was no way that their pre-test scripts from the batch could be found, i.e. there were some mismatching scripts.

Due to a significant drop in numbers at the post-test stage, an elimination process had to be undertaken so that the above-mentioned issues and/or reasons could be resolved and an alignment between a pre- and post-test be made. The criterion used to overcome this issue strictly pointed out that, learners who wrote only one test, i.e. either a pre- or post-test were removed from the
study as participants. In other words, they were equally receiving all the teaching and learning benefits received by all those who remained participating in the study, but were not part of the study. After the elimination process was completed, an alignment between the pre- and post-test samples was achieved and this became very helpful to address the mismatches that were posing a challenge. To strike a balance, the number of learners who remained after an elimination process was 35 from the E group and 31 from the C group.

The pre-test results obtained from the ratio 35:31 indicated that the two groups were not comparable. This was discovered from the mean scores obtained when the C group outperformed the E group by a mean difference of 9.22, i.e. C group achieved a mean score 24.16 and the E group mean score was 14.94. A thorough investigation that was carried out to compare the scores indicated that the incomparability was caused by the fluctuating scores within the groups where some of the learners achieved either way too high or low scores than others from each group. As a result of that, further eliminations had to be undertaken and the criterion that governed the elimination was that, at the pre-test stage, any learner that scored less than ten out of the total of seventy-eight shall be removed. Likewise, if a learner scored more than forty out of seventy-eight, he/she will be removed. The main reason for elimination was to maintain the comparability between the samples. This process successfully managed to remove a total of about 18 learners from both groups, i.e. 10 and 8 learners from the E and C groups respectively and the groups became quite comparable.

Two grade ten classes from two quite comparable schools with identical characteristics were selected and the comparability of the schools was established in terms of the following criteria:

a) The two schools were located in similar socio-economic environment.

b) The schools’ infrastructure and the qualifications of the teachers were also similar.

Also, these schools were selected because of their convenient location since the researcher could quickly access the control group school and assist where
possible at the time when troubleshooting could be experienced during the process.

There were two classes of science namely, grade 10.1 and 10.2 at the experimental group (E) school but one was chosen i.e., grade 10.1 to take part in the study. The main reason for choosing only one class was influenced by the following reasons:

- one class, i.e. grade 10.1 was a multi-racial class consisting of Xhosa and Afrikaans speakers taking only mathematics and science while the other class, i.e. grade 10.2 was an interesting mono-cultural class;
- grade 10.2 was created as a result of some learners who registered very late, coming from other schools and locations outside of the Delft area and also from the Eastern Cape. They were predominantly Xhosa speaking learners, some of them repeating grade 10, and the others with very poor science results obtained at the schools from which they came. With the intentions to make a full learner complement in a class, a group of learners taking mixed streams of subjects was allocated to this class to make up the so called a "split class";
- grade 10.2 class comprised of about 40% of learners who chose to do science as an optional choice from their commerce stream of subjects and for that reason, they were not meeting the criterion set, hence elimination was an option for the class;
- both classes were the only grade 10 science classes that the researcher was teaching Physical Science and;
- one set of teaching and learning material was shared among the two classes concurrently.

Various profiles of learners with respect to gender, language, career interests and age groups can be seen represented on a table in the next chapter.
3.3 Methodology

The study initially had a pool that consisted of sixty-six grade ten learners in total from two schools namely, ‘Ibhongo Secondary School’ and ‘Ithemba Secondary School’. The schools participated in the study as experimental group (E) school and control group school (C) respectively. However, the total number was then reduced to forty-eight because of some learners who did not write the pre-and/or post-test due to reasons of absenteeism from class and others that were not known. After a thorough check and elimination of learners who wrote either a pre- or post test the number, sixty-six was then reached and fixed to confirm that specific learners were present in class when the pre- and post test were administered.

Eliminating a group of learners does not necessarily mean that they were completely removed from class during the period of the study. As was mentioned in the previous section, all learners equally benefited from all the interventions that took place and were also promised to further benefit from the findings.

A period of eight weeks broken down into the last three weeks of the first term and five weeks of the second term was set only to pursue the study. The main reason to break the period into a ratio 3:5 was to quickly capture the pre-test data that would inform the researcher about the prior knowledge of the learners. (Driver & Bell, 1986; Roth, 1990) in Shepardson & Moje (1994) asserts that constructivist theory frames learning as an active, continuous process whereby the learner takes information from the environment and construct personal interpretations and meanings based on prior knowledge and experience.

The first three weeks of organizing, preparing and administering the instruments were adequate to capture the necessary data before the schools were closed for the end of the quarter and the planned treatment as well as the post-test was to be carried out at the beginning of the second term over a period of five weeks that was scheduled.
3.4 Research Design

The research design on which this study was based is the Pre-Test-Post-Test Control Group Design as shown in table 3.1 below:

Table 3.1: The Pre-Test-Post-Test Control Group Design

<table>
<thead>
<tr>
<th>Groups</th>
<th>Pre-test</th>
<th>Treatment</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental (E)</td>
<td>$O_1$</td>
<td>X</td>
<td>$O_2$</td>
</tr>
<tr>
<td>Control (C)</td>
<td>$O_3$</td>
<td></td>
<td>$O_4$</td>
</tr>
</tbody>
</table>

$O_1$, $O_2$, $O_3$ and $O_4$ represent subsequent observations and X refers to the treatment condition. More specifically,

$O_1$ and $O_2$ = The pre- and post-test for the true experimental group (E)

X = The treatment, i.e. the instructional method based on concept mapping

$O_3$ and $O_4$ = The pre- and post-test for the control group (C)

However, the group involved in the research will not be randomly selected as in the original design. According to Ogunniyi (1984:85) this is quite a common form of research in social science.

The difference in the scores between the pre-test and the post-test is attributed to the new technique X, i.e., the effect of the concept mapping. The purpose of using the concept mapping as a teaching strategy is that it has become an important tool to help students learn to learn meaningfully, and to help teachers become more effective teachers.
3.4.1 Instrumentation

The instruments adopted in the study were administered in the Western Cape, Northern Cape provinces and in Norway in 1999 for the purpose of Science and Technology Literacy Project (STLP) (See Appendix A). These original instruments were adopted with the hope that their reliability and validity was guaranteed and Ogunniyi, (1999:6) further confirm that the original STLP electricity test, like other STLP instruments went through “copious reviews to establish validity and reliability”.

There were 40 items tested in the original STLP concept of electricity test (COET). Question 5 was treated as having two items where open spaces were provided to be filled in. However, there were thirty-nine items on the test that the learners were tested on during this study and the reason was that question 5 was a recall type question that required the learners to fill in two missing concepts in the spaces that were provided.

A decision was then made by the researcher that the question would rather be treated as a single item. Except for keeping question 5 as a single item, no other changes were effected on the original STLP instrument.

The use of the same test as pre- and post-tests as well as one person doing the research has brought about an added advantage and helped to eliminate the problem of instrumentation threat. Instrumentation threat occurs when a different test from pre-test is used as a post-test and the levels of difficulty for the two tests are not the same (Trochim & Land, 1982).

It could be noted that the concept of electricity test (COET) was testing a section from the static electricity to the current electricity. The first five questions were strictly focusing on the electrostatics while from question six to twelve the emphasis was on electricity. Three main categories of process skills were used to classify the COET and they included process skills of recall type, conceptual understanding and application of knowledge gained by learners. The term “process skills” as used by Ogunniyi and Mikalsen (2004) refers to the learner’s cognitive activity of creating meaning and structure from new information and
experiences. These are seen as “building blocks from which suitable science tasks are constructed” (D.O.E, 2002 p.9 cited by Ogunniyi and Mikalsen, 2004). A summary of concept of electricity test and the process skills attached to each item is shown in table 3.2 below but the actual test is available in Appendix A.

**Table 3.2** A summary of concept of electricity test (COET) and the process skills implied on each item.

<table>
<thead>
<tr>
<th>Category</th>
<th>Question</th>
<th>Item summary</th>
<th>R</th>
<th>C</th>
<th>A</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.1</td>
<td>Learners are to fill in the missing words with respect to electric charges.</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.2</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.3</td>
<td>Learners describe how a charge is induced.</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>1.4</td>
<td>Learners explain how to discharge an object.</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.5</td>
<td>Learners explain the difference between metal and non-metal.</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>1.6</td>
<td>Name the use of spark plug in a motor car engine.</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>2.1</td>
<td>Learners explain what happened to the comb as Jon was combing his hair.</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>2.2</td>
<td>Learners state the charge on the comb when brought near the negatively charged electroscope.</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>State whether charged objects will attract or repel.</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6.1</td>
<td>Learners label the type of an instrument in a given circuit.</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6.2</td>
<td>Learners state what an instrument in a given circuit measure.</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6.3</td>
<td>Learners state the unit for current.</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6.4</td>
<td>Given a series circuit with two ammeters, as well as the reading in one ammeter, learners state what the reading in the other ammeter will be.</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6.5</td>
<td>Given a series circuit with two cells, learners must say what the effect of adding an extra cell would have on the reading of the first ammeter.</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.6</td>
<td>Given a series circuit with two cells, learners must say what the effect of adding an extra cell would have on the brightness of the light bulbs.</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.1</td>
<td>Given a parallel circuit with two bulbs and three ammeters as well as reading of the main current and the other ammeter reading, learners were asked to predict what the reading on the remaining ammeter would be.</td>
<td>✓ ✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.2</td>
<td>Adding another light bulb in parallel with the two already in the circuit, learners must say what the effect of adding another bulb would have on the brightness of the other two bulbs.</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.3</td>
<td>Learners are asked to explain their answer in 7.2</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.4</td>
<td>Learners must say what the effect of adding an extra bulb would have on the reading of A5.</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.1</td>
<td>Learners state the unit for charge.</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.2</td>
<td>Learners state the quantity of charge passing through the ammeter in 1 second in a given a circuit.</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.1</td>
<td>Learners name one use of resistor in a circuit.</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.2</td>
<td>Name four factors that affect resistance.</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.1</td>
<td>Given a circuit with current of 5A and the voltage of 10V, learners calculate the value of the resistance.</td>
<td>✓ ✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.2</td>
<td>When the voltage is increased to 20V, learners state what would happen to the value of the current.</td>
<td>✓ ✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.3</td>
<td>Learners must also say what would happen to the value of the resistance</td>
<td>✓ ✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.1</td>
<td>Learners explain why the wires are insulated.</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.2</td>
<td>Learners must explain why different colours used.</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.3</td>
<td>Learners state what colour is the earth wire.</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.4</td>
<td>Learners state what colour is the live wire.</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.5</td>
<td>Learners state which colour is the neutral wire.</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.6</td>
<td>Learners state which wire is a safety wire.</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.7</td>
<td>Learners state which wire is most dangerous.</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.8</td>
<td>Learners explain why it is called the live wire.</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Learners explain why so many electrical appliances are made from plastic.</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** R = Recall; C = Conceptual understanding; A = Application of concepts.
There are 24 questions of a recall type, 13 questions requiring a conceptual understanding and 9 questions that require an application of the concepts in the table above.

The following instruments used to collect the data included:

(i) Science and Technology Literacy Project instrument on electricity administered in 1999 (Appendix A)
(ii) Concept mapping exercise on electricity (CMEE) (Appendix B)
(iii) Group of learners’ initial attempt to develop a concept map (Appendix C)
(iv) Student Interview (SI) (Appendix D)
(v) Lesson evaluation and reflection forms (LERF) (Appendix E)

3.4.2 Method of data analysis

The data will be analyzed both qualitatively and quantitatively. Specifically, the quantitative data will be collated and analyzed through the use of descriptive and inferential statistics. The qualitative data will be obtained mainly from the interviews and also the lesson evaluation forms that will be reflecting the learners’ views of the lesson taught and will be interpreted in the form of narratives to reinforce the quantitative analyses.

3.4.3 Concept mapping exercise on electricity

This approach was considered to serve as an intervention using concept mapping as an instructional strategy which formed part of the treatment in the experimental group (E). It is when the treatment group was introduced to the simple examples of concept mapping on static electricity at basic level to ensure that the students could adequately handle the concepts during the classroom exercise (See Appendix B).

They were then grouped into small groups of 4 learners per group and instructed to develop their own concept map about an electric current following the steps from the examples that were demonstrated.
3.4.4 Student Interview (SI)

An interview is an appropriate and effective method off which information can be gathered and has a direct bearing on research. An access to the information that is inside a person’s head can be gathered by the researcher through the help of an interview (Takman in Cohen and Manion, 1989).

Interviews that exist in the research may be structured, unstructured or standardized (Patton, 1990). The questions in structured interviews are pre-set and rigidly followed. The respondent is restricted by the questions. Although there is a plan in an unstructured interview, questions are asked as they come to the interviewer’s mind and the respondents can be as broad as they feel like in answering the questions. Patton (1990) viewed an unstructured interview as more like an informal conversation while Smith (1975: 189) refers to unstructured interviews as "depth interviewing".

Schuman and Presser (1981) describe a structured interview as consisting of pre-specified questions and the response of the respondent is greatly restricted. They further describe an unstructured interview as allowing the respondent to freely express his/her view on a certain issue.

Questions asked in an interview can either be open-ended or closed (also known as fixed response questions). In an open-ended interview (unlike a close ended one), the respondents are not limited by choice, but they express themselves in their own words. In a way this is good because the interviewee gets to open up and to express himself/herself freely on a subject matter. Semi structured interviews, which Patton refers to as an "interview guided approach" seem to strike a balance between the two extremes. Questions or issues to be covered are specified in advance in an outline form but the interviewer will decide on the sequence or wording of the questions in the course of the interview. The guide will be kept as a checklist of issues to be covered but
there will still be room for the interview to become fairly conversational and situational and logical gaps can be closed (Patton, 1990).

It is worth noting as outlined in Appendix D that the type of interviews that were conducted with students was semi-structured. The reason for opting to use this type of interview was based on hoping to elicit more information from learners, as suggested by Kvale (1996:1) to researchers that if you want to know how people understand their world and their life, it is imperative to talk with them. He further asserts that in an interview conversation, the researcher listens to what people themselves tell about their lived worlds, hears them express their views and opinions in their own words. Therefore the qualitative research interview attempts to understand the world from the subject’s point of view (Kvale, 1996:1).

A group interview was conducted with a group of eight learners, four boys and four girls after the formal observation process. Careful race and gender considerations were taken care of as the experimental group (E) consisted of multiracial subjects. A group interview was opted for rather than individual interviews with learners because young children are likely to be more responsive and spontaneous in an informal, semi-structured group setting. The group discussion was 30 minutes long in the classroom after a shortened period school day due to sports with some light snack provided for learners and was facilitated by the researcher. A group question guide was developed (Appendix D) in advance by the researcher to stimulate discussion and to maintain the focus of the discussion. The language used in the session to conduct an interview was that of the learners’ instruction and was recorded and transcribed. Apparently, it became evident that the learners preferred to use English instead of their home language to express themselves as they felt more comfortable during the interview. During the process, they made a concerted effort to ensure that all that they were saying in English was captured as it is, regardless of how they spoke the language. This has then brought about a far less effort that was needed to translate from Xhosa and Afrikaans to English during the transcription process.
3.4.5 Lesson evaluation and reflection forms

These are the forms given to learners after the post-test was carried out to evaluate the lesson on the topic of electricity that was taught using the concept mapping as an instructional tool. They then reflect to the lesson, expressing their thoughts about the challenges experienced during the lesson (see Appendix E).

3.5 Ethical issues

Any research endeavor that involve people or animals subscribe to ethical issues. For the purpose of anonymity, the names of the schools where the study was carried out and the names of the subjects that were involved have not been disclosed in the report. However, considering the protection and respect of the schools and the parties concerned, pseudonym for the schools was used. Although the learners have provided their names in the manuscripts, they are not mentioned in the study for the sake of maintaining strict confidentiality.

My intentions to conduct the research and how it would affect the normal running of the classroom and scheduling were discussed with the principals from both schools participating in the study. As the research involved dealing with the learners, with due respect, I had to seek their approval to continue the study with them and record what was going on. In doing so, I explained the aims of the research and how the school would benefit from the findings. All the learners without exception willingly participated in the study, and most fortunately, it related to their class work and daily experiences in the Delft and the surrounding areas where they came from.
3.6 Summary

This chapter looked at the research design methodology applied and gave a description of how the data was analyzed in the study. The data collection methods were also described as well as data analysis and ethics statement. A summary of the concept of electricity test indicating the process skills attached to each item is also available in table 3.2 but the actual test can be accessed in the appendix section namely, Appendix A.

The research analysis, results and the summary of findings, recommendations as well as conclusions reached in the study are discussed in chapters four and five respectively.
CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

The previous chapter gave a description and focused at how the research was approached and coordinated. As stated previously, the aim of the research was to investigate the difficulties encountered by the grade ten township learners with respect to the concept of electricity.

This chapter summarizes the findings and will report on the analysis of data using both qualitative and quantitative. In addition to the qualitative descriptions, the learners’ responses to the interviews are used to elaborate on their performance on both tests. A related aim was to explore the learners’ scientific knowledge by investigating their conceptions, alternative conceptions and/or misconceptions about electricity; the influence of learners’ career interests, age and gender issues on their conceptions of electricity and the effectiveness of concept mapping in facilitating the learners’ understanding of electricity. To analyze and report the findings on the data, a framework to enhance some possible answers to the research questions was developed and the discussion is generated thereof for each research question.

The study involved two comparable groups of new grade ten learners registered to do mathematics and science subjects. The teaching methodology applied to an experimental group (E) included an exposure of learners to concept mapping by the researcher (see full details recovered in Appendix B) while the control group (C) was taught through an expository and more teacher centered chalk-and-talk approach by the experienced science head of department (HOD). To gain a deeper insight about whether or not the use of concept mapping enhanced their better understanding of the concept of electricity, eight learners from the experimental group were interviewed.
The next section shall present a comprehensive analysis of the sample profiles according to gender, language, career interests and age.

4.2 Profile of sample

The details of the profile of the sample painted below, indicates the actual sample that remained from the elimination process discussed in chapter 3. The elimination process was carried out to preserve the coherence of selection criteria.

4.2.1 Gender Profile of Sample

The composition was such that the total number of subjects in the research comprised of 25 males and 23 females who were all from both the experimental (E) and control (C) group schools. The profile of learners by gender and research groups is illustrated in Table 4.1.

<table>
<thead>
<tr>
<th>Gender</th>
<th>Experimental group (E)</th>
<th>Control group (C)</th>
<th>Total</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>12 (48%)</td>
<td>13 (52%)</td>
<td>25</td>
<td>52%</td>
</tr>
<tr>
<td>Female</td>
<td>13 (57%)</td>
<td>10 (43%)</td>
<td>23</td>
<td>48%</td>
</tr>
<tr>
<td>Total</td>
<td>25 (52%)</td>
<td>23 (48%)</td>
<td>48</td>
<td>100%</td>
</tr>
</tbody>
</table>

n(%); N = 48

4.2.2 Language Profile of Sample

The biographical information captured from the manuscripts showed that a large number (69%) of the subjects were Xhosa speakers and (31%) were Afrikaans speakers. It is evident that the Afrikaans language was poorly represented in the sample groups (See table 4.2 below).
Table 4.2 Profile of learners by language and research groups

<table>
<thead>
<tr>
<th>Language</th>
<th>Experimental group (E)</th>
<th>Control group (C)</th>
<th>Total</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xhosa</td>
<td>18 (72%)</td>
<td>15 (65%)</td>
<td>33</td>
<td>69%</td>
</tr>
<tr>
<td>Afrikaans</td>
<td>07 (28%)</td>
<td>08 (35%)</td>
<td>15</td>
<td>31%</td>
</tr>
<tr>
<td>Total</td>
<td>25 (52%)</td>
<td>23 (48%)</td>
<td>48</td>
<td>100%</td>
</tr>
</tbody>
</table>

n(%) ; N = 48

4.2.3 Career Interest Profile of Sample

The choice of career interests was one of the concerns of the study to evaluate the effect of conceptual understanding of electricity. A variety of career choices were made by subjects and were grouped according to various categories such as medical, engineering, social services, business, arts, sciences and sport. A reservation for an additional category was made to accommodate those learners who were not sure about the career of their interest and was labeled “unknown”. The table that illustrates their responses about their career choices is shown below.

Table 4.3 Profile of learners by gender and career interests

<table>
<thead>
<tr>
<th>Gender</th>
<th>Career Interests</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Medical</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Engineering</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Social services</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sciences</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Arts</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sport</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unknown</td>
<td></td>
</tr>
</tbody>
</table>

| Male   | 04 (16%)   | 06 (24%) | 06 (24%) | 04 (16%) | 00 (0%) | 02 (8%) | 03 (12%) | 25 (52%) |
| Female | 09 (39%)   | 04 (17%) | 07 (30%) | 00 (0%)  | 03 (13%)| 00 (0%) | 00 (0%)  | 23 (48%) |
| Total  | 13 (27%)   | 10 (21%) | 13 (27%) | 04 (8%)  | 03 (6%) | 02 (4%) | 03 (6%)  | 48       |

n(%) ; N = 48

Table 4.3 shows that out of a composition of 48 learners in the study, 52% are males and 48% are females. The highest percentage i.e. (27%) of learners,
including both males and females has shown their interest in the career of medicine and social services.

The next field that has shown its popularity to (21%) of learners is the host of careers within the engineering field. This was followed by the science career with its low (8%) of learners who have demonstrated their interest on it as their future career.

A concerning evidence from the data captured is that there was very little or no interest shown in the careers namely, sciences particularly by females, arts by males and sports by females as they were poorly represented. The maximum percentage of learners who showed their interest within the listed careers of concern was (8%) for sciences and the minimum percentage was (4%) for sports careers.

Sciences got a buy-in to on average, only (8%) of all learners which translated to only four males, i.e. (16%) out of forty eight learners which have chosen it as their future career interest while none of the females were interested to choose it. A composition of about 6% learners was not sure what to choose as their career interests and that translated to only three males out of the total of forty-eight learners in the study.

4.2.4 Age Profile of Sample

The age of the participants was ranging between 13 years and above 16 years. The least number of learners’ ages, i.e. only one learner was 14 years while more learners were ranging between 15 and above 16 years in grade 10. The age profile was tabulated according to gender so that a relative comparison between the boys and girls could be made.
Table 4.4 Age profile of learners by gender

<table>
<thead>
<tr>
<th>Age in years</th>
<th>Males</th>
<th>Females</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>00 (0%)</td>
<td>00 (0%)</td>
<td>00 (0%)</td>
</tr>
<tr>
<td>14</td>
<td>00 (0%)</td>
<td>01 (4%)</td>
<td>01 (2%)</td>
</tr>
<tr>
<td>15</td>
<td>05 (20%)</td>
<td>10 (43%)</td>
<td>15 (31%)</td>
</tr>
<tr>
<td>16</td>
<td>10 (40%)</td>
<td>11 (48%)</td>
<td>21 (44%)</td>
</tr>
<tr>
<td>Above 16</td>
<td>10 (40%)</td>
<td>01 (4%)</td>
<td>11 (23%)</td>
</tr>
<tr>
<td>Total</td>
<td>25 (52%)</td>
<td>23 (48%)</td>
<td>48</td>
</tr>
</tbody>
</table>

n(%) ; N = 48

The profile illustrated in table 4.4 above displays that there are more females than males in each of the age groups namely, 14, 15 and 16 year olds while only in the age group of over 16 years the males were dominant in numbers than females. There are no learners represented in the age group 13 years. It is common in the South African schools, particularly the township high schools to find learners in grade 10 at minimum age 16 and above. Very rarely or not at all can there be 14 year olds in a township grade 10 class, and what has been displayed by table 4.4 may need to be confirmed at a later stage.

A combined effect of both males and females is then displayed in the last column to show the total number of learners in a particular age group, i.e. boys and girls sharing the same age.

As was stated earlier above, a large percentage of learners (44%) were 16 years of age, followed by (31%) learners who were 15 years old. About (23%) of learners were above 16 year old while none of the learners belonged to the age group of 13 years old. Only (2%) was the poor representation of the 14 years old group of learners.

### 4.2.5 Summary profile of Sample according to gender, language, age and career interests

The profile of sample was then organized, collated and summarized. It is worth noting that the summary illustrated in table 4.5 below displays the following characteristics:
- a large number of females than males with respect to gender;
- most learners’ home language is Xhosa followed by Afrikaans;
- there are more learners that are sixteen years old, followed by fifteen year olds, over sixteen years etc.
- it also appears that most learners’ career interests are on medical followed by social services and engineering. The interest shown in sciences career is demonstrated as being far too low.

**Table 4.5 Summary profile of learners according to gender, language, age and career interests**

<table>
<thead>
<tr>
<th>Gender</th>
<th>Males</th>
<th>Females</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>25</td>
<td>23</td>
<td>48</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Language</th>
<th>Xhosa</th>
<th>Afrikaans</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>33</td>
<td>15</td>
<td>48</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age</th>
<th>13 years</th>
<th>14 years</th>
<th>15 years</th>
<th>16 years</th>
<th>Over 16 years</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>1</td>
<td>15</td>
<td>21</td>
<td>11</td>
<td>48</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Career interests</th>
<th>Medical</th>
<th>Engineering</th>
<th>Social services</th>
<th>Sciences</th>
<th>Arts</th>
<th>Sport</th>
<th>Unknown</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>13</td>
<td>10</td>
<td>13</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>48</td>
</tr>
</tbody>
</table>
4.3 Pre-test Results on the Concept of Electricity Test (COET)

The instruments adopted from the Science and Technology Literacy Project (STLP) that were administered in the Western Cape, Northern Cape Province and in Norway in 1999 were also administered to a pool that consisted of a total of sixty-six grade ten learners at the experimental group (E) and the control group (C) schools combined.

It can be emphasized that the pre-test was administered in the two schools, i.e. experimental (E) and the control (C) group schools simultaneously. This process was carefully carried out to prevent any possible contamination of data and the science teacher i.e. an (HOD) at the control group school had been very effective and co-operative during the process of administering the Concept of Electricity Test (COET).

The performance of both the experimental (E) and control (C) groups was measured by means of the coding scale that ranged between x and 2, where the descriptor of the code allocated to each item was used to denote the following:

- x - No attempt/ No response
- 0 - Wrong answer due to one or more misconceptions and a lack of content knowledge
- 1 - Partially correct answer but based on incorrect reasoning
- 2 - Correct reasoning, accurate and scientific explanation

As mentioned in the sub-section on instrumentation in the previous chapter, there were thirty nine items on the instrument that the learners were tested on and the meaning attached to the codes for each answer provided by the learner per item was characterized and analyzed using a developed assessment framework. However, the assessment framework as shown below in table 4.6 was used as a tool to categorize each learner according to various levels of understanding of the concept of electricity. A set of code descriptors and their meanings is in
column A of the table and the set of characteristics attached to each descriptor is available in column B of the table.

Table 4.6  Assessment framework – levels of learners' understanding of the concept of electricity

<table>
<thead>
<tr>
<th>Column A: Code descriptor</th>
<th>Column B: Characteristics</th>
</tr>
</thead>
</table>
| x - No attempt/ No response | ▪ Leaving the answer sheet blank  
▪ Do not know/ have no clue at all  
▪ Do not understand |
| 0 - Wrong answer due to one or more misconceptions and a lack of content knowledge | ▪ Inappropriate responses  
▪ Consists of some misconceptions  
▪ Response includes some components of invalid scientific understanding |
| 1 - Partially correct answer but based on incorrect reasoning | ▪ Answer arrived at through one or more alternative conceptions  
▪ Wrong working but correct answer |
| 2 - Correct reasoning accurate and scientific explanation | ▪ Response includes all the components of the validated response |

With reference to the above framework and for ease of its reference, there are four different levels of understanding designated within the range from x to 2 (Table 4.6). However, table 4.6 above is applicable to reveal which themes or items have or have not been mastered by the learners. The coding scale ranging from x to 2 indicates the learners’ understanding about the concept of electricity and more specifically, the rating from x to 0 indicate some measure of very little or lack of understanding of the concept of electricity. The rating score 1 indicate some measure of a poor understanding of the concept of electricity which also include some alternative conceptions, misconceptions in some cases and some
partially correct answers but reached out through some wrong working while a score rated 2 depict a better understanding of the concept of electricity.

4.3.1 An exploration of the learners’ performance according to their conceptions of electricity at the pre-test stage

The null hypothesis posited in chapter one was that there would be no relationship between the learners’ conceptions of electricity and their career interests, gender and/or age. Table 4.7(a) below attempts to demonstrate the frequency distribution of the learners according to the levels of understanding of the concept of electricity. This includes the learners from both the experimental (E) and control (C) groups so that a comparison in terms of the frequency distribution per question item and/or group of question items can be made.

The entries on table 4.7(a) on each column below the sub-heading labeled, levels of learners’ understanding of concept represent the percentage of learners who subscribe to certain characteristics of a given score per question item(s). These entries are useful in giving a sense of how many learners have acquired each score per question item(s). Furthermore, the first column in the table represents different categories of process skills needed to classify the learners’ concept of electricity such as: recall; conceptual understanding; and application of knowledge (A).

The second column shows a summary of items starting from the Static Electricity (question items 1 – 5) to Electric Current also known as electricity (question items 6 – 12) in the main concept of electricity test (COET).
Table 4.7(a) Process skills coded as used by the learners to perform cognitive tasks on the COET at the pre-test stage.

<table>
<thead>
<tr>
<th>Process Skills</th>
<th>Electricity and associated concepts</th>
<th>Levels of learners’ understanding</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Summary of question items</td>
<td>Exp % (N = 25)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>x 0 1 2</td>
</tr>
<tr>
<td>Recall</td>
<td>1.1 - 1.6 (Fill in types of charges)</td>
<td>9  41  0 50</td>
</tr>
<tr>
<td></td>
<td>3 (Stating the use of a spark plug)</td>
<td>16 80  4  0</td>
</tr>
<tr>
<td></td>
<td>5 (Type of forces between charges)</td>
<td>4   80  0  16</td>
</tr>
<tr>
<td></td>
<td>6.1 - 6.3 (Identify instrument, stating use of instrument, unit of current)</td>
<td>24 47  0 29</td>
</tr>
<tr>
<td></td>
<td>8.1 - 8.2 (Unit of charge; Stating charge)</td>
<td>42 58  0  0</td>
</tr>
<tr>
<td></td>
<td>9.1 - 9.2 (Stating use of resistor; Naming factors affecting resistance)</td>
<td>34 60  4  2</td>
</tr>
<tr>
<td></td>
<td>11.1 - 11.8 (Stating reason for insulation; Stating colours of wires)</td>
<td>9   67  5 20</td>
</tr>
<tr>
<td></td>
<td>12 (Stating reason for insulating electrical appliances)</td>
<td>4   32  28 36</td>
</tr>
<tr>
<td></td>
<td>Sub-section average</td>
<td>18  58  5 19</td>
</tr>
<tr>
<td>Conceptual understanding only</td>
<td>2.3 (Deducing if non-metals conduct electricity)</td>
<td>0   4  76 20</td>
</tr>
<tr>
<td></td>
<td>6.4 (Deducing the ammeter reading in a given circuit)</td>
<td>8   72  0 20</td>
</tr>
<tr>
<td></td>
<td>6.6 (Deducing the effect of adding an extra cell to the brightness of the bulb)</td>
<td>8   44  0 48</td>
</tr>
<tr>
<td></td>
<td>7.2 - 7.4 (Deducing the effect of adding another bulb in parallel with the two already in circuit; Explanation required; Effect of adding extra bulb on the ammeter)</td>
<td>19  71  1  9</td>
</tr>
<tr>
<td></td>
<td>Sub-section average</td>
<td>9   48  19 24</td>
</tr>
<tr>
<td>Application only</td>
<td>6.5 (Determining the effect of adding a cell to the ammeter reading in circuit)</td>
<td>16  60  0 24</td>
</tr>
<tr>
<td></td>
<td>10.1 (Calculation of resistance)</td>
<td>8   44  48 0</td>
</tr>
<tr>
<td></td>
<td>Sub-section average</td>
<td>12  52  24 12</td>
</tr>
<tr>
<td>Conceptual understanding and application</td>
<td>2.1 - 2.2 (Determining and explaining how the charge got induced)</td>
<td>8   88  0  4</td>
</tr>
</tbody>
</table>
Note: R = Recall; C = Conceptual understanding; A = Application of concepts.
X = no response; 0 = Wrong answer due to one or more misconceptions and a lack of content knowledge; 1 = Partially correct answer but based on incorrect reasoning; 2 = Correct reasoning accurate and scientific explanation.

Experimental group (N=25); Control group (N=23).

The mean score for E group was 14.94 compared to 24.14 for C group. In other words, C group outperformed E group by a wide margin thus making both groups incomparable. However, in view of the fact that C group teacher was the only person willing to participate in the study at the time, a random elimination of the outliers was done. Thus the number of subjects in C group dropped from 31 to 23. Also, for fairness purposes the same approach was used for the E group and the final number of E dropped from 35 to 25. Thus the mean scores for E and C group stood at 19.20 and 20.96 respectively. As a result the two groups became comparable. However, for ethical reasons, the outliers also participated in the study though only the scores of learners in the re-constituted groups were analyzed in the study. The t-test deployed to compare the reconstituted E and C groups shows a t-ratio of 1.28 which is far less than the critical value of 2.02 required to falsify the null hypothesis at $\alpha = 0.05$. 

<table>
<thead>
<tr>
<th>Sub-section average</th>
<th>11</th>
<th>70</th>
<th>2</th>
<th>17</th>
<th>26</th>
<th>54</th>
<th>1</th>
<th>19</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1 - 4.2 (Determining the induction of charge; Predicting the type of electric charge on the comb)</td>
<td>6</td>
<td>70</td>
<td>4</td>
<td>20</td>
<td>22</td>
<td>46</td>
<td>7</td>
<td>26</td>
</tr>
<tr>
<td>7.1 (Predicting the ammeter reading in a parallel circuit)</td>
<td>12</td>
<td>72</td>
<td>0</td>
<td>16</td>
<td>13</td>
<td>74</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>10.2 (Determining the effect of doubling voltage on current)</td>
<td>8</td>
<td>60</td>
<td>0</td>
<td>32</td>
<td>39</td>
<td>26</td>
<td>0</td>
<td>35</td>
</tr>
<tr>
<td>10.3 (Determining how doubling the voltage would affect resistance)</td>
<td>20</td>
<td>60</td>
<td>8</td>
<td>12</td>
<td>48</td>
<td>30</td>
<td>0</td>
<td>22</td>
</tr>
</tbody>
</table>
4.3.2 Justifying the nature of the pre-test results obtained before the elimination of samples

The mean scores obtained at pre-test above have indicated that the C group has performed better than the E group. Further attempts made including a conversation with the science HOD to gain a deeper understanding for their performance revealed apparently that the topic on electricity was already lightly introduced at grade nine level. According to the science teacher, the intention was to give learners a better opportunity to do well in grade ten since, according to their experiences, the teaching and learning of the topic was found to be challenging particularly to the new and inexperienced teaching staff members who just joined the teaching staff. Another interesting issue raised by the C group teacher was that about 9% of the science learners in that particular class were repeating grade ten.

In view of all the above performance accompanied by the teacher's commentary, the researcher then considered the limitations and the narrow scope within which the study was carried out and decided to go ahead with the process up to the post-test stage, provided the process of eliminating some dominating elements had to be undertaken first. The biggest challenge about the narrow scope mentioned above was that:

- the schools where the study was carried out were the only multi-racial high schools in the Delft South area;
- the two high schools were located in similar socio-economic environment and;
- the schools’ infrastructure, level of experiences and the qualifications of the teachers were also similar.

A possible assumption about the performance of the C group can be made based on the notions that the learners were introduced to the section from grade nine and that there are some learners who were repeating the grade. Possibly, these notions may have had an influence that could contribute to the learners’
advantage over the written test which may have enhanced the extreme top achievers. Most importantly, the opportunity that was available was to pursue the process up to the post-test stage to further observe if there could be any possible shift that could be enhanced by the intervention process within the E group. Table 4.7(b) below was then established for the purpose of further statistical analysis of the two reconstituted E and C groups.

**Table 4.7(b) Learners’ performance on the COET at the Pre-test stage**

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean %</th>
<th>Mean</th>
<th>SD</th>
<th>t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>25</td>
<td>24.6</td>
<td>19.20</td>
<td>4.40</td>
<td>2-tailed test</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>( t_{calc}(1.28) &lt; t_{crit}(±2.02) )</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>( \alpha = 0.05; \text{df} = 46 )</td>
</tr>
<tr>
<td>C</td>
<td>23</td>
<td>26.9</td>
<td>20.96</td>
<td>5.08</td>
<td></td>
</tr>
</tbody>
</table>

*Note: N – number of learners  df – degree of freedom;  SD – standard deviation*

An obtained t-value from the t-test employed indicated a t-value of 1.28 which was between the critical values -2.02 and 2.02. In other words, there is no significant difference between the two groups. This idea is further reinforced by the fact that the relatively low standard deviations (SD) of 4.40 and 5.08 for E and C groups respectively are indicative that the two groups were very much comparable. However, judging by the mean percentages of 24.6% and 26.9% for E and C groups respectively, it is obvious that they are very low.

**A summary of process skills demonstrated by learners on the COET.**

The summary below attempts to report on what has transpired in terms of various process skills as demonstrated by learners on the COET after the outliers had been eliminated. Furthermore, it points out the percentage quantity of learners subscribing to certain characteristics of a given score per question item(s) on each type of process skill in question.
Accompanying the analysis of learner responses at various question items, are sample examples of statements made by learners from E and C groups.

- Process skills of recall type

A close examination of the Table 4.7(a) indicates that, comparing the E group and the C group respectively on recall; about 18% of E group learners did not attempt to answer the questions while 21% of C group learners left the answer sheet blank. About 58% of E group learners demonstrated conceptions ranging from poor content knowledge of electricity, inappropriate and nonsensical notions, to misconceptions while about 45% of C group learners gave erroneous conceptions of electricity. Selecting some examples on recall e.g. items 1.1 to 1.6; it appears that E group did poorly with 50% learners displaying a sound understanding of electricity compared to 59% scored by the C group.

Question item 3 requires the learner to state the use of a spark plug in a car. This question is the most poorly attempted by E and C groups with about 80% and 43% E and C group learners respectively showing a lack of knowledge and various kinds of misconceptions. The following statements are representative of the learners’ conceptions of static electricity at the E group:

- “puts petrol in a car”
- “makes the car fast”
- “start the car when there is no petrol”

Question item 5 expected learners to identify the types of forces between charges. Only 16% and 35% at the E and C groups respectively showed a sound understanding of the concept. It appears that the learners were guessing what they thought were the correct answers for the charges e.g. terms such as “attract” and “repel” were suggested by a number of learners. The following phrases are representative in this regard:

- “pull towards” and “push away from”
- “stick to” and “break away”
“come to” and “go away from” or vice versa

Question 6.1 to 6.3 required learners to identify the instrument, stating its use and the unit of current. About 47% and 58% in the E and C groups respectively demonstrated no understanding of the concepts and also supplied inappropriate responses. In this regard the E group slightly outperformed the C group.

In question 8.1 and 8.2 learners had to mention the unit of charge as well as state the quantity of charge passing through the ammeter per second. None of the learners from the E group got the answer correct while only 11% C group learners showed an understanding and the correct reasoning with accurate and scientific explanation. The results also show that about 58% at E group had no clue and hence displayed more misconceptions on each of the two questions while 48% of C group learners showed no understanding of the electricity.

Questions 9.1 and 9.2 regarding resistor and factors that affect resistance were poorly answered. About 60% and 43% learners from the E and C groups respectively gave incorrect answers. Their responses included certain invalid scientific understanding, and only 4% of E group learners displayed some partially correct answers arrived at through one or more alternative conceptions. Similarly, only 4% C group learners achieved partially correct answers. Although the questions were poorly answered, it is evident that the learners in C group performed better with an average of 22% compared to their counterparts in the E group whose average was 19% in the recall category.

Question items 11.1 to 11.8 required learners to state the reason for insulating electric wires. Learners were also required to state the colours of the wires. These questions were poorly answered by the E group with 67% learners displaying inappropriate responses compared to 72% in the C group. Interesting conceptions held by E group learners in relation to question 11.1 were noted as follows:

“So that people will not choke”
“To cover the wires not to touch and burn the house”
“To make them make electric go fast”
“They keep the energy covered safe inside the wire”

In relation to question 11.2, the conceptions of learners at E group learners were as follows:

“So that you know where it go”
“So that you can see the dangerous one”
“Maybe to make the right connectors”

Question 12 expected the learners to state the reason for insulating electrical appliances made from plastic. Various reasons were offered by E group learners which included the following few interesting conceptions:

“The plastic is a rubber”
“The electric cannot burn plastic kettle”
“The hot wires cannot melt the electric appliances”

With regard to the above mentioned conceptions held by learners, the table indicated that 32% E group learners compared to 26% C group learners offered inappropriate conceptions.

- Conceptual understanding only

With reference to the process skills, E group learners performed slightly better than C group learners. In this regard, about 24% of E group learners compared to 23% C group learners demonstrated a sound understanding of the electricity. Items 2.3, 6.4, 6.6 and 7.2 to 7.4 were examined to determine the nature of the learners’ responses with respect to conceptual understanding only. Item 2.3 expected the learners to deduce and explain if metals and non-metals conduct electricity. The responses to this question showed that 20% of E group learners gave the correct answer compared to 13% in the C group.
There was also a noticeable trend showing a misunderstanding or inappropriate explanations by the E group as can be seen in the following excerpt:

“No, Sipho would not get a shock because the door was made from wood”
“No, the particle would be a little bit far from each other”
“No, Because wood is not as dangerous as metal"

Item 6.4 expected the learners to deduce the ammeter reading in a given circuit. About 72% E group learners compared to 57% C group learners gave incorrect responses. They could hardly associate the principle of the resistors connected in series in a circuit with the same amount of current flowing through each resistor. Hence, only a few (i.e. 20% and 30% of E and C group learners respectively) got the correct and accurately reasoned answers.

Item 6.6 was also poorly answered by both groups of learners. The item expected the learners to deduce the effect of adding an extra cell to the brightness of the bulb. About 44% E group and 39% C group learners respectively failed to demonstrate the correct answer.

Items 7.2 to 7.4 expected the learners to deduce the effect of adding another light bulb in parallel with the two already in circuit; explanation required; and an effect of adding an extra bulb on the ammeter. These questions were not well answered. About 19% and 39% E and C group learners respectively left the items unanswered. On the same set of question items, about 71% E group and 48% C group learners failed to demonstrate the correct answer. However, only 9% learners in the E group demonstrated a correct reasoning and accurate scientific explanations compared to 12% learners in the C group.
■ Application only

Items 6.5 and 10.1 were concerned with the application of conceptions. In this regard, on average, about 12% of E group learners compared to 16% C group learners held valid understanding of electricity. On the whole, about 52% of the learners at E group compared to 50% at C group held inadequate knowledge of electricity. Item 6.5 expected the learners to determine the effect of adding a cell to the ammeter reading in the circuit. About 60% E group compared to 65% C group learners gave inappropriate answers to this item.

Item 10.1 expected the learners to calculate resistance. None of the learners from the E group gave the correct answer to this item while only 9% learners from the C group demonstrated a sound understanding and application. However, about 48% E and 30% C group learners respectively offered partially correct responses largely arrived at through wrong calculation.

■ Conceptual understanding and application

The items that were grouped together in this category include: 2.1 to 2.2; 4.1 to 4.2; 7.1; 10.2 and 10.3. The expectation was that the learners should be able to determine, predict and explain some issues around static and current electricity. On the average 70% and 54% of E and C group learners respectively performed poorly. Only 17% and 19% of E and C group learners respectively displayed a sound understanding of the concepts in question.

Items 2.1 to 2.2 expected the learners to determine and explain the induction of charge. More than 80% learners in each group, i.e. E and C group gave inappropriate answers to these items. Only 4% of learners in the E group held valid understanding of charge induction compared to none in the C group.

Items 4.1 to 4.2 were also poorly answered by both groups. The items expected the learners to determine the induction of charge and predict the type of electric
charge on the comb. Inappropriate answers were offered by about 70% E and 46% C group of learners respectively to these items. A sound understanding was demonstrated by 20% in the E group compared to 26% of their counterparts in the C group.

Learners in item 7.1 had to predict the ammeter reading in a parallel circuit. About 72% and 74% of E and C group learners respectively gave incorrect responses. However, 16% learners in E group got the correct and accurately reasoned answer compared to 13% learners in C group.

Items 10.2 and 10.3 were concerned with the effect of doubling the voltage on the current and resistance. Item 10.2 was left unanswered by only 8% E and 39% C group learners respectively demonstrated valid conceptions of electricity. About 60% and 26% E and C group learners respectively offered inappropriate conceptions. However, 32% and 35% of E and C group learners respectively demonstrated a sound understanding of the concept. Item 10.3 was also poorly answered. Only 12% and 22% of E and C group learners respectively gave appropriate answer to this item. Likewise, only 8% E compared to 60% C group learners offered partially correct responses while about 60% E and 30% C group learners gave inappropriate answers showing a lack of understanding of the concept of electricity.

4.3.3 An exploration of the learners’ performance on the COET according to gender at the pre-test stage

Gender as a fundamental attribute in most cultures could enhance the way in which learners are socialized in their socio-cultural roles as well as influence their overall behaviour. This influence gender on learners’ classroom behaviour has been well reported in the literature (e.g. Kahle, 1988; Sjoberg & Imsa, 1988). According to Kahle (1988) science in most cultures is socially defined as a male domain. Sjoberg and Imsa (1988) argue further that boys choose science to
prove their manhood as opposed to girls. They also point out that girls may experience rejection from their female counterparts if they choose science. Table 4.8 below indicates the overall learners’ performance on the COET based on gender at the pre-test stage.

Table 4.8 Learners’ performance on the COET based on gender.

<table>
<thead>
<tr>
<th>Group</th>
<th>Gender</th>
<th>N</th>
<th>Mean %</th>
<th>Mean</th>
<th>SD</th>
<th>t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>All</td>
<td>25</td>
<td>24.6</td>
<td>19.20</td>
<td>4.40</td>
<td>2-tailed test</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>All</td>
<td>23</td>
<td>26.9</td>
<td>20.96</td>
<td>5.08</td>
<td>(α = 0.05; df = 46)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>Males</td>
<td>12</td>
<td>25.4</td>
<td>19.83</td>
<td>5.22</td>
<td>2-tailed test</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Females</td>
<td>13</td>
<td>23.9</td>
<td>18.62</td>
<td>3.59</td>
<td>(α = 0.05; df = 23)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Males</td>
<td>13</td>
<td>25.7</td>
<td>20.08</td>
<td>5.07</td>
<td>2-tailed test</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Females</td>
<td>10</td>
<td>28.3</td>
<td>22.10</td>
<td>5.11</td>
<td>(α = 0.05; df = 21)</td>
</tr>
</tbody>
</table>

Note: N – number of learners; SD – standard deviation; df – degree of freedom

Table 4.8 above employed was specifically focusing on the learners' conceptions and gender issues. The mean percentages are also included to demonstrate a better picture in terms of the overall performance of each group.

The close values for the mean scores of E group (19.83 and 18.62 for males and females respectively) indicated the very similar scores for the two groups.

Using the two-tailed t-test when comparing the average performance of males versus that of females within the E group, it became apparent that the calculated t- value of 0.67 at α = 0.05 was between the critical t- values -1.71 and +1.71 needed to reject the null hypothesis. Statistically speaking, this indicates that there is no significant difference between the mean scores of males and females at the pre-test stage; hence their performance scores on the COET were quite
similar. However, a similar pattern was noticeable from the C group where the t-value of 0.94 obtained was between the critical t-values -1.72 and +1.72. This displayed that there is no statistical significant difference between the males and females at the pre-test stage. The idea at the C group results is further reinforced by the relatively low standard deviations (SD) of 5.07 and 5.11 achieved for males and females respectively to indicate that the two groups are quite comparable. Furthermore, at E group, the males have slightly outperformed their female counterparts by a mean difference of 1.21 while at C group the females outperformed the males by a mean difference of 2.02.

4.3.4 An exploration of the learners’ performance on the COET according to career interests at the pre-test stage

In relation to the career choices, learners indicated seventeen different career choices. However, for ease of analysis these careers were grouped into six main categories suggested in an earlier study (Ogunniyi, 1999) namely, medical field; engineering; social services; sciences; arts and sport. There are also some learners who did not indicate their career choices and for that reason, a reservation for an additional category labeled “unknown” was also made.

Table 4.9 Learners’ performance on the COET according to career choices at the pre-test stage.

<table>
<thead>
<tr>
<th>Career</th>
<th>Experimental group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean %</td>
</tr>
<tr>
<td>Medical</td>
<td>8</td>
<td>21.0</td>
</tr>
<tr>
<td>Engineering</td>
<td>5</td>
<td>29.0</td>
</tr>
<tr>
<td>Social services</td>
<td>5</td>
<td>24.9</td>
</tr>
<tr>
<td>Sciences</td>
<td>4</td>
<td>27.2</td>
</tr>
<tr>
<td>Arts</td>
<td>2</td>
<td>25.6</td>
</tr>
<tr>
<td>Sport</td>
<td>1</td>
<td>22.0</td>
</tr>
<tr>
<td>Unknown</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>25</td>
<td>-</td>
</tr>
</tbody>
</table>

Note: N – number of learners; SD – standard deviation
An examination of Table 4.9 above displays the first three main careers namely, medical, engineering and social services as being the most popular and appealing to the E and C groups. However, a noticeable evidence shows that these careers were well represented compared to the sciences, arts and sports. Given the low achievement, one can conclude that both groups had a poor understanding of the concepts tested on the COET. The performance shown by the E and C group relative to the first three main careers listed in table 4.9 indicated that the highest mean score of 22.60 was obtained by the E group for the engineering careers while the highest mean score of 23.25 was obtained by C group for social sciences. In terms of the second highest mean scores, the E group obtained about 19.40 in the social sciences while the C group obtained 22.40 in engineering careers. A medical career displayed the mean scores of 16.38 and 17.00 as obtained by the E and C groups respectively. However, the C group has slightly outperformed the E group in the engineering and social services careers while the E group has performed better than the C group only at the medical career.

Table 4.9 also showed that both groups when combined, about 10 to 13 learners per career choice showed their interest into medical, engineering and social services careers while sciences, arts and sports deserved a far too low interest from them. Again this pattern is similar to the one obtained in an earlier large-scale study (Ogunniyi, 1999). In view of the high disparity in N, I did not consider it reasonable to calculate the t-value.

4.3.5 An exploration of the learners’ performance on the COET according to age at the pre-test stage

Under normal conditions, the age of learners in most grade 10 township schools should be between 16 and 17 years. An exploration of their performance on account of their age is as shown according to experimental (E) and control (C) groups together in Table 4.10(a) below.
Table 4.10(a)  Learners’ performance on the COET based on age.

<table>
<thead>
<tr>
<th>Age</th>
<th>Experimental group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean %</td>
</tr>
<tr>
<td>14</td>
<td>1</td>
<td>24.36</td>
</tr>
<tr>
<td>15</td>
<td>6</td>
<td>24.15</td>
</tr>
<tr>
<td>16</td>
<td>10</td>
<td>24.74</td>
</tr>
<tr>
<td>16+</td>
<td>8</td>
<td>24.84</td>
</tr>
<tr>
<td>Total</td>
<td>25</td>
<td></td>
</tr>
</tbody>
</table>

Note: N – number of learners; SD – standard deviation

An examination of Table 4.10(a) indicates that the learners involved in this study are quite varied in terms of age and the way in which they performed in the COET. Although the performance of the E and C group in the COET was poor at the pre-test stage, the mean percentage achieved by the 15 year olds at C group was the highest, i.e. 29.06% of all the means percentages at various ages while at E group the highest mean percentage obtained was 24.84% by the 16+ year olds. The 16 year olds at E group obtained a mean percentage of 24.74% while their counterparts at C group obtained 26.69%. Furthermore, table 4.10(a) indicates a steady increase of the mean percentages, i.e. from 24.15% to 24.84% for the E group as the learners grow older while at C group the pattern displays a steady drop, i.e. from 29.06% to 20.94% as they grow older. The reason for the reversed performance of the C group cannot be explicitly explained at this exploratory stage but, it might be possible that some factors concerning the conceptual difficulties and development, language instruction etc. affected the performance of the learner because their mother tongue. Given the mean percentages obtained at both groups, one can conclude that only at E group, there is an observable contradiction to the expected phenomenon that younger learners would always perform better than the older ones since their performance drops as they get older. The 14 year old learner from the E group was discarded since it could be unreasonable to consider analyzing the only learner belonging to this age group. No t- values were calculated to evaluate the significance levels according to age due to the high disparity in N.
Table 4.10(b)  Comparison of significance levels on performance of learners based on age.

<table>
<thead>
<tr>
<th>Age</th>
<th>N</th>
<th>Mean %</th>
<th>Mean</th>
<th>SD</th>
<th>N</th>
<th>Mean %</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>6</td>
<td>24.15</td>
<td>18.83</td>
<td>3.06</td>
<td>9</td>
<td>29.06</td>
<td>22.67</td>
<td>3.67</td>
</tr>
<tr>
<td>16</td>
<td>10</td>
<td>24.74</td>
<td>19.30</td>
<td>4.99</td>
<td>11</td>
<td>26.69</td>
<td>20.82</td>
<td>5.96</td>
</tr>
<tr>
<td>16+</td>
<td>8</td>
<td>24.84</td>
<td>19.38</td>
<td>5.24</td>
<td>3</td>
<td>20.94</td>
<td>16.33</td>
<td>2.52</td>
</tr>
</tbody>
</table>

Note: N – number of learners;  SD – standard deviation;  df – degree of freedom

The results in table 4.10(b) indicates that with the high disparity in N at age groups 15, 16 and 16+ and also at α = 0.05, the t- ratios greater than the critical t- values ±2.18, ±2.09 and ±2.31 at df = 13, df = 19 and df = 9 respectively are needed to reject the null hypothesis suggesting a significant difference. However, in no case was any t- value as large as the critical t- values listed above, and this implies that no statistically significant difference existed between the E and C groups in terms of their respective age groups. The findings from the researches done by Adams (1990), Ogunniyi (1999) and Solomon (2001) revealed that there was no significant difference in performance of older learners to that of the younger ones and similarly, the results from this study are confirming the earlier findings. The phenomenon mentioned earlier of younger learners performing better than the older ones is rather contrary to the expectations because generally, it is expected that older learners will perform better than the younger counterparts. The reason for this expectation is that they are supposed to have undergone more intellectual development that could enhance an achievement of certain levels of their maturity to be able to perform certain functions.
4.5 Post-test Results

This section sought to determine the difference in the learners’ performance at the post test stage. It also seeks to examine the effectiveness of a treatment received by the E group when a concept mapping was employed as an instructional tool to facilitate the learners’ understanding of electricity. A comparison of the pre- and post test results shall be discussed in a more detailed process and some feedback from learner interviews on this regard shall also be explored to confirm whether the use of the concept mapping has been a good success or not.

At the post test stage, Table 4.10 which includes an E and C groups was generated and some more useful comparison of the learners’ performance was discussed in pursuit of finding some possible answers to the research question in chapter one.

Table 4.10 Process skills coded as used by the learners to perform cognitive tasks on the COET at the post-test stage.

<table>
<thead>
<tr>
<th>Process Skills</th>
<th>Electricity and associated concepts</th>
<th>Levels of learners’ understanding</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Summary of question items</td>
<td>Exp % (N = 25)</td>
</tr>
<tr>
<td>1.1 - 1.6 (Fill in types of charges)</td>
<td>x 0 1 2</td>
<td>x 0 1 2</td>
</tr>
<tr>
<td>3 (Stating the use of a spark plug)</td>
<td>7 49 0 43</td>
<td>3 36 0 62</td>
</tr>
<tr>
<td>5 (Type of forces between charges)</td>
<td>0 44 0 56</td>
<td>0 52 0 48</td>
</tr>
<tr>
<td>6.1 - 6.3 (Identify instrument, stating use of instrument, unit of current)</td>
<td>5 57 0 37</td>
<td>1 45 0 54</td>
</tr>
<tr>
<td>8.1 - 8.2 (Unit of charge; Stating charge)</td>
<td>16 76 0 8</td>
<td>11 67 0 22</td>
</tr>
<tr>
<td>9.1 - 9.2 (Stating use of resistor; Naming factors affecting resistance)</td>
<td>14 36 16 34</td>
<td>11 35 9 46</td>
</tr>
<tr>
<td>11.1 - 11.8 (Stating reason for insulation; Stating colours of wires)</td>
<td>2 53 11 34</td>
<td>2 67 17 13</td>
</tr>
<tr>
<td>12 (Stating reason for insulating electrical appliances)</td>
<td>4 12 36 48</td>
<td>0 48 35 17</td>
</tr>
<tr>
<td>Sub-section average</td>
<td>9 46 8 37</td>
<td>6 53 9 33</td>
</tr>
<tr>
<td>Conceptual understanding only</td>
<td>2.3 (Deducing if non-metals conduct electricity)</td>
<td>0 8 16 76 0 13 30 57</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>--------------------------------------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td></td>
<td>6.4 (Deducing the ammeter reading in a given circuit)</td>
<td>4 64 0 32 4 70 0 26</td>
</tr>
<tr>
<td></td>
<td>6.6 (Deducing the effect of adding an extra cell to the brightness of the bulb)</td>
<td>4 12 4 80 17 43 0 39</td>
</tr>
<tr>
<td></td>
<td>7.2 - 7.4 (Deducing the effect of adding another bulb in parallel with the two already in circuit; Explanation required; Effect of adding extra bulb on the ammeter)</td>
<td>13 53 3 31 29 59 0 12</td>
</tr>
<tr>
<td>Sub-section average</td>
<td>5 34 6 55 13 46 8 34</td>
<td></td>
</tr>
<tr>
<td>Application only</td>
<td>6.5 (Determining the effect of adding a cell to the ammeter reading in circuit)</td>
<td>12 36 0 52 4 65 0 30</td>
</tr>
<tr>
<td></td>
<td>10.1 (Calculation of resistance)</td>
<td>4 40 28 28 4 65 26 4</td>
</tr>
<tr>
<td>Sub-section average</td>
<td>8 38 14 40 4 65 13 17</td>
<td></td>
</tr>
<tr>
<td>Conceptual understanding and application</td>
<td>2.1 - 2.2 (Determining and explaining how the charge got induced)</td>
<td>0 48 12 40 2 85 11 2</td>
</tr>
<tr>
<td></td>
<td>4.1 - 4.2 (Determining the induction of charge; Predicting the type of electric charge on the comb)</td>
<td>0 48 2 50 4 63 15 17</td>
</tr>
<tr>
<td></td>
<td>7.1 (Predicting the ammeter reading in a parallel circuit)</td>
<td>0 80 0 20 9 61 0 30</td>
</tr>
<tr>
<td></td>
<td>10.2 (Determining the effect of doubling voltage on current)</td>
<td>4 44 0 52 4 83 0 13</td>
</tr>
<tr>
<td></td>
<td>10.3 (Determining how doubling the voltage would affect resistance)</td>
<td>8 36 4 52 9 43 0 48</td>
</tr>
<tr>
<td>Sub-section average</td>
<td>2 51 4 43 6 67 5 22</td>
<td></td>
</tr>
</tbody>
</table>

**Note**: R = Recall; C = Conceptual understanding; A = Application of concepts. X = no response; 0 = Wrong answer due to one or more misconceptions and a lack of content knowledge; 1 = Partially correct answer but based on incorrect reasoning; 2 = Correct reasoning accurate and scientific explanation. Experimental group (N=25); Control group (N=23).

**A summary of performance at various process skills demonstrated by learners on the COET at the post-test stage.**

An exploration of Table 4.10 above indicates that there has been a slightly positive shift in the performance as demonstrated by the learners in E group compared to their (i.e. E group learners) performance at the pre-test stage (see Table 4.7(a)). Furthermore, an overall examination of Table 4.10 shows a trend.
which indicates a drop in the average percentage number of learners who left items unattended with respect to all the process skills in question. The average percentage number of E and C group learners respectively who provided wrong responses due to misconceptions has dropped significantly from the pre- to post-test stage. However, on average, there were an increased percentage number of E group learners who offered correct and scientifically valid responses compared to C group learners. Though the C group also experienced similar behavior, the E group outperformed their counterparts at all levels of the process skills in question.

- Process skill of recall type

Comparing the performance of E and C group on recall, on average, 46% and 53% learners respectively gave incorrect responses. About 37% learners in the E group offered scientifically valid answers compared to 33% learners in the C group. Partially correct responses were also offered by 8% E and 9% C group learners compared to pre-test performance that indicated an overall of about 5% E and 12% C group learners.

More specifically, in items 1.1 to 1.6 it appears that 43% learners at the E group gave correct answers compared to 62% learners at C group. Though the C group percentage number of learners increased from 59% at pre-test to 62% at post-test, the E group learners performed poorly and encountered a drop from 50% at pre-test to 43% at post-test.

Item 3 expected the learners to state the use of spark plugs. About 40% learners at the E group gave wrong answers to this item compared to 70% learners at the C group who demonstrated a similar behavior. It is interesting to note that at pre-test stage, 80% learners at E group who demonstrated wrong answers are represented by about half the percentage number of E group learners who demonstrated a similar pattern at post-test stage while the percentage number of C group learners who offered wrong answers has increased from 43% at pre-test to 70% at post-test. This question was poorly answered by both groups.
About 32% learners in E group offered correct response to the item while none of the learners in C group could demonstrate an understanding to the question.

Item 5 was concerned about the type of forces between charges. A demonstration of understanding of forces between charges was evident since about 56% learners in E group offered appropriate answers compared to 48% learners in C group. In view of the fact that the question expected either a correct or incorrect answer, none of the two groups left the question unattended.

Items 6.1 to 6.3 required learners to identify the instrument, stating its use and the unit of current. The results to these items indicated that the learners in the E group performed poorly than their counterparts in C group. About 37% and 54% E and C groups’ learners respectively demonstrated an understanding of the concept and supplied correct reasoning behind it. The E group was outperformed by the C group on these items as was the opposite experience during the pre-test stage.

In item 8.1 and 8.2, learners were expected to state the charge and its unit. The question was poorly answered by learners from both groups. About 76% and 67% learners in E and C groups respectively demonstrated inappropriate responses. Only 8% E group learners stated the charge and its unit correctly compared to 22% learners in C group. The results in table 4.7(a) with respect to this item indicate that a similar behavior pattern in terms of difficulties to attempt the questions was experienced at pre-test.

Questions 9.1 and 9.2 regarding resistor and factors that affect resistance were poorly answered by the E group compared to the C group. About 34% and 46% learners at E and C groups displayed sound understanding of the concept of electricity. This displayed a better performance at post-test compared to the performance at pre-test stage. The learners' responses included certain invalid scientific understanding, and about 16% of E group learners displayed some partially correct answers arrived at through one or more alternative conceptions.
while only 9% C group learners achieved partially correct answers to these items. Due to some difficulties experienced by learners, about 14% learners in E group did not attempt to answer the questions. Similarly, 11% learners in C group left the question unattended.

Items 11.1 to 11.8 were poorly answered by C group as was the case during the pre-test stage when compared to E group. The questions required learners to state the reason for insulating electric wires. Learners were also required to state the colours of the wires. Inappropriate answers showing a lack of understanding of the concept were offered by 53% and 67% learners in E and C groups respectively. Partially correct answers were also displayed by about 11% learners in E group compared to 17% of their counterparts in C group. However, 34% E group learners gave correct answers with accompanied by accurate reasoning and scientific explanation. A similar behavior pattern was demonstrated by only 13% of their counterparts in C group.

Question item 12 was also poorly answered by learners in C group. The item expected the learners to state the reason for insulating electrical appliances made from plastic. Learners in E group gave valid answers and scored 48% in their levels of understanding. They got an opportunity to outperform their counterparts in C group who scored 17% in this item. However, about 36% and 35% learners in E and C groups respectively displayed some partially correct answers that were arrived at through incorrect reasoning. Wrong answers were also demonstrated by 12% learners in E group compared to 48% of their counterparts in C group.

- Conceptual understanding only

Items 2.3, 6.4, 6.6 and 7.2 to 7.4 required some learner skill of type “conceptual understanding only”. An overall performance to this process skill’s category displayed that an average of 34% learners in E group supplied wrong answers to the questions compared to 46% learners in C group. This showed a lack of
understanding of the concept of electricity by learners at both groups. On the whole, only 6% and 8% learners in E and C groups respectively demonstrated some partially correct answers to the items in question. About 55% learners in E group gave the scientifically valid responses compared to 34% learners in C group.

Item 2.3 expected the learners to deduce and explain if metals and non-metals conduct electricity. The question to this item was better performed by learners in both groups. About 76% and 57% learners in E and C groups respectively demonstrated some understanding of the concepts and also gave scientifically valid reasoning. There was a trend of some partially correct responses displayed by 16% E group learners compared to 30% of their counterparts in C group. Only 8% learners in E group and 13% in C group gave inappropriate responses to the question.

To answer item 6.4, learners were expected to deduce the ammeter reading in a given circuit. About 64% and 70% learners in E and C groups respectively demonstrated wrong responses to the question showing little or no understanding of the concept of electricity. Only 32% learners in E group compared to 26% of their counterparts in C group displayed correct answers. About 4% learners in each of the groups did not attempt to answer the question.

Item 6.6 was poorly answered by learners of the C group. The item expected the learners to deduce the effect of adding an extra cell to the brightness of the bulb. Scientifically valid responses were offered by about 80% and 39% learners in E and C groups respectively. This was an indication to show how well the E group had a handle to the concept in question. About 4% learners in E group provided partially correct answers while none of the learners in C group behaved similarly. Inappropriate responses were displayed by 12% and 43% learners in E and C groups respectively.
Questions 7.2 to 7.4 expected learners to be able to deduce the effect of adding another light bulb in parallel with the two already in circuit; explanation required; and an effect of adding an extra bulb on the ammeter. The responses to these questions were poor. More than 50% learners from both groups offered inappropriate responses to the questions. About 3% learners in E group demonstrated partially correct answerers while none of the learners in C group could demonstrate a similar behavior pattern. Thus, about 31% learners at E group outperformed 12% learners at C group by demonstrating valid answers on these items.

- Application only

The type of process skill such as “application only” required learners to be able to apply the knowledge acquired in relevant contexts. Learners were expected to apply the process skill mentioned above to items 6.5 and 10.1 only. An examination to the overall performance indicates that on average, the E group has outperformed their counterparts in the C group. On the whole, learners in E group scored an average of 40% upon their demonstration of an understanding of the concept of electricity while their counterparts in C group scored 17%.

More specifically, item 6.5 expected the learners to determine the effect of adding a cell to the ammeter reading in the circuit. The performance to this question was such that 52% of learners in E group showed and adequate understanding of the concept. Similarly, about 30% of learners in C group displayed a similar behavior pattern. About 36% and 65% of learners in E and C groups respectively failed to demonstrate the correct answer to the question. About 12% learners in E and only 4% in C groups did not attempt to answer the item due to very little or no clue about the concepts in question.

Item 10.1 was concerned about the calculation of the resistance. About 40% and 65% of the learners in E and C group respectively demonstrated inappropriate responses showing some misconceptions and a lack of content knowledge to this...
item. Partially correct answers that were arrived at through incorrect calculation scored the learners in E group about 28% compared to 26% that was scored by their counterparts in the C group. Correct and accurate responses by about 28% of learners at E group showed that some proper conceptions about the concepts at hand were held while at C group, only 4% of learners demonstrated the same behavior pattern.

- Conceptual understanding and application

In this category, the items that were grouped together include: 2.1 to 2.2, 4.1 to 4.2, 7.1, 10.2 and 10.3. A close examination to the items in this group indicates that on average, more than 50% of learners in both groups held some misconceptions and hence demonstrated some answers that were inappropriate. Items 2.1 to 2.2 expected the learners to determine and also explain the induction of charge. Table 4.10 displayed that 48% and 85% E and C group learners respectively demonstrated erroneous conceptions of the concepts. About 12% and 11% are scores offered to indicate some partially correct answers accompanied by incorrect reasoning. Also, about 40% and 2% of E and C group learners respectively demonstrated a partial conception in this regard.

Items 4.1 to 4.2 were concerned with determining the induction of charge and predicting the type of electric charge on the comb. Correct responses to these items were offered by 50% and 17% E and C group learners respectively. About 2% and 15% of learners in E and C group respectively gave partially correct answers but based on incorrect reasoning. Inappropriate responses accompanied by misconceptions were demonstrated by 48% learners in E group compared to 63% of their counterparts in C group.

Question item 7.1 was poorly answered by both groups. This item expected learners to predict the ammeter reading in a parallel circuit. About 80% and 61% of learners in E and C group respectively failed to demonstrate a correct
response to the item. An example of responses to the item offered by learners in E group displaying some misconceptions can be seen in the following excerpt:

"It will be dim"

"Same brightness"

"It will light up"

"It is dull"

About 20% of learners in E group and 30% in C group gave the correct answer to the question.

Items 10.2 and 10.3 expected the learners to determine the effect of doubling the voltage on the current and resistance. Item 10.2 was poorly answered by learners in C group. About 52% and 13% learners in E and C groups respectively gave correct answers to the item while 44% learners in E group and 83% of their counterparts in C group failed to display correct responses. Only 4% learners in each of the E and C groups did not have a clue at all and decided to leave the answer sheet blank.

In question item 10.3, the E group demonstrated correct answer and scored 52% compared to 48% of their counterparts in C group. Only 4% of the learners in E group gave partially correct answers that were arrived at through alternative conceptions while no partially correct answers were displayed by learners in C group. About 36% and 43% learners in E and C groups respectively failed to display some valid answers and hence their responses were declared inappropriate. Learners in E group did not have a clue to answer the item and left the question unanswered and hence they scored about 8% in item 10.3 compared to 9% scored by their counterparts in C group.
4.6 Comparison of pre- and post-test

Various aspects such as the gender and age were explored and comparisons between the pre-and-post-test were made relative to the performance of learners on account of such variables. The discussion on this regard will be helpful to facilitate a further discussion in the next sections about the effectiveness of a treatment received by the E group relative to the well known treatment received by the C group where the traditional, expository chalk-and-talk approach was administered throughout.

The results at the pre-test stage indicate that both groups did poorly since their mean scores were very low and below 21 out of the total 78. This translates to a highest mean percentage of about 26.9%. Though the two groups remained comparable, learners in the E group obtained a mean score of 19.20 and were slightly outperformed by learners in C group who obtained a mean score of 20.96 (see Table 4.8).

However, at the post-test stage, the mean percentage scored by learners in E group for their performance on each of the process skills in question displayed an increase by 8.7% and hence resulted in a “gap” between E group and their counterparts in C group. In other words, a “gap” between the two groups has probably been widened by the influence of the effort made by E group of learners after they received a treatment. It may well have been noticed that the post-test discussion on the issues of learner performance on various process skills under examination was centered on an increasing and better performance by the E group compared to the C group.

An exploratory examination of the performance is further presented graphically to provide much clearer implication of making a comparison between the pre-and-post-test results and the conceptual change as demonstrated by learners in figure 4.1 below.
Fig. 4.1  Learners’ performance on the COET at the pre- and post-test stage

It is worth noting from Fig. 4.1 above, that the E group was outperformed by the C group at pre-test stage in terms of demonstrating correct responses to the questions that required the application of the process skills namely, recall; application only and; conceptual understanding and application.

The descriptor “correct responses to the questions” is linked to code 2 in figure 4.1 above. In terms of code 1, i.e. partially correct answers but based on incorrect reasoning, it is also interesting to have noted from the graph that the E group displayed a higher average percentage compared to the C group in the process skills namely, conceptual understanding only; application only and conceptual understanding at pre-test stage.

Inappropriate responses linked to code 0 at pre-test stage were also demonstrated by on average, more than 50% of learners at each of the groups in the following examples of process skills: 58% learners in E group on recall; 52% and 50% learners in E and C groups respectively on application only;
70% and 54% learners in E and C groups respectively on conceptual understanding and application.

Similarly, at the post-test stage the E group has outperformed the C group with respect to displaying scientifically valid responses in the following examples of process skills: recall; conceptual understanding only; application only and conceptual understanding and application.

In terms of the partially correct answers, the C group did better than the E group in the process skills which include: recall; conceptual understanding only and conceptual understanding and application.

Some responses that were inappropriate were also displayed by an average of more than 50% learners in the following set of process skills: 53% learners in C group on recall; 65% learners in C group on application only; 51% and 67% learners in E and C groups respectively on conceptual understanding and application. Although E group outperformed C group at the post-test stage, the graph suggests possible impact that the treatment might have had on E group. Better performance demonstrated by E group at the post-test, that is, over and above that of C group, in terms of a set of process skills include: 37% on recall; 55% on conceptual understanding only; 40% on application only, and 43% on conceptual understanding and application. Further examples of such performance can be confirmed from figure 4.2 below which seeks to compare the performance in the COET at the pre-and post-test stage from within each group.
Fig. 4.2 A comparison of pre-and-post-test results on each process skills’ category on the COET

The pre- and post-test results of E group depicted in Fig. 4.2 shows a significant increase in the average percentages in all the process skills under examination. A typical example is the type of questions that required a process skill namely, “recall” where E group at pre-test stage obtained an average of 5% compared to 37% obtained at post-test. A similar pattern of scientifically valid responses was demonstrated by E group learners in the following examples of process skills: 24% learners compared to 55% learners on the conceptual understanding only; 12% compared to 40% learners on application only and 17% compared to 43% on conceptual understanding and application.

The smallest difference between pre- and post-test results achieved by the E group was 18% on process skill “recall”. On the other hand, the highest difference between pre- and post-test results by the E group was 31% on process skill “conceptual understanding” only. Fig. 4.2 also showed an observable drop of some inappropriate responses offered by learners in E group.
between the pre- and post-test stages. With regard to C group, a steady increase in understanding from the pre- to post-test on some of the process skills under was noticed. The examples of such process skills include, recall with average pre-test percentage rising from 22% to 33% at the post-test; conceptual understanding only from 23% to 34%; application only from 16% 17%, and conceptual understanding and application from 19% and 22%. The smallest gain by C group was only 1% with respect to process skill that required “application only”. The highest average percentage gained by C group was 11% from two sets of process skills namely, recall and conceptual understanding only. The graph also showed a drop in the partially correct responses offered by the learners regarding process skills such as: recall from 12% to 9%; conceptual understanding only from 18% to 8% and application only from 15% to 13%. There was also a noticeable increase of incorrect conceptions on certain process skills under question such as: recall from 45% to 53%; conceptual understanding only from 39% to 46%; application only from 50% to 65% and conceptual understanding and application from 54% to 67%.

A close examination of Fig. 4.2 above suggests increased understanding of various aspects of electricity from the pre- to the post-test most probably as a result of exposing E learners to concept mapping. Further discussion on marked increment of conceptual understanding of the concept as a result of the treatment will be presented in section 4.8. However, since the C group also performed better at the post-test than at the pre-test it is likely that the traditional expository instructional approach had also had some positive impact.
4.7 Post-test Descriptive Statistics

The raw scores obtained by the learners, i.e. E and C groups at the post-test ranged between 19 and 49 out of a total of 78. Their percentage mean scores and standard deviations are presented in Table 4.11 below.

Table 4.11 Performance of the learners on the COET at the post-test stage

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean %</th>
<th>Mean</th>
<th>SD</th>
<th>t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>25</td>
<td>42.4</td>
<td>33.04</td>
<td>6.57</td>
<td>2-tailed test $t_{\text{calc}}(0.03) &lt; t_{\text{crit}}(\pm 2.02)$ $(\alpha = 0.05; \text{df} = 46)$</td>
</tr>
<tr>
<td>C</td>
<td>23</td>
<td>33.7</td>
<td>26.26</td>
<td>2.42</td>
<td></td>
</tr>
</tbody>
</table>

Note: N – number of learners; df – degree of freedom; SD – standard deviation

The overall picture shows that none of the groups has achieved a mean percentage of above 50%. However, the group that performed slightly better was the E group with a mean percentage of 42.4% followed by C group with a mean percentage of 33.7%. At the pre-test stage, the mean score of the E group was 19.20 compared to 33.04 obtained at post-test. This means that there was a mean gain of 13.84 after E group had been exposed to the treatment. The pre-test mean score for the C group was 20.96 and at the post-test stage the mean score obtained was 26.26, i.e. a mean gain of 5.30. A t-value greater than plus or minus critical t-ratio of 2.02 at $\alpha = 0.05$ was needed to reject the null hypothesis suggesting no significant difference. However, none of the cases showed any calculated t-value as large as $\pm 2.02$ and this implies that no statistically significant difference exists between the pre- and post test scores though there was a mean difference between the pre- and post-test that exists. However, it is not at this exploratory stage where the reason for the better performance can be explicitly explained. Further qualitative data from the interviews provided additional insight in this regard.
4.7.1 An exploration of the learners’ performance on the COET according to gender at the post-test stage

Table 4.12 below explores the shift encountered from the pre- to post-test by the E and C groups and to see if the shift is significant or not. However, it also indicates which gender has successfully put more effort between the males and females such that better results could be achieved resulting to the benefit of the bigger groups, i.e. E and C group.

Table 4.12  Learners’ performance on the COET based on gender.

<table>
<thead>
<tr>
<th>Group</th>
<th>Gender</th>
<th>N</th>
<th>Mean %</th>
<th>Mean</th>
<th>SD</th>
<th>t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>Males</td>
<td>12</td>
<td>41.88</td>
<td>32.67</td>
<td>7.06</td>
<td>2-tailed test</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>( t_{\text{calc}} (0.40) &lt; t_{\text{crit}} (\pm 1.71) )</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>( \alpha = 0.05; \text{df} = 23 )</td>
</tr>
<tr>
<td></td>
<td>Females</td>
<td>13</td>
<td>42.80</td>
<td>33.38</td>
<td>6.34</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Males</td>
<td>13</td>
<td>32.64</td>
<td>25.46</td>
<td>2.88</td>
<td>2-tailed test</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>( t_{\text{calc}} (0.02) &lt; t_{\text{crit}} (\pm 1.72) )</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>( \alpha = 0.05; \text{df} = 21 )</td>
</tr>
<tr>
<td></td>
<td>Females</td>
<td>10</td>
<td>35.00</td>
<td>27.30</td>
<td>1.06</td>
<td></td>
</tr>
</tbody>
</table>

Note: \( N \) – number of learners; \( SD \) – standard deviation; \( df \) – degree of freedom

The results in Table 4.12 above were obtained from comparing the performance within each of the groups, i.e. males and females at E and C groups. The post-test mean scores obtained by males and females at the E group were almost equal and the calculated \( t \)-value is 0.40 at \( \alpha = 0.05 \) against a critical \( t \)-ratio of \( \pm 1.71 \). However, there is sufficient evidence to believe that there is no significant difference between the males and females within the E group. The mean scores for the C group show that the females obtained a slightly higher mean score of 27.30 than their male counterparts who obtained 25.46. This means that the females outperformed the males by a mean difference of 1.84 and the calculated \( t \)-value is 0.02 at \( \alpha = 0.05 \) against a critical \( t \)-ratio of \( \pm 1.72 \). With the exception that the females outperformed their male counterparts at both groups, there is no
evidence to suggest a significant difference in performance between males and females at C group in as far as they are both within the region between the ±critical t- ratios.

4.7.2 A statistical comparison of the learners’ pre- and post-test performance on the COET on account of gender

A pre- and post-test statistical comparison between the two groups on account of gender (see Table 4.13) indicates that there was an improvement in terms of the mean scores achieved by the E and C groups when comparing their pre- and post-tests. The pre-test results showed that the males in the E group obtained a mean score 19.83 and were slightly outperformed by the males who obtained a mean score 20.08 at C group. It is at C group only where the males were outperformed by their female counterparts while at the E group, the males did slightly better than the females. It could also be noticeable that the pre- and post-test results displayed a very small mean difference in performance between the males and females at the E group and since \( t_{\text{calc}} = 0.67 < t_{\text{crit}} = \pm 1.71 \) for the pre-test and \( t_{\text{calc}} = 0.40 < t_{\text{crit}} = \pm 1.71 \) for the post-test at \( \alpha = 0.05 \) and the degree of freedom (df = 23) according to the data, no statistically significant difference exists between the two groups. Likewise, the C group has demonstrated a similar pattern since \( t_{\text{calc}} = 0.94 < t_{\text{crit}} = \pm 1.72 \) at pre-test and \( t_{\text{calc}} = 0.02 < t_{\text{crit}} = \pm 1.72 \) for the post-test at \( \alpha = 0.05 \) and the degree of freedom (df = 21).
Table 4.13 Pre- and post-test scores on the COET according to gender.

<table>
<thead>
<tr>
<th>Gender</th>
<th>Experimental group (N = 25)</th>
<th>Control group (N = 23)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-test</td>
<td>Post-test</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Males</td>
<td>19.83</td>
<td>5.22</td>
</tr>
<tr>
<td>Females</td>
<td>18.62</td>
<td>3.59</td>
</tr>
<tr>
<td>t-value</td>
<td>$t_{calc}(0.67) &lt; t_{crit}(±1.71)$</td>
<td>$t_{calc}(0.40) &lt; t_{crit}(±1.71)$</td>
</tr>
</tbody>
</table>

$\alpha = 0.05; \text{df} = 23$  \hspace{1cm} $\alpha = 0.05; \text{df} = 21$

Note: E-group: Males=12; Females=13; C-group: Males=13; Females=10;
SD – standard deviation

According to the post-test results, Table 4.13 indicates that the males in E group have outperformed the C group males. While the same is true for the females in both groups, it is also worth noting that there is an improvement in terms of the mean scores achieved. The calculated t-values 0.40 and 0.02 for both groups at post-test were less than their respective critical t-values ±1.71 and ±1.72. This confirms that there is no statistical significant difference between the two groups and are also quite comparable.

4.7.3 An exploration of the learners’ performance on the COET according to career interests at the post-test stage

It is worth noting at the post-test stage that the learners’ career interests and performances varied from career to career (see Table 4.14 below). Different careers such as medical; engineering; social services; arts and an “unknown” have undergone some shifts in terms of the total number of learners when compared with those in the pre-test Table 4.9. The pre- and post-test tables displayed that the interests shown by learners to the careers chosen earlier have changed and the examples of the career choices that had undergone such changes are engineering gaining N = 1 and N = 1 learner at E and C groups.
respectively; social services gaining \( N = 1 \) learner at E group; arts losing \( N = 1 \) learner at E group and sport lost \( N = 1 \) and \( N = 1 \) learners at both groups. The medical; sciences and "unknown" career choices have maintained the status of the interests shown earlier by learners.

Table 4.14 Learners’ performance on the COET according to career choices at the post-test stage.

<table>
<thead>
<tr>
<th>Career</th>
<th>Experimental group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean %</td>
</tr>
<tr>
<td>Medical</td>
<td>8</td>
<td>40.38</td>
</tr>
<tr>
<td>Engineering</td>
<td>6</td>
<td>44.23</td>
</tr>
<tr>
<td>Social services</td>
<td>6</td>
<td>39.53</td>
</tr>
<tr>
<td>Sciences</td>
<td>4</td>
<td>47.76</td>
</tr>
<tr>
<td>Arts</td>
<td>1</td>
<td>39.74</td>
</tr>
<tr>
<td>Sport</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Unknown</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>25</td>
<td></td>
</tr>
</tbody>
</table>

Note: \( N \) – number of learners; \( SD \) – standard deviation

For ease of reference, the careers indicated by learners in table 4.14 have been kept in the same order as displayed in table 4.9. However, there is a great improvement in performance displayed by the mean scores as reflected by each career choice. The maximum mean score achieved at the E group is 37.25 for a science career compared to a mean score of 21.25 obtained at the pre-test stage. At pre- and post-test stages, no learner showed interest to choose science as career in the C group. At post-test stage, the sports career has shown a loss of interest by learners in the C group. Furthermore, in the C group, the maximum mean score obtained was 27.67 for the “unknown” category compared to the mean score of 20.33 obtained at the pre-test. The reason for the steady increased mean score at this category is not known and could possibly be further investigated and analyzed. The social services’ career obtained a minimum mean score of 30.83 at the E group while at C group; it deserved a minimum
mean score of 25.50. On the whole, the performance at post-test was better than that demonstrated by the pre-test with exception of arts career choice where there is a slight drop by a mean difference of one.

Figure 4.3 illustrates the difference between the learners’ performances at the pre- and post-test stage in terms of career interests. At the pre-test stage, the performance levels for both groups in terms of their mean percentages were below 35%. Only the arts career at C group displayed a better performance than all the other careers that were chosen. At the post-test stage, there was a noticeable increase which demonstrated a better performance of more than 40% by the E group for the fields of medicine; engineering and sciences while the C group was performing at below 35% for all career fields except the learners who chose not to write their career choices.
4.7.4 An exploration of the learners’ performance on the COET according to age at the post-test stage

As shown in Table 4.15 below, it appears that the highest mean percentage of 43.27 was obtained by the 16+ year olds, i.e. the oldest age group of learners, as opposed to the case in Table 4.10(a) where the 16+ year olds at C group obtained the least mean percentage score of 20.94 in the pre-test. There was only one learner at pre-test who belonged to the 14 year old bracket and during the post-test there appear to be no one. The reason for the disappearance of the 14 year old age at post-test is that, the learners’ birthday fell between the pre- and post-test periods, which resulted to the learner being promoted to the 15 year old bracket.

Table 4.15  Learners’ performance on the COET on account of age.

<table>
<thead>
<tr>
<th>Age</th>
<th>Experimental group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean %</td>
</tr>
<tr>
<td>14</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>15</td>
<td>6</td>
<td>43.16</td>
</tr>
<tr>
<td>16</td>
<td>11</td>
<td>41.67</td>
</tr>
<tr>
<td>16+</td>
<td>8</td>
<td>43.27</td>
</tr>
<tr>
<td>Total</td>
<td>25</td>
<td>23</td>
</tr>
</tbody>
</table>

Note: N – number of learners;  SD – standard deviation

The lowest mean percentage score in Table 4.15 is 29.91% achieved by the C group in the 16+ year old bracket. This underachievement is similar to that obtained by the oldest age group i.e. 20.94% in the pre-test. The only difference in performance is that there is a slight improvement in performance at the post-test stage compared to the pre-test results for the C group. As mentioned earlier, the underachievement of the 16 year old group compared to the youngest group is against expectation since a number of studies do corroborate such findings (see Adams (1990), Ogunniyi (1999) and Solomon (2001)).
In other words, it is not the age alone that leads towards better understanding of the concepts of electricity, but there could be other possible factors that could contribute to underachievement of older learners when compared to the younger ones.

4.8 Relative effectiveness of the Concept mapping

The main purpose of the study as mentioned in chapter one seeks to explore the effectiveness of concept mapping in facilitating the learners’ understanding of electricity. An attempt was made to answer a fourth question of the research questions that is concerned with finding out if there is any difference in terms of performance when learners are exposed to the instructional strategy called concept mapping on electricity and the learners that are not so exposed. Furthermore, the supporting evidence to the possible answers provided for this question is the account of learners when they were encouraged to freely express their views during an interview. Out of interest and to know about the learners’ opinions about the new method used during the process of teaching and learning, an arrangement was made to create a conducive space where eight learners were to talk about the use of concept map as an instructional tool. This exercise was carried out in the form of open-ended interviews and also by means of lesson evaluation forms which will then be discussed later.

4.8.1 Interviews

As was mentioned earlier in the previous chapter, a group of eight learners took part in an interview process where they shared their experiences after being exposed to the concept mapping for the first time in their learning process. Due to excitement acquired as a result of being selected to participate in interviews, some learners had various challenges such as being shy to speak in English as they were Xhosa speakers.
Learners’ views on the Concept mapping

Since the learners were introduced to concept mapping, it was the researcher’s fundamental interest to know their opinions about this method of instruction. During the interviews which consisted of eight learners, they were asked to freely express their views about concept mapping to which they had been exposed. When asked to describe the challenges they have experienced during the lesson on the topic of electricity, it is worth noting from the interview data that was captured, the following statements they have made:

\[\text{Learner}_3:\text{ “Sir..., this lesson was not easy but you tried to explain for us to understand.”}\]

\[\text{Learner}_2:\text{ “If you did not teach us the way you did Sir, the topic would be difficult for me. I think the whole class could find it the same like me.”}\]

\[\text{Learner}_6:\text{ “There was no challenge for me..., Sir only showed us another way of teaching it (electricity) and I could easily understand.”}\]

With respect to the difficulties they have experienced and in more details, the following was noted:

\[\text{Learner}_4:\text{ “I was scared of writing the test because I didn’t get a good mark in the previous test.”}\]

\[\text{Learner}_1:\text{ “…I was worried because I was not sure how to understand the new method you used to teach us.”}\]

Asked about the scores they obtained in both tests (pre- and post-test) that they wrote and how they felt about them and the change in scores if there was any, the following comments from them were worth noting:

\[\text{Learner}_4:\text{ “I got less than 25% when we started writing the}
first test, which was so bad because it (test) was difficult. The second time we wrote, I did pass, I got 47% and I was fine. Maybe, the way you taught us again is the one that helped me to cope.”

Learner₅: “I got 37%, I don’t know how but the test was tough. The second one, I got 63% because I knew how to apply the concept map and I was showing (mentioning a few names of classmates) how you can understand it (topic on electricity).”

Learner₇: “I was supposed to get more than 50%, but I got 31% in the first test. I think, I didn’t know much but the second test I scored 51% after you changed your style of teaching us. I think, I gained more confidence.”

When the researcher was seeking for more elaboration on the pre-test, treatment and post-test processes that took place and what they thought were the reasons for why they obtained such percentages before and after, several responses were as follows:

Learner₇: “At least…, I know this chapter from Grade 9, I did good on it. What you showed us (concept mapping instructional strategy) made it more easy to understand.”

Learner₅: “I did very well for the second time, I got 63% and I improved because doing a concept mapping was helpful for me to understand the chapter. I also studied, and the concept map was also helpful Sir… though it was hard to use it.”

Learner₆: “I also studied using the concept map and got 50%. As I said before, the different way you
explained the concepts Sir..., was very helpful to the class, yes! but also difficult at first time.”

Learner$_2$: “I studied to pass and got 58% in the second test. Maybe, its because I understand the concept map approach although it was difficult for me.”

Asked to tell how much effort and to what extent they have made to apply the concept map as part of their preparation for the post-test. Also, reflect on the assistance offered by the teacher to get them understand the application of the instructional tool exposed to them and some recommendations, if any. These points were made by the learners and were worth to be noted:

Learner$_2$: “Yes Sir, but I worked with [#@*$] (mentioning a friend’s name) and it was easy to do it with her, at home alone it was confusing. Maybe, Sir if you can teach us using it every time you introduce a topic, then I can enjoy and understand well.”

Learner$_1$: “It’s very easy to understand you Sir when you use it in class, but it helped me to understand these concepts and I wish to go on using it in every topic.”

Learner$_8$: “My opinion is, ... it’s (concept mapping) good and I shall use it. I learn the topic of electricity quick from it. It makes science clear and fun.”

Learner$_6$: “Sir, I don’t mind if you can teach us using a concept map. This is a good strategy for me.”

Learner$_5$: “Maybe I wouldn’t know science if Sir didn’t show us the concept map. But, ...if we can work in pairs then we’ll get used to it because the others (friends) in class, I saw they got good marks after you showed us the concept map when you taught electricity.”
In as far as enhancing conceptual understanding is concerned, the learners in the dialogue above have shown that the traditional way of teaching and learning is a tedious process and far less beneficial.

Getting them to write the tiring long notes which they store haphazardly in the mind and later become difficult to recall is meaningless and is a waste of time. They then want to see how concepts are related in order to make full sense of the bigger picture. Generally, the use of concept mapping seemed to have achieved the desired effects many of the learners mentioned that it helped them in the understanding of the concepts of the chapter.

4.8.2 Lesson evaluation forms

After a full treatment intervention was carried out and after the post-test was written, copies of the lesson evaluation form were distributed to each learner in the E group to be filled in. Considering to use the evaluation forms (see a sample in Appendix C) has brought about a sense of how effective was the treatment particularly, the exposure to the concept mapping when learners were also being prepared to write the post-test.

The data that was captured from the lesson evaluation forms indicated that thirty-five learners who filled in their evaluation forms reflected some various opinions about the impact of the concept mapping strategy they were newly exposed to. Out of eight questions that they were responding to, question one indicated that 89% of learners scored below 30% and about 11% learners scored between 31% and 40% in the first test while in question two the percentage dropped and showed that about 26% of learners scored below 30%; 17% scored between 31% and 40%; 49% scored between 41% and 60% and lastly, about 9% scored between 61% and 80% in the second test. This data has marked a great improvement in terms of the pre- and post-test scores when they were compared.
Question numbers three, four and five were only the agree/disagree types of questions and the responses attached to them respectively were as follows:

- About 77% learners agreed that they were helped by the concept mapping strategy to improve their test scores;
- 89% agreed that enough practice for the new skill was provided and;
- 97% agreed that enough feedback was provided by the teacher and they felt more comfortable to ask for extra help.

Question six was seeking to find out about the possibility of mastering an activity where a concept mapping needed to be applied and the learners’ responses showed that about 69% learners felt it is much easier to do concept mapping with a group instead of doing it individually as was felt by the other 9% group of learners. The two last questions, i.e. seven and eight refers to the use of concept mapping when new topics are to be introduced on each lesson. To start with question seven, the learners’ responses indicated by about 63% learners showed that they found the concept mapping strategy very clear and user friendly while 29% found the concept mapping interesting but very difficult to apply. About 9% learners found the concept mapping confusing and when given a chance to make a choice for a good instructional strategy, they would rather choose to be taught in a traditional way of teaching.

Lastly, question eight asks if the teacher should continue to teach all lessons using the concept mapping strategy and among the responses offered by the group of learners, about 86% learners showed a positive attitude towards the use of concept mapping in every lesson, 3% felt that concept mapping could be employed in some lessons but not for all topics and about 9% learners were totally against the concept mapping instructional strategy.
4.9 Conclusion

From what has been reported in chapter four of this study one can conclude that learners involved in this study, like other learners elsewhere have common misconceptions about the concept of electricity which are very difficult to remove since they still persist even after the intervention (Clough, Driver & Wood-Robinson, 1987; Fleer, 1994).

One could therefore acknowledge the contribution of the study to being able to potentially bring about a significant better performance by those learners who were taught using concept mapping when they were compared to those who were taught using a traditional approach. The improvement was marked in the areas (in descending order of achievement) such as: conceptual understanding, application only and recall type of knowledge. Further evidence that was collected from the interviews clearly indicated that although the concept mapping was found to be challenging especially at the initial stages, however, they seemed to find it useful and has enhanced their process skills as well as their understanding of the concept of electricity. Another point that has come up strongly from the lesson evaluation forms that they filled in was the desire to continue to be taught in almost all lesson topics using the concept mapping instructional strategy instead of a traditional teaching style. The next chapter shall further highlight the main findings, implications as well as limitations of the study.
CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Overview

This study attempted to investigate the difficulties encountered by the grade ten township learners with respect to the concept of electricity. More specifically, the study has been attempting to explore the learners’ scientific knowledge by investigating their conceptions, misconceptions and/or alternative conceptions about electricity; the influence of learners’ career interests, age and gender issues on their conceptions of electricity and the effectiveness of concept mapping in facilitating the learners’ understanding of electricity.

Furthermore, the research questions as espoused in chapter one that this study has been attempting to answer successfully were the following:

- What conceptions of the electricity do grade 10 learners hold?
- What process skills do grade 10 learners (to perform cognitive tasks on the topic of electricity) use?
- Are the learners’ conceptions of the electricity related to their gender, age and/or career interests?

Is there any difference in terms of performance when learners are exposed to the instructional strategy called concept mapping on electricity and the learners that are not so exposed?

This chapter summarizes the major findings and examines the implications of such findings for further developments in curriculum and instructional practice. Finally, the chapter proffers some suggestions for various stakeholders.
5.2 Summary of findings

As mentioned in chapter three, two groups that were involved in the study namely, an experimental (E) and control (C) groups wrote a pre- and post-test. The experimental group (E) received a treatment as an intervention and the new instructional strategy involving a concept mapping was exposed to them while there was no treatment for the control group (C). The major findings of the study can be summarized as follows:

- The initial pre-test mean percentages scored by E and C groups were 19.2% and 31.0% respectively. Although the C group had better results than the E group, the meaning attached to these results indicates that the grade ten learners at both schools have poor understanding of the concept of electricity.

- The two groups were found not to be comparable at pre-test stage due to the large gap in their mean scores and an investigation that included an interview with the science HOD at the C group school revealed that the learners who were repeating the grade were at an advantage than others when the instrument was administered and had scored the marks that were too high.

- An elimination process, governed by strict criteria, of removing such learners both at the C and E groups became useful to strike a balanced distribution of scores between the two groups in a fair way. Then the sample size was reduced into 25 learners at E group and 23 learners at C group.

- The results at pre-test after the elimination showed some very poor mean scores which indicated and confirming in an emphatic way that, learners are possessing a poor understanding of the concept of electricity.

- Based on the later pre-test results and statistically, there was no significant difference between the performances of groups E and C, i.e. they were quite comparable.

- The post-test results showed an increase in the mean percentages for each group, i.e. the E group scored 42.4% while the C group scored 33.7%. This increase was probably due to the fact that the E group was exposed to the
treatment which includes a concept mapping whereas with respect to the C group the reasons for the rise in mean percentage score were not known since they were taught only in a traditional way. Therefore, one can reasonably attribute the better performance of the E group to the concept mapping.

- The issues of age has suggested that the underachievement of the older learners compared to the younger ones has once again surfaced and that is against expectation since a number of studies carried out earlier (see Ogunniyi (1999)) have already corroborated such findings.

- Grade ten learners do hold misconceptions about the concept of electricity even after they were exposed to intervention that include concept mapping. Ramahlape (2004) citing (Aikenhead and Jegede, 1999; Gunstone and White, 2000) asserts that although learners can be made aware of the invalidity of their ideas, they are not always eager to change their ideas for scientific ideas which are largely abstract, unnatural, counter-intuitive and uncommonsensical.

- There was no significant difference in performance of the boys when compared to that of the girls in terms of the conceptions of electricity as other previous studies have found out (e.g. see the studies carried out by Ogunniyi & Taale, 2004; Ogunniyi & Fakudze, 2003; Habte, 2003).

- With respect to career interests, what the learners reflected as their future dreams, i.e. what they intend to do and become, seems to have influenced their performance at the pre- and post-test stages. At pre- test stage their scores were relatively low but after the post-test a different picture emerged where the mean percentage difference between the pre- and post-test ranged between 7.94% and 16.67% across all careers which resulted to an overall mean difference of 13.62%.

- At the initial stages of a new instructional strategy including concept mapping that was exposed, learners found it challenging and they chose to work in pairs or groups to gain better understanding of it since they were engaging in dialogues, arguments during their hands-on experiences on an activity.
• The discussions that took place in the interview revealed that learners taught and exposed to concept mapping, found this method useful and facilitative to their learning.

• From the evaluation forms it appeared that learners liked the instructional strategy that was implemented to introduce the concept of electricity and were very keen to be taught using concept mapping in all the science topics.

5.3 Implications

The data results provided in chapter four of this study have some implications in at least two specific areas of science education namely:

• Curriculum and;
• Instructional practice

With respect to these two specific areas of science education just mentioned above, the next section shall briefly discuss the implications of each of them.

5.4 Instructional and curricular implications of the findings

The data provided in chapter four helps one to see how learners did their best in committing to try and understand the concept of electricity. It also unpacked the difference in performance made by the group of learners who attempted to use concept mapping as a learning tool in order to facilitate meaningful learning and gain a better understanding and a more in-depth knowledge of the concept of electricity.

5.4.1 Implication for curriculum

In the South African context, the curriculum is designed such that learners are able to acquire certain knowledge and skills considered germane to their educational aspirations and goals. This is because the way they are taught
often does not allow them to develop knowledge and skills required in the next grade. As a result learners tend to become systemically “recycled back” Koopman (2004:89) by having to repeat the grade until they achieve mastery to succeed or until they drop out of school. However, the design of this curriculum does not fully regard the learners’ experience as the most important, but only the effect of the curriculum upon the learners is what matters the most. Gilbert and Watts (1983) have argued that it is for many years that the phenomenological world of the learner has been ignored. The idea of meaningful learning (that which is opposed to this type of learning model) embraces the ideas that the learners bring to class and also believe that learners acquire new knowledge more easily when they are able to relate it to existing ideas or to a language that is understandable to them.

This study has shown the complexities of various groups of learners’ ideas including misconceptions and some alternate misconceptions held within the science curriculum at pre-test stage. After the experimental group of learners received an instruction, (i.e. at post-test stage) which included an exposure to concept mapping to address the difficulties encountered by learners before, there was an improvement in the results and a change in the learners’ ideas. As a practice based on constructivist epistemology the construction of concept mapping by learners could help them interrogate their prior knowledge and seek for ways to make necessary adjustments in their own understanding of a given phenomenon. However, it is worth further considering the potential of this instructional tool in a different context for enhancing the learners’ understanding of the concept of electricity and some other science concepts. This has marked an achievement of a meaningful learning process and therefore the evidence attached to these findings can be attributed to addressing the incorrect notions about topics on electricity in an explicit way. Furthermore, the importance of the curriculum rests upon the following provision and commitments by all parties in the teaching and learning fraternity:
• An extensive teacher training with regard to the concept of electricity to achieve the aims of Physical Science curriculum.

• Teachers as the agents that are directly hands-on, are aware of the challenging areas in terms of understanding that need to be acquired by learners on each topic they have an experience of teaching. Therefore, it is imperative for them to be invited by the science curriculum panel of the department of education to participate in the curriculum development sessions.

• The authors of the science textbooks must work collaboratively with science panel of the education department when developing the science curriculum and also ensure an acknowledgement of the teachers’ voice.

• The language in which the science textbooks are written should also be accessible to the majority of learners using it to alleviate further linguistic challenges often experienced by the second language learners to understand the content.

• The learners’ thinking skills are vital and must be promoted both in a classroom and textbooks to enhance a presentation of science that takes cognizance of the socio-cultural environment of the learners.

The knowledge included in the curriculum should be relevant, appropriate and recognizable by learners. It should also make the space available to accommodate and integrate the learners’ ideas to be meaningful in order to shape their scientific knowledge. Lastly, it should be amendable to a pedagogy that makes school science attractive, exciting and a rewarding experience.
5.4.2 Implication for instruction

One could agree when exposed to the findings of this study that there are practical implications for practicing science teachers, particularly those in the township schools. As much as other studies has revealed that there is little or no benefit from the traditional expository methods of teaching, the results of this study has also confirmed and suggested that the traditional expository method is not as effective as the alternative method in which concept mapping has played a significant role in helping learners learn the concept of electricity. However, it is worthy for the teachers to be equipped with some tools including concept mapping instructional strategies that could enable them to better examine the learners’ conceptions on the topic of electricity and some more others as opposed to being dependent only on the traditional expository method which promotes a tapping of the knowledge.

The danger of applying the pressure by the Education Department towards the completion of the syllabus has resulted to the science teachers’ tendency to ignore the crucial aspects such as learners’ ideas, their cultural background, their experiences with the environment and a number of assumptions are made in relation to their prior experiences. Very often the notion of electricity is introduced before an understanding of the learners’ conceptions and opinions are considered. As much as the learners’ opinions in relation to the concept in question can be the determining factor, it is also imperative to consider integrating what is taught in class to their everyday lives. Nevertheless, this will enable the learners to know that science is not only what is taught in class but a part of their everyday experiences. If they are made aware of that, there may be a possibility of an improved attitude towards science as a subject and consequently this might also enhance an improvement in their performance.
The integration of everyday science in teaching should not only end in class but should be extended and be part of the assessments such as test and examinations since the Learning Outcome 3 (LO3) of the C2005 expects learners to develop and be “able to demonstrate an understanding of the interrelationships between science and technology, society and environment” (Department of Education, 2002, p.10). The challenge that is posed by LO3 is not experienced by the teachers and their learners alone but also by the curriculum planners as well since they were all used to the previous curriculum which was examination driven and all that the learners used to do was largely to regurgitate the facts.

It could be very useful for the science teachers to take note of the fact and be mindful that according to Posner et al (1982:223) teaching science involves providing a rational basis for conceptual change which can be potentially threatening, particularly when the individual is firmly committed to the prior assumptions. The explanation they provided (as frequently cited in the literature) of the tenacity in which alternative conceptions are held by learners suggest that learners would not abandon the alternative conceptions they hold and accept new ones unless they were dissatisfied with former. Also, learners wouldn’t accept new conceptions unless such conceptions are intelligible, plausible and fruitful.

5.5 Recommendations

A space where the quality and effectiveness of science education in any township school with similar conditions as Ibhongo Secondary School is highly essential and must be provided. However, no matter how good any intervention can be, for it to be fully effective there is a need to be a mobilization of skilled human resources. There also need to be a change of mindset to those who believe that nothing works optimally in the schools due to complexities of the townships and an adoption of a more descriptive identity of what a science
teacher is capable of being, i.e. a change agent and what he or she can do in a science classroom or laboratory.

Furthermore, the space to be provided includes finding out about teachers’ understanding of the concept of electricity. This might help to identify how strong or weak are the teachers’ conceptions of electricity so that a provision of assistance can be made to:

- upgrade their conceptual understanding of the concept;
- strengthen confidence to teach the concept to their learners as well as
- ensuring a gain in instructional skills so that they become better teachers.

For any educational expectation to be realistic, I would therefore recommend that the curriculum planners should plan in such a way that the curriculum itself makes provision for meaningful learning to occur. This could be achieved only if they make the curriculum more relevant, more useful and more meaningful to the learners’ lives to enhance learners who are able to relate the new knowledge from school to what they already know from home so that they can easily cross the boundaries in their journey of learning. Mpofu (2006) citing Dinnie et.al asserts that textbook writers can only make their textbooks more reader friendly for the second language learners to enhance a high reading and comprehensive ability. They should also include pictures and cartoons with short descriptive notes.

On a small scale, the findings of this study, as were analyzed against the research questions and discussed has shown a significant improvement in learners’ performance in the concept of electricity test (although four out of thirty five learners in a group scored between 50% and 76%) as a result of employing a concept mapping. However, it will be totally unfair to make a direct comparison to what might have been achieved in a well resourced Model C kind of school.
Based on the findings of this study, it is reasonable to suggest that further in-depth research into “Difficulties encountered by grade 10 township learners with respect to electricity” be carried out on a much larger scale and over a longer period of time.

5.6 Conclusion

This study has shown that adopting creative instructional skills such as concept mapping could enhance learners’ performance in science including the difficult topics they generally find difficult e.g. electricity. The use of concept mapping in the study as an instructional tool has enhanced the understanding of electricity by township learners generally believed to be weak and non-performing. From the analysis of the results the conclusion that have been reached is that some good progress in performance have been made by the majority of the learners and even the very weak ones have had some knock-on effect. A major lesson from this study is that if learners are exposed to a conducive environment and appropriate instructional strategy such as concept mapping used in this study they are able to perform well.
BIBLIOGRAPHY


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Ogunniyi, M. B. and Fakudze, C. G. (2003). Grade nine students’ conceptions of force, energy and power. A seminar series at the University of the Western Cape.


APPENDIX A: Electricity

Please complete the following:

<table>
<thead>
<tr>
<th>Gender</th>
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<table>
<thead>
<tr>
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<tr>
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<table>
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</tr>
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<td></td>
</tr>
<tr>
<td>Secondary/High School</td>
<td></td>
</tr>
<tr>
<td>Technical School</td>
<td></td>
</tr>
</tbody>
</table>

My career interests are:
________________________________________________________________________

My school is in:
________________________________________________________________________

My first/home language is:
________________________________________________________________________
Fill in the missing words.

1.1 Electrons have a _________ charge.
1.2 Protons have a _________ charge.
1.3 An atom which has an equal number of electrons and protons is said to be ________.
1.4 An atom which has an excess of electrons is ________ charged.
1.5 An atom which has shortage of electrons is ________ charged.
1.6 A plastic comb can be charged by ________ it with a cloth.

2 Sipho walks across the carpet as he is about to touch the metal door handle he gets a small shock.

2.1 What happened to Sipho as he was walking across the carpet?

________________________________________________________________________

2.2 Can you explain what happened when Sipho touched the handle?

________________________________________________________________________

2.3 If the door handle was made from wood would Sipho still have got a shock?

Explain your answer.

________________________________________________________________________

________________________________________________________________________

3 Most cars have four spark plugs. What is the purpose of a spark plug in the motor car engine?

________________________________________________________________________
4 Jon got bored in class and combed his hair. As he was about to put the comb down he noticed a small piece of paper jump up onto the comb.

4.1 What happened to the comb as Jon was combing his hair?

_______________________________________________

4.2 Jon’s teacher brought the comb near a negatively charged electroscope and the leaves opened further.

What was the charge on the comb?

_______________________________________________

5 Read the sentences below and fill in the missing words.

When a plastic comb is rubbed with a cloth, the comb becomes negatively charged. The cloth becomes positively charged. When these two objects are brought close together they ____________________ each other.

When two objects with the same charge are brought close together they ____________________ each other.

6 The following questions are based on the circuit below.

6.1 What type of instrument is A1? ____________________
6.2 What does $A_1$ measure? _________________________

6.3 What are the units of current? _________________________

6.4 If the reading on $A_1$ is 6A. What would the reading be on $A_2$?

6.5 Another cell is added in series with the two cells in Circuit A. What happens to the reading on $A_2$?

6.6 How would this extra cell change the brightness of the light bulbs?

7. Look at the circuit below and answer the questions.

7.1 The current in $A_3$ is 4A, and the current in $A_4$ is 6A. What would the reading on $A_3$ be?
7.2 Another light bulb is added in parallel with the two already in the circuit. What effect will this have on the brightness of the other two bulbs?

11.8 Explain your answer to the question above.

11.9 What effect will adding the extra bulb have on the reading of $A_5$?

12 The reading on the ammeter in the circuit below is 5A.

8.1 Charge is measured in units of __________________.

8.2 What quantity of charge passes through the ammeter in 1 second?

______________________________
9 Resistors are used in most electronic circuits.
9.1 Name one purpose of a resistor in a circuit?

___________________________________________________________.

9.2 What are the 4 factors on which the resistance of a conductor depends?

________________________________

________________________________

________________________________

________________________________

10 The value of a resistance can be found by dividing the voltage across the resistor by the current in the resistor:

\[
\text{Resistance} = \frac{\text{Voltage across resistor}}{\text{Current in resistor}}
\]

Look at the circuit below and answer the questions:

[Diagram of a circuit with voltage and current indicated]
10.1 The current in the resistor is 5A and the voltage across the resistor is 10V. Calculate the value of the resistance.


10.2 The voltage is increased to 20V. What would happen to the value of the current?


10.3 What would happen to the value of the resistor?


11 Your mother buys a new kettle and asks you to connect the lead to a three-pin plug. The lead has three wires inside it, each wire is covered with a different coloured plastic insulation. The insulations are: green with yellow strips, blue and brown.

11.1 Why are the wires insulated?


11.2 Why are different colours used?


11.3 What colour is the earth wire? __________________
11.4 What colour is the live wire? _______________________

11.5 Which colour is the neutral wire? _______________________

11.6 Which wire is a safety wire? _______________________

11.7 Which wire is most dangerous? _______________________

11.8 Why is it called the live wire?

__________________________________________________________________

12 Why are so many electrical appliances made from plastic?

__________________________________________________________________
Complete the following exercise in small groups of 4 learners per group.

(i) Steps 1 to 3:

1. Write down all the key ideas about static electricity in the page.
2. Identify and list all the key concepts in the answer provided above.
3. Then, complete the diagram below

(ii) Develop your own concept map on another page about electric current following the same procedure as in steps 1 to 3.
APPENDIX C: Group of learners’ initial attempt to develop a concept map
APPENDIX D:  Student interview – (Group)

i. Describe the challenges you have found during the lesson on the topic of electricity.

ii. What score do you think you managed to get in the first test written? What makes you to think so?

iii. You wrote the same test for the second time after you went through this topic of electricity with your teacher (me). How did you find the second attempt to the test?

iv. Looking back to how the teacher has helped you with the understanding of the concepts using a concept mapping, would you recommend that he should continue with the application of this instructional tool? Why?

v. Describe how the concept mapping instructional strategy has changed your understanding of this topic.

vi. If the score obtained in the second test was better or worse than that of the first test, what do you think was the reason for that?
APPENDIX E: Electricity lesson evaluation form

Name (optional): ________________________________________
Grade:  ________________________________________
Gender:  Male _____     Female ____
[Please put a tick (✓) on the block or circle the letter that applies to you]
_____________________________________________________________________________

Please answer all the questions that follow:

1. My score in the **first** electricity test was …

<table>
<thead>
<tr>
<th>less than 30%</th>
<th>between 31% and 40%</th>
<th>between 41% and 60%</th>
<th>between 61% and 80%</th>
<th>more than 80%</th>
</tr>
</thead>
</table>

2. My score in the **second** electricity test was …

<table>
<thead>
<tr>
<th>less than 30%</th>
<th>between 31% and 40%</th>
<th>between 41% and 60%</th>
<th>between 61% and 80%</th>
<th>more than 80%</th>
</tr>
</thead>
</table>

3. The strategy of using a **concept map** during the lesson on a topic of electricity helped me to better understand and hence improved my test score.

A. I agree  
B. I disagree

4. The teacher has provided enough practice for a new skill and ensured that everyone is on task.

A. I agree  
B. I disagree

5. The teacher has provided enough feedback and I felt comfortable asking for extra help.

A. I agree  
B. I disagree

6. The class activity that we did on concept mapping was …

A. easy to do alone  
B. easy to do with a group

7. To introduce the new topic, I find the concept mapping strategy …

A. very clear and user friendly  
B. clear but very difficult to understand  
C. confusing and would rather choose to be taught in a traditional way of teaching

8. How often do you think the teacher should teach his/her lessons using the concept map approach to introduce a new topic?

A. Use this approach in every lesson  
B. In some lessons, not for all topics  
C. Never use concept map approach at all

**Thank you!!!**
## APPENDIX F:

Raw data samples

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### PRE-TEST: EXPERIMENTAL GROUP Grade 10

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<th>PRE-TEST</th>
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### PRE-TEST: CONTROL GROUP Grade 10

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### UNIVERSITY OF THE WESTERN CAPE

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### PRE-TEST: EXPERIMENTAL GROUP Grade 11

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### PRE-TEST: CONTROL GROUP Grade 11

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**Note:**
- The table above represents the test scores of students in grades 100, 95, 90, and 85 respectively.
- The scores are out of 100 for each subject.

**Final Scores:**
- John: 360 (Sum of individual scores)
- Jane: 340
- Mike: 320
- Susan: 300

**Average Score:**
- Overall average score: 90