EFFECTS OF CONCEPT MAPPING BASED INSTRUCTION ON STUDENTS' ACHIEVEMENT IN PHYSICS IN PUBLIC SECONDARY SCHOOLS, NAIROBI COUNTY, KENYA

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other University.

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DEDICATION

To my late mum Linet for laying foundation for my education and inspiring me, and to my wife Irene and daughter Riya for their prayers and support throughout my studies.

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ABBREVIATIONS AND ACRONYMS

ASEI	-	Activity, Students, Experiment, Improvisation
CEMASTEA	-	Centre for Mathematics, Science and Technology Education in Africa
CIT	-	Conventional Instructional Techniques
CLIM	-	Cooperative Learning in Multicultural groups
COS	-	Classroom Observation Schedule
CVR	-	Content Validity Ratio
ICM	-	Instructional Concept Maps
ICT	-	Information, Communication, Technology
INSET	-	In-Service Education and Training
JICA	-	Japan International Co-operation Agency
KCSE	-	Kenya Certificate of Secondary Examination
KNEC	-	Kenya National Examinations Council
MOEST	-	Ministry of Education Science and Technology
NCTM	-	National Council of Teachers of Mathematics
PAT	-	Physics Achievement Test
PDSI	-	Plan, Do, See, Improve
QASOs	-	Quality Assurance and Standard Officers
SMASSE	-	Strengthening of Mathematics and Science in Secondary Education
SPSS	-	Statistical Package for Social Sciences

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ABSTRACT

Concepts in physics education underpin a high level of technical knowledge and therefore are crucial to success in many technical disciplines. However, misconceptions in elementary physics are quite common among secondary school students. According to the Kenya National Examinations Council (KNEC) report, the candidates' responses to a large extent showed partial concept development at school level. Therefore, it was important to identify and implement the most effective teaching and learning methods that can reduce instances of physics misconceptions and enhance both short-term and long-term achievement. The purpose of this quasi-experimental study was to determine if combining instructional concept mapping (ICM) and conventional instructional techniques (CIT) would improve students' achievement in physics, focusing on the topic 'electric current'. The quasi-experimental design used pre-test and post-test with control and experimental groups. The main independent variables were the instructional concept mapping and conventional instructional techniques while the dependent variable was "students' achievement in physics". The samples were four streams of Form Three students from two secondary schools in Nairobi County. The experimental group comprised one stream from the boys' school and girls' school randomly selected and was taught physics using a combination of instructional concept mapping and CIT. The control group comprised of similar composition but taught using CIT only. Data was gathered on the students learning achievements in physics, the role of physics teacher and student, and challenges encountered in lessons employing ICM and CIT. Four validated data gathering instruments were used, (i) a classroom observation schedule, (ii) a teacher questionnaire, (iii) a student questionnaire, and (iv) two physics' achievement tests. Content validity was achieved through subject matter expert's verifications based on the experts' opinion of experienced physics teachers. Analysis of data was done using both descriptive and inferential statistics. For descriptive statistics, frequency distribution, means and standard deviations was used. The t- test was employed for the inferential statistics, that is, to determine the level of significance between marks scored in achievement tests. It was found that students in the concept mapping group were more participative in class and obtained a statistically significant higher mean gain on the physics test compared to the non-concept mapping class, with $p < 0.05$. This short-term learning gain is therefore academically significant. The concept maps also provided better ways of summarizing concepts learned during the lesson thereby making it relatively easier for the lessons to be reviewed and key points in the lesson reported or reinforced as is required. It was concluded that generating instructional concept maps is an effective teaching and learning tool for developing concepts of electric current in physics.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Kenya's economy requires a steady supply of scientifically and technologically knowledgeable human resource (Mutahi, 2009). This underscores the fact that science and technology have immense contribution to the growth and development of a country. Consequently, students should be equipped with the necessary knowledge and skills in science and technology to function in modern times.

Any breakthrough in science and technology is deeply rooted in the strength of science education. It is in recognition of this dominant position occupied by science that during the Fifth Ordinary Session of the Conference of Ministers of Education in Africa (COMEDAF V) held in April 2012 in Abuja, Nigeria, Centre for Mathematics, Science and Technology Education in Africa (CEMASTEA) was showcased as model 'Centre of Excellence' in the promotion of quality of mathematics and science education at the basic level in Africa (Mutula, 2012).

Physics is one of the science subjects taught under science education. Advancements in technologies in information and communication, medical, environmental, crime control and security, among others, are some of the achievements brought about by physics. Therefore, specific priority of physics in the development of scientific and technological programmes of a nation is important.

In Kenya, the experience of low enrolment and poor performance in physics among students at varying levels of learning is reflected in the candidates' performance in the

Kenya Certificate of Secondary Education (KCSE) Physics examination between the years 2006 and 2010 as shown in Table 1.1.

Table 1.1: Candidates' overall performance in Physics in the years 2006 to 2010

Year	Candidature	Percentage Candidature	Maximum Score	Mean Score	Standard Deviation
2006	72,299	29.70%	200	80.63	73.00
2007	83,162	30.12%	200	82.63	35.00
2008	93,692	30.72%	200	73.42	35.43
2009	104,883	31.09%	200	62.62	34.02
2010	109,811	30.72%	200	70.22	35.73

Source: KNEC KCSE examination reports (2006 - 2010).

From Table 1.1, it can be observed that students' participation in physics reduces as they progress through education with enrolment in KCSE ranging between 29.70% and 31.09% of the total candidature. The mean students' performance in the examinations has also stagnated at scores between 62.62 and 82.63 out of a maximum score of 200.

The poor performance in the physics national examinations calls for intervention. This formed the basis of cooperation between the Government of Kenya (GOK) through Ministry of Education, Science and Technology (MOEST) and the Government of Japan (GOJ) through Japan International Cooperation Agency (JICA) since 1998 to build capacities of mathematics and science teachers through the Strengthening of Mathematics and Science in Secondary Education (SMASSE) Project. It was an intervention to address poor students' performance in mathematics and science subjects in the KCSE examination. The overall goal was to upgrade ability of secondary school students in mathematics and science through In-Service Education and Training (INSET) of teachers of these subjects to improve their teaching.

At the onset of SMASSE Project in 1998, a baseline study was conducted to identify factors responsible for poor performance in mathematics and science at secondary school level. The study identified negative attitude toward mathematics and science, poor teaching methodology, inadequate mastery of teaching subject content, inadequate teaching and learning materials that include ill-equipped laboratories, and school management among other factors (Waititu and Orado, 2009). The project technical team identified teaching methodology as the overriding factor and focused on INSET for teachers to improve their teaching practices. The project team designed an instructional approach known as ASEI-PDSI approach, an acronym for Activity, Student, Experiment, and Improvisation (ASEI) and Plan, Do, See and Improve (PDSI). This approach endeavours to shift teaching and learning from knowledge-based teaching to activity-based learning, teacher-centred teaching to learner-centred learning, expository to experiment, research and improvisation.

Concept mapping based instruction is one of the instructional strategies advocated by CEMASTEA as a learner-centred learning approach (Makoba, 2012). Concept mapping is a meta-learning strategy based on the Ausubel-Novak-Gowin theory of meaningful learning (Novak and Gowin, 1984). Its advantage lies on the fact that learning new knowledge is dependent on what is already known. It upholds that new knowledge gains meaning when it can be largely related to a framework of existing knowledge rather than being processed and stored in isolation. It mainly emphasizes the meaningful relationships between variables or sub-concepts in the main concept.

Concept mapping based instruction is considered an active rather than passive learning task, and it serves as an elaborative study activity when students are guided to construct concept maps in the presence of the materials they are learning. It requires students to enrich the material they are studying and encode meaningful relationships among concepts within an organized knowledge structure. Instructional concept maps also serve to reinforce students' understanding, and assess their achievement, among other educational applications.

In view of the immense contribution of concept mapping based instruction to the process of teaching and learning science and mathematics, it is an invaluable area for more research, particularly in the case of SMASSE's ASEI-PDSI implementation programme.

1.2 Statement of the Problem

Teaching and learning of physics concepts should take into account that students are from varied backgrounds and that they do not all learn in the same way. Hence, teaching should not be considered a linear process with a one-way delivery of knowledge but rather a combination of learner-centred learning and an interactive process between students and teachers. If learner-centred ASEI-PDSI approaches are appropriately selected and correctly put into practice by physics teachers then this would immensely contribute towards improving the students' poor performance currently being experienced in the national examinations. This study intended to research on concept mapping based instruction, a strategy less explored by teachers in Kenya, but which can enable learners to fully develop and clearly remember physics concepts, and consequently perform better in physics examinations.

1.3 Purpose of the Study

The purpose of this quasi-experimental study was to determine if combining instructional concept mapping and conventional instructional techniques would improve students' achievement in physics, focusing on the topic 'electric current'.

1.4 Objectives of the Study

The study focused on the following objectives;

a) To evaluate students' achievement in Electric Current when taught through concept mapping strategy and conventional instructional techniques.

b) To assess the roles of the teacher and the student in physics lessons employing concept mapping strategy and conventional instructional techniques.

c) To identify the challenges encountered by physics teachers and students when using concept mapping strategy and conventional instructional techniques.

1.5 Research Questions

To carry out this study, effort was made to answer the following questions;

a) Does concept mapping strategy improve students' achievement in Electric Current?

b) What are the roles of teachers and students in lessons employing concept mapping strategy and conventional instructional techniques?

c) What are the challenges encountered by physics teachers and students when using concept mapping strategy as compared to those using conventional instructional techniques?

1.6 Significance of the Study

The findings of this study would shed more light on the process of teaching physics using concept mapping based instruction. This will be of significance to physics teachers and the ways in which they address gaps in the learners' knowledge and understanding. The students are encouraged through concept mapping to become 'active learners', taking responsibility for their own development in terms of improving their knowledge and understanding of physics.

The findings would also be of significance to the SMASSE Project in that it will provide monitoring and evaluation information about the project implementation. In particular, the findings of the study would assist the Quality Assurance and Standard officers (QASO'S) both at the district and the national levels in doing the follow up of SMASSE INSET so as to give more advice and guidance to physics teachers on how to improve on their teaching approaches and methodology.

1.7 Delimitations and Limitations

1.7.1 Delimitations

This study focused on concept mapping as a learner centred approach and students' achievement in Physics in public secondary schools in Nairobi County. Achievement was evaluated on the basis of students' performance in achievement tests.

Various aspects of the teacher and the learner during physics instruction were considered. Among the teacher aspects included variation and integration of instructional strategies during physics lessons. These strategies range from teacher centred and interaction approaches to learner centred approach with main emphasis on concept maps (Figure 1.1).

On the other hand, learners' characteristics during the physics lessons were evaluated on their ability to integrate new knowledge to existing structures in order to retain knowledge and receive meaning of the concepts learned, and to identify gaps in knowledge. This involves diagnosis of misconceptions.

1.7.2 Limitations

Only public schools offering the Kenya national secondary curriculum for physics were considered. The findings of this study are limited to the sampled schools and may vary from the rest due to their unique characteristics and other factors which influence performance other than instructional techniques, such as attitude and motivation. The findings are also limited to the topic 'electric current' and the extent to which the guideline for using the concept mapping approach was adhered to.

1.8 Assumptions

In this study, the following assumptions were made:

a) All the lessons taught in experimental class using concept mapping were conducted as per the guideline for using the concept mapping approach.

b) All the lessons taught in control class did not involve use of concept mapping as one of the approaches integrated in the learning process.

c) The responses that the respondents gave constituted a true record of their independent and unbiased opinion and views.

d) All physics teachers were trained teachers.

1.9 Theoretical and Conceptual Framework

1.9.1 Theoretical Framework

This study was guided by the Piaget’s Constructivist Learning Theory (Linda et al., 2002). The essence of constructivism is that learners individually build and discover their own knowledge. Learners are seen as active participants in their learning and not as passive recipients of information (Duffy and Cunningham in Jonassen, 1996). In practice it means that students learn through experiencing information and reflecting on those experiences.

Novak’s original work with concept mapping was developed within the constructivist approach to teaching and learning (Novak, Gowin and Johansen, 1983). Constructivist learning theory states that new knowledge should be integrated into existing structures in order to be recalled and receive meaning. Concept mapping stimulates this process by making it explicit and by requiring the learner to pay attention to the relationship between concepts.

Jonassen (1996) states that students show some of their best thinking when they try to represent something graphically. Additionally, experiments have shown that subjects using concept mapping outperform non-concept mappers in longer term retention tests (Novak, Gowin and Johansen, 1983).

1.9.2 Conceptual Framework

Concept maps can help teachers to explain complex structures and relationships of concepts, and to integrate graphically new knowledge with existing knowledge. Comparing his or her own concept map with a learner’s concept map, a teacher can diagnose misunderstandings and misconceptions for the learned topic, and evaluate the learning results at the end of the topic.

Constructing one concept map before a topic and one after the topic is useful for identifying gaps in knowledge. That is, it can be used to help learners know what it is they have learned and what it is they still do not understand. By matching correctly new knowledge to their own schema, eventually learners will achieve a deeper understanding of the knowledge.

Analysis of learner constructed concept maps helps identify conceptual areas on which a student should concentrate and to consider appropriate 'remedial' programmes to meet individual needs and develop these accordingly.

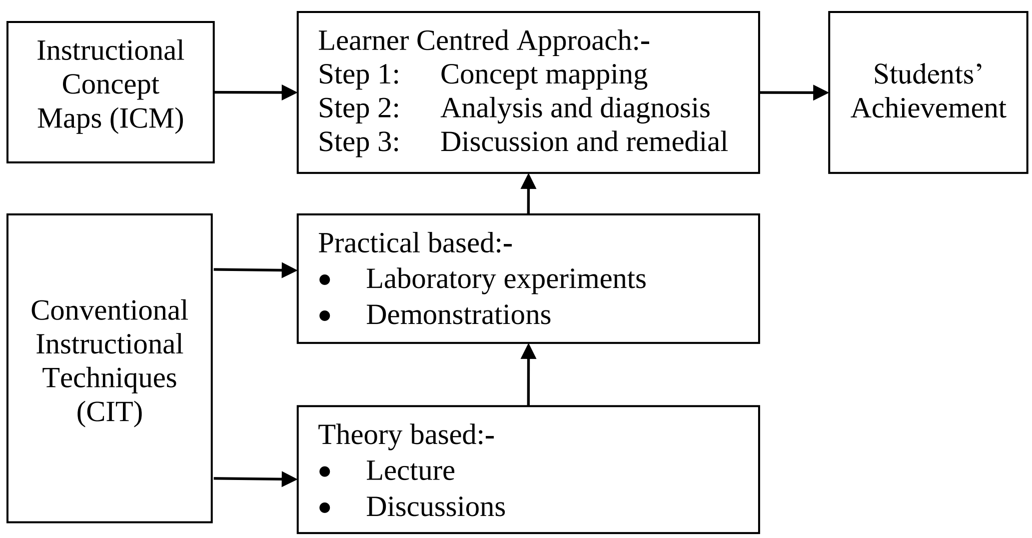


Figure 1.1: Conceptual model for the study

1.10 Operational Definition of Terms

Concept - is the smallest unit of thought that can be totally abstract.

Conventional Instructional Techniques – are regular based teaching methods such as lecture, discussions, demonstrations and laboratory experiment.

Instructional Concept Maps – are graphical representations of knowledge that are comprised of hierarchy of concepts and the inter-relationships between them.

Effects - A result or condition produced by a cause.

Expository teaching – is a teaching strategy in which the teacher uses "pure verbal" techniques.

In-service Training - Planned courses and activities in which a serving teacher, head teacher, school inspector or educational administrator may participate for the purpose of improving his/her instructional or professional knowledge, interest or skills

Performance in Physics – the mean scores students obtain in KCSE physics examinations

Private School – is a school owned, staffed, managed, and supported by individuals or private bodies

Public School – is a school owned, staffed, managed, and supported by various agencies of the Government of Kenya

Secondary School – An institution of learning that offers four years of formal schooling preceding university education. The education offered at this level is based on the four year curriculum which is broad based and builds on concepts, principles, skills and attitudes established at the primary school level.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter has reviewed literature which relates to instructional concept mapping covering both local and international research studies. The sources reviewed were obtained from books, journals, and institutional or organizational reports both print copy and on the internet. The review helped identify and explains the gaps for this study and set how they were addressed.

2.1 Concept Teaching and Learning

To a teacher, teaching students how to think is more important than just conveying information to them. Concepts in any subject are the basic building blocks for thinking, particularly higher-level thinking. Arends (2009) is in agreement when he writes;

> Concept learning is more than simply classifying objects and ideas and deriving rules and principles; they provide the foundations for the idea networks (schemata) that guide our thinking (p. 320).

One important aspect underlying concept teaching comes from the field of human development. Research in this field has shown that the process of learning concepts begins at an early age and continues throughout life as people develop more and more complex concepts, both in school and out (Barsalou, 2000; Benjafield, 1992; Piaget, 1963; Starkey, 1980; Tharp and Entz, 2003). Students come into classrooms with a variety of prior experiences from which they have formed conceptions, or schemata, about the physical and social worlds (Arends, 2009). Sometimes these conceptions are accurate and other times they misrepresent reality. Misconceptions cannot be changed by simply presenting new information. Instead, change requires teaching processes that enable students to become aware of their existing schemata and help them to develop new concepts and reformulations of existing ways of thinking.

Concept teaching approach employed is a key determinant for understanding these schemata and enhancing meaningful learning. Novak, Mintzes and Wandersee (2000) state that

> rote learning occurs when the learner makes no effort to relate new concepts and propositions to prior relevant knowledge he/she possesses (p. 3).

When students are presented with innumerable bits of information to be recalled, it is difficult for them to consider how each bit of information relates to what they already know, thus they resort to rote learning. Such information learned by rote in the absence of connections with previously acquired frameworks is largely forgotten (Novak, 1998). This view is supported by KNEC Report (2006) which indicated that candidates' responses to a large extent showed partially developed and poorly remembered concepts. Thus, the goal of education should be to develop educational experiences that facilitate meaningful learning and reduce the need for rote learning. Ausubel (1968) describes meaningful learning as the establishment of non-arbitrary relations among concepts and sees that meaningful learning is achieved if learners choose to relate new information to ideas they already know. By employing instructional concept mapping in the Kenyan learning environment, it is hoped that students will be able to attain meaningful learning and perform better in examinations.

2.2 Instructional Concept Maps (ICM)

In an attempt to identify more conceptually based teaching and learning methods, research has investigated the use of instructional concept maps at different stages of learning. During the early years of research in instructional concept maps, Symington and Novak (1982) found that primary-grade students are capable of developing very thoughtful instructional concept maps, which they can explain intelligently to others. This observation led the researchers to explore even more the value of instructional concept maps in organizing the instructional material and helping students learn this material.

A particularly interesting and important study on concept learning in primary science done by Novak and Musonda (1991) showed that ICM instructed students possessed more valid science concepts throughout their school life, and they held fewer misconceptions than did non-instructed students. They further noted that although wide variation existed for both groups, the ICM instructed group consistently scored better. Research has also investigated the use of instructional concept maps in advanced content areas such as biology, physics, and chemistry. Below are some of these researches;

A study by Illa (2006) was designed to test the effects of concept mapping strategy on students' creativity in Kenyan secondary school physics. This quasi-experimental study employed two instruments namely; Physics Creativity Test and Concept Map Assessment Test to assess the students' scientific creativity level and to evaluate the quality of the concept maps developed by the Form three physics students, respectively. The results showed that the students who used the concept mapping strategy obtained higher scores in the physics creativity test than those who did not.

The goal of a study by Bascones and Novak (1985) was to test the effect of Concept Mapping on students' problem solving in physics. The teaching process used in this study was based on Ausubel's (1968) theory of meaningful learning. The course was a required physics course taught throughout Venezuela. The design involved two groups. The treatment group had general-to-specific orderings of content and routine Concept Mapping exercises, while the control group had traditional instructional methods. The results showed large effects in favor of the treatment group on every test administration and at all ability levels. The results of this study clearly present a strong statement for the benefit of the instruction that was based on Ausubel's (1968) learning theory and some sort of utilization of Concept Maps. Unfortunately, the nature of this instruction is not fully described.

Pankratius (1990) sought to test if Concept Mapping, and especially the amount of Concept Mapping, would affect achievement in physics problem solving. The main variable was the amount of Concept Mapping practice/experience the students were engaged in. One treatment group created Concept maps at the beginning of a unit and continuing to improve them throughout, a second treatment group made Concept Maps once at the end of a unit. A control group did not make Concept Maps. The results showed statistically significant differences, with both treatments performing better than the control, and periodic Concept Mapping being more effective than Concept Mapping just at the end of the unit.

A study by Czerniak and Haney (1998) was designed to test if the addition of Concept Mapping to instruction in a physical science course would improve achievement, reduce anxiety toward physical science, and reduce anxiety about teaching physical science at the elementary school level. The results showed that Concept Mapping increased achievement, decreased anxiety for learning physical science, and decreased general (trait) anxiety. Results did not indicate an increase in self-efficacy for teaching physical science.

A study by Spaulding (1989) addressed the effects of Concept Mapping versus “concept defining” on learning achievement in biology and chemistry. The results showed no differences between Concept Mappers and Definers. There was also no differential effect for chemistry versus biology. The statistical interactions indicated that lower ability students performed better with Concept Mapping, and higher ability students performed better when just defining the concepts. In another study that found no treatment effect, Lehman, Carter and Kahle (1985) tested the effects of Concept Mapping (with Vee diagraming) verssus “outlining” on improving achievement in a biology course. No statistically significant differences were found in the study.

The purpose of a study by Moreland, Dansereau and Chmielewski (1997) was to test the effect on learning from Concept Mapping versus using text annotations, which are learner-generated enhancements of learning materials, including underlining, marginal notes, etc. These have found to be effective for learning in other studies, but here they were used for learning with Knowledge Maps (Knowledge Maps are very similar to Concept Maps except for more restriction on the nature of links and less restriction on the content of nodes in K-Mapping). There was no statistically significant difference on recall between the mapping condition and the text condition, although a difference in favor of the mapping group approached significance ($p<.08$).

Research has also demonstrated that concept mapping is a skill that requires time for mastery. However, a meta-analysis conducted by Horton, McConney, Gallo, Woods, Senn and Hamelin (1993) has shown that positive effects were achieved in studies that ranged in length from 2 to 22 weeks, with an average duration of six weeks. As a study tool, concept mapping is most effective if it is used on an on-going basis over the course of instruction. Thus, when students build concept maps in homework assignments recurrently, they will get the chance to revise their understanding by modifying their maps leading to better understanding. Furthermore, because of personal involvement and the ability to revise offered by homework assignments, concept mapping is expected to help students overcome difficulties with abstract and complex science concepts by integrating them into well-structured cognitive frameworks.

From the researches mentioned above, it can be argued that research addressing the use of instructional concept maps in physics has no limit in terms of experimental conditions or variables and has often produced inconclusive results. In Kenya, only one study is featured in the area of concept mapping (Illa, 2006) while those who have researched on "effects of science instruction" have looked at practical work (Orado, 2009), ICT (Jesse, 2011) among others. This study will therefore bring a new dimension to factors that influence achievement in science and physics in particular.

2.3 Educational Applications of Instructional Concept Maps

Instructional concept maps have been used in a variety of educational contexts. Each context reflects an alternative theory of knowledge acquisition. On the one hand, the rationalist theory of learning suggests that disciplines have inherent structures that should be conveyed to learners. Therefore, instructional concept maps should be evaluated by relating them to ideal maps, teacher constructed maps, or expert instructional concept maps. On the other hand, constructivists highlight the uniqueness of each individual's representation of concepts (Beyerebach and Smith, 1990) leading them to devise various mechanisms to evaluate students' concept maps. Nevertheless, both theories concur that meaningful learning occurs when concepts are organized in an individual's cognitive structure.

Instructional concept maps are flexible tools that can be used in a variety of educational settings (Stewart, Van-Kirk, and Rowell, 1979). For example, they

> can play a significant role in curriculum development, learning, and teaching (Novak and Gowin, 1984:86).

Instructional concept maps are useful in science curriculum planning for separating significant from trivial content (Starr and Krajcik, 1990) and in focusing the attention of curriculum designers on teaching concepts and distinguishing the intended curriculum from instructional techniques that serve as vehicles for learning (Stewart, Van-Kirk, and Rowell, 1979). Furthermore, instructional concept maps have been used as assessment tools to measure learning outcomes different from those revealed in commonly used psychometric instruments (Markham, Mintzes, and Jones, 1994). However, Johnstone and Otis (2006) suggested that concept maps should be treated as very personal learning tools and consequently, are not appropriate for assessment purposes.

Other practical applications of instructional concept mapping for students include; note-taking during lesson, group brainstorming, planning studies and career, providing graphics for presentations and term projects, and refining creative and critical thinking about problems, questions, explorative ideas. This study will adopt the constructivists' context of using instructional concept maps with students required to brainstorm in group and provide graphic representations of concepts learned during physics lessons.

2.4 Construction Methods for Instructional Concept Maps

Instructional Concept Maps can be constructed by using a variety of methods. The method that is employed depends on the purpose of map construction. The Concept Mapping method defined by Novak and Gowin (1984) involves five phases. The first phase is the brainstorming. At this stage, you come up with the concepts, items, descriptive words or questions that can be associated with the topic, or sub-topic. The teacher may provide a list of prime descriptors or key words, which are taken from a sub-topic. Prime descriptors may also be provided by an initial brainstorming session with the students. From their memory or by going through the topic notes, the students identify facts, terms, and ideas that are associated with the sub-topic.

The second phase is organizing. At this stage, you identify the central word, concept, question or problem around which to build the concept map. Spread out your concepts on a flat surface so that all can be read easily and, together, create groups and sub-groups of related items. Group the items to emphasize hierarchies. You may also introduce new items that you omitted initially. Note that some concepts will fall into multiple groupings.

The third phase is Layout. On a large sheet of paper, you come up with an arrangement (layout) that best represents your collective understanding of the interrelationships and connections among groupings. You are free to rearrange things at any time during this phase. Use a consistent hierarchy in which the most important concepts are in the center or at the top. Within sub-grouping, place closely related items near to each other. At this point, you should think in terms of connecting the items in a simple sentence that shows the relationship between them and not expect your layout to be like that of other groups.

The fourth phase is linking. You use lines with arrows to connect and show the relationship between connected items. Write a word or short phrase by each arrow to specify the relationship. Many arrows can originate or terminate on particularly important concepts.

The last phase involves finalizing the Concept Map. It may take three or more revisions to create a good concept map. Once you are through with an arrangement of items that coveys your understanding, you need to convert the concept map into a permanent form that others can view and discuss. Be creative in a constructive way through the use of colors, fonts, shapes, and border thickness to communicate your understanding. Give your instructional concept map a title.

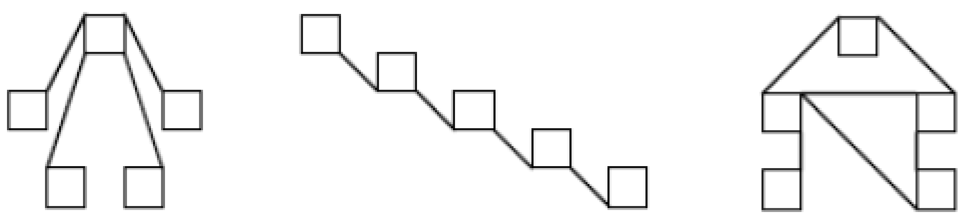
In reviewing your instructional concept map, you should consider the following attributes; first is the accuracy and thoroughness of the maps. Are the concepts and relationships correct? Are important concepts missing? Are any misconceptions apparent? Secondly, consider the organization. Was the concept map laid out in a way that higher order relationships are apparent and easy to follow? Does it have a title?

Thirdly, consider the appearance. Was the assignment done with care showing attention to details such as spelling and penmanship? Is it neat and orderly or is it chaotic and messy? Last, consider creativity. Are there unusual elements that aid communication or stimulate interest without being distracting?

This study will rely on this method of construction of concept maps. Both the teacher and the students either in groups or individually will follow this steps while constructing their maps.

2.5 Concept Mapping and Structure

There are three map structures as proposed by Kinchin (2000); namely spoke, chain, and net structures (Figure 2.1 and Appendix I).



a) Spoke b) Chain c) Net

Figure 2.1: Concept Map Structures

Building on the spoke, chain, and net structures, researchers from Stanford University (Yin, Vanides, Ruiz-Primo, Ayala and Shavelson, 2005) propose five possible structure types that could be used to describe concept maps; Linear, Circular, Hub Spokes, Tree, and Network / Net. The five concept map structures are shown in Appendix II. While employing the Novak and Gowin (1984) method of constructing instructional concept maps, the students can adopt any of the concept map structures in figure 2.1 appendix I.

2.6 Concept Mapping and Graphic Organizers

An ICM is a graphic organizer which uses schematic representation to hierarchically organize a set of concepts, connected by means of words in order to build meaningful statements (Appendix III and IV). Graphic organizers provide visual images and are a good way for students to link new information. This view was echoed by Anderson and Smith (1987) in their study that showed that visual aids and pictures greatly facilitate student understanding of complex concepts.

Concept Maps can be constructed either by hand or with the assistance of software that supports specific tasks or general diagramming. Concept mapping software has been designed to provide different types of facilitation for map construction, including online scoring and assessment of maps, or suggestions about improvements that may be made to the Concept Map. Students are encouraged to explore any of these means of concept map construction in their lessons.

2.7 Grading Concept Maps

Several schemes for scoring concept maps have been suggested. McClure, Sonak and Suen (1999) compared six different scoring methods of concept maps and found them all to be correlated with each other. Shavelson and Ruiz-Primo (2000) presents a scoring scheme adapted from the outline developed by the Cornell University (Novak, 1990) group. It involves scoring the components found in the student’s map, focusing on three components, that is, propositions (concepts and content), hierarchy levels (relationships, links, and cross-links), and examples. The student’s map is then compared with an expert’s map. Finally, a combination of map components and comparison with an expert’s map.

The scoring scheme devised by Markham, Mintzes and Jones (1994) utilized six observed aspects of a student's map; number of concepts presented, concept relationships, branching, hierarchies, cross-links, and examples. This can be summarized based on the following guiding questions. First, are the most important concepts depicted? Second, are the links among concepts scientifically acceptable? The relevance of the 'links' is evaluated, not only for individual linkages but over a coherent number of linkages, as applicable. Third, is there a substantial amount of branching, hierarchy, and cross-linking? The number of links made is considered and whether all prime descriptors have been used, as this gives an indication of the extent of their knowledge base. Last, do any of the propositions suggest that the student subscribes to significant misconceptions? Individual links are considered in terms of the accuracy of the link; propositional statement and direction of the arrow. This helps identify any misconception.

A sample scoring rubric of the concept map is shown in appendix V. The number of markings on the concept maps indicates the extent of misconceptions and depth of understanding of the concepts. This information is of immense value in this study as it will form the basis of assessing students' constructed concept maps.

2.8 Summary

This chapter reviewed literature that is specific to instructional concept mapping and student achievement in science education, with emphasis on physics. It examined the following aspects of concept mapping in physics learning; Concept Teaching and Learning, Instructional Concept Maps (ICM), Educational Applications of Instructional Concept Maps, Construction Methods for Instructional Concept Maps, Concept Mapping and Structure, Concept Mapping and Graphic Organizers, and Grading Concept Maps.

Not much research studies and writing has been done in this area and this explains why the literature is not as elaborate as in other area in Education

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Introduction

This chapter outlines the method and procedures that were used to collect and analyze data. It examines the following issues; research design and variables, location of the study, target population, sampling techniques and sample size, construction of research instruments, pilot study, validity and reliability, data collection and analysis, and logistical and ethical considerations.

3.1 Research Design

This study used quasi-experimental design using pre-test and post-test with a control group and experimental group. This research design was as shown in Figure 3.1.

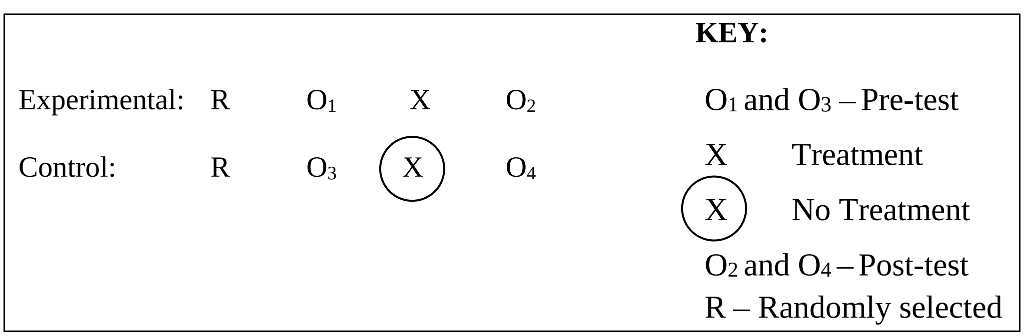


Figure 3.1: Research design for the study

Both groups sat for the pre-test to determine their abilities in physics concepts before the treatment (instruction). The experimental group was then exposed to Instructional Concepts Maps (ICM) during electric current lessons while the control group continued with Conventional Instructional Techniques (CIT). The CIT included lecture, discussions, demonstrations, and laboratory experiments. After the treatment, the two groups were again exposed to the post-test. This was to determine if the use of concept maps made a difference in understanding of the electric current concepts learned.

3.2 Variables

The following were considered the main variables of the study. The independent variable was "use of Instructional Concept Maps (ICM) and Conventional Instructional Techniques (CIT)" while the dependent variable was "Students' achievement in physics".

3.3 Location of the Study

The study was carried out in Nairobi City County (Appendix XIV). The County has a total of 58 public, and 143 private secondary schools (Table 3.1). The location was suitable in terms of administration of instruments and data collection since it is a cosmopolitan region and the findings can apply to other regions in the country.

Table 3.1 Distribution of schools in Nairobi County

Category	Public	Private	Total
Number of Schools	58	143	201
Percentage Representation	28.86%	71.14%	100%

Source: County Director of Education, Nairobi (2012)

3.4 Target Population

This study targeted boys' and girls' public secondary schools in Nairobi County, which register candidates in physics for KCSE examinations (Appendix VI). The participants for the study were four whole classes of form three physics students and their teachers in the selected schools.

3.5 Sampling Techniques and Sample Size

3.5.1 Sampling Techniques

Purposive sampling was used to select public secondary schools that offer physics curriculum at form three since they were the target population for this study. Stratified random sampling was then used to select the boys' and girls' secondary schools.

In the sampled schools, Form Three physics students were purposively selected to consider the topic, *electric current*, which was being taught at this level. Random sampling was then used to select streams and assign them into experimental and control groups.

3.5.2 Sample Size

Four streams (whole classes) of form three physics classes were used for this study. The boys' and girls' schools were represented by two streams each (Table 3.2).

One stream in sampled boys' school was assigned experimental group. The other one was assigned control group. A similar approach was used for sampled girls' school. The three physics teachers for the sampled streams were included in the study.

Table 3.2 Experimental and Control groups

School	Group	No. of Students in Sample Stream
A – Boys	Experimental Control	33 33
B – Girls	Experimental Control	33 33
Total		**132**

3.6 Construction of Research Instruments

Data collection was based on a combination of quantitative and qualitative methods. Four data gathering instruments were used; physics achievement tests, classroom observation schedule, student questionnaire, and teacher questionnaire

3.6.1 Physics Achievement Tests (PAT)

Two types of physics achievement tests were used; pre-test and post-test (Appendices VII and VIII). These were free response style written tests consisting of 20 items to be answered in one hour and were used to measure the learners' performance in physics. The objective was to measure the students' knowledge on concepts of physics before and after the treatment.

Both pre-test and post-test were set and moderated by a panel of three physics teachers. A table of specification was used to construct the test items and to ensure they were well balanced in terms of knowledge and skills tested (Maundu, Sambili and Muthwii, 2005). The pre-test was set from topics before electric current while post-test was set from the electric current topic.

3.6.2 Classroom Observation Schedule (COS)

The instrument, COS was used to gather data on the observed roles of teachers and students in lessons using ICM and those of CIT (Appendix IX). The researcher administered the instrument during the lessons.

3.6.3 Student Questionnaire (SQ)

Student questionnaire was adapted and modified from Simonson (1984:302) (Appendix X). It was used to gather data on the challenges faced by teachers and learners during instructional process. It consisted of a number of items on a Likert scale that required the participants to give a rating to a given statement on a scale of 1 (strongly disagree) to 5 (strongly agree). The reliability estimate of the questionnaire was determined during the pilot study and necessary modifications made on the items.

3.6.4 Teacher Questionnaire (TQ)

Teacher questionnaire was also used to gather data on challenges faced by teachers during instructional process (Appendix XI).

3.7 Pilot Study

The pilot study was used to determine the validity and test the reliability of the research instruments (Kombo and Tromp, 2006). Two streams were used for the pilot study; one from boys' school and the other from girls' school. The two streams were selected by simple random sampling from the schools not sampled for the main research.

The pilot study took a period of one week. During this time, pre-test and post-test were administered and their validity and reliability established. The sampled students and teachers were also requested to complete the questionnaires.

From the data gathered, the suitability and the appropriateness of the instruments' items and the language used in the instruments was evaluated and the necessary modifications made. Expert opinion was also consulted in establishing content validity and reliability of pre-test and post-test, the questionnaire and the observation schedule.

3.7.1 Content Validity

To determine content validity of the pre-test and post-test, a panel of subject matter experts examined the set of items and rated them by indicating whether the items are "essential," "useful" or "not necessary". The group of experts consisted of five experienced physics teachers, all with over 10 years of continuous active teaching. The content validity ratio, CVR (Lawshe, 1975) was then determined using the formula; CVR = $(N_e - N/2)/(N/2)$ where N is the Total number of Experts, and N_e, the Number of Experts indicating item "essential" and thereafter mean content validity ratio of all items in the tests calculated. Content Validity Ratio (CVR) values range -1.00 to 1.00. A value closer to 1.00 is acceptable as it indicates that the item is essential.

In the pre-test, the mean CVR was 0.87 while in the post-test, the mean CVR was 0.91. This indicates that more than half of the subject matter experts rated each item in the test as essential, hence the test is valid. However, the recommended adjustments were done on both the pre-test and post-test.

3.7.2 Reliability

Internal consistency reliability of pre-test and post-test was determined using Split-Half method. The test was split into two halves with one half consisting of all the odd-numbered items and the other half consisting of all the even-numbered items. The scores of the two halves are correlated using Pearson Product Correlation to obtain split-half correlation, r. The coefficient was then adjusted using the Spearman-Brown prophecy formula with correction factor of 2 to represent the reliability of the whole test (Mugenda and Mugenda, 1999:98).

$$\text{Reliability, } r_{sb} = (2)(r) / [1 + (2 - 1)(r)].$$

Split-Half Reliability assumes that, if a test is reliable, a student should score equally on two randomly selected halves of the test. A reliability of 0.8 and higher will be considered to be good (Mugenda and Mugenda, 1999:96). A reliability of 0.83 and 0.94 were obtained for pre-test and post-test respectively.

The reliability of the student questionnaire was determined using the equivalent-form technique. The same group took two different but equivalent versions of the same items on Likert-type scales at two times. The two sets of scores were then correlated using Pearson Product Correlation, r. A reliability value of 0.86 was obtained.

3.8 Data Collection Techniques

Pre-test on physics was given to both groups prior to the intervention. The pre-test result enabled the researcher to determine the equivalence of the groups' ability in physics concepts at the beginning of the study (Table 4.1), which is essential in the quasi-experimental method.

During the intervention, the experimental group was taught the chosen physics concepts using *concept maps* as a teaching and learning tool while the control group was taught the same concepts without using concept maps. In other words, the main difference between the learning experiences of the two groups was in the use of concept maps by teacher and students in the experimental group. Concept maps were drawn progressively by the teacher and students in line with the progress of the lesson. At the end of the lesson, an overview of the main concepts and their sub-concepts including their propositional links were produced. Students further worked in supervised groups to produce more concept maps for the same concepts learned during a lesson.

The classroom observation schedule was used to collect observed data on lessons employing instructional concept mapping and on those of conventional instructional techniques. The two groups in girls' school were taught by two teachers through a coordinated team teaching while the two groups in boys' school were taught by one teacher. Therefore, teacher differences had minimal influence on the research variables. Both groups also received a set of identical brief notes covering the concepts in the study topic.

Both groups were given the post-test after completion of the topic. The students' and teachers' questionnaires were then administered to the participating students and teachers. This process is outlined in Table 3.3.

Table 3.3 Typical Unit of Teaching and Learning Activity

Concept map group	**Non-concept map (CIT) group**
• Teacher explains	• Teacher explains

• Teacher draws concept map • Students copy concept map • Students encouraged to ask questions • Students encouraged to expand on the concepts by giving examples • Students asked to explain using the concept map	• Teacher writes notes • Students copy notes • Students encouraged to ask questions • Students encouraged to give examples to elaborate points • Students asked to explain in a manner he/she understand best

The teacher's instructional guides (Appendix XII) prepared by the researcher with the support of the subject matter experts were used as specific working guides given to participating teachers to ensure that they adhered to the principles guiding the experiment especially the teaching methods while they taught the 'electric current' topic and its related concepts. It was to eliminate the possibility of the teachers introducing their biases.

Electric current topic was divided into fifteen content phases. At the end of teaching each phase, the teacher provided a list of prime descriptors (key words), which were taken from the phase. The learners were introduced to free-range concept mapping, building upon the idea in stages. The learners in work team of 4 to 6 members were then invited to construct their own maps using the prime descriptors.

The maps were then collected for analysis. Analysis of the completed maps was carried out at different levels. First, individual links were considered in terms of the accuracy of the link (propositional statement and direction of the arrow). This helped identify any misconceptions. Next, the number of links made was considered and whether all prime descriptors have been used, as this gave an indication of the extent of their knowledge base. Lastly, the relevance of the links was evaluated for individual linkages and related linkages forming a whole map.

The analyzed concept maps had a number of markings on them indicating misconceptions and irrelevant ‘links’. The teacher also wrote comments on each map indicating the general level of the whole map and conceptual areas on which the students should concentrate.

Afterwards, the teacher discussed the concept maps with each work team. During this discussion the teacher made sure to confirm with the students the meaning they gave to the concepts, in order to get a concept improvement in relation to them. As a result, the students’ concept maps were progressively corrected and used to reinforce learning. Besides, the concept maps were enlarged with new concepts as learners moved to a new block in a process of structuring and re-structuring the students’ knowledge. This is referred to as progressive concept mapping.

Following the analysis of the post-phase concept maps, discussion with students regarding their concept maps allowed the researcher to consider appropriate ‘remedial’ programmes to meet learners’ needs and develop these accordingly. The post-test was constructed primarily to examine students’ level of understanding the electric current concepts learned.

3.9 Logistical and Ethical Considerations

The researcher obtained a research permit from the National Council for Science and Technology to carry out the study. The researcher then visited the sampled schools to seek permission from the respective principals to carry out the research from the schools.

Meetings with the participating physics teachers were arranged to seek their consent and to discuss the purpose of the study and the work plan. The teachers informed their students about the study and introduced the researcher to them. After seeking the consent of the sample students, the final execution stage was to involve testing the instruments (pilot study) and administering the instruments; achievement test, observation schedule and questionnaires.

The information collected is treated with confidentiality. The researcher did not misuse privileges given, distort research or conceal the research findings for personal or group interest.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Introduction

This chapter considers analysed data, its interpretation and discussion with regard to the objectives and research questions for this study. The study focused on the following objectives; to evaluate students' achievement in Electric Current when taught through concept mapping strategy and conventional instructional techniques, to assess the role of physics teacher and student in lessons employing concept mapping strategy and conventional instructional techniques, and to identify the challenges encountered by physics teachers and students when using concept mapping strategy and conventional instructional techniques. Analysis of data was done using both descriptive and inferential statistics. For qualitative data, frequency distribution and percentages were used. For quantitative data, mean ($\overline{X}$), standard deviation and t-test were used. The significance was tested by computing the P-value at a significance or alpha level of 0.05. The SPSS was useful in the analysis of most statistics. Data were presented thematically based on the objectives of the study.

4.1 Evaluation of Students' Achievement when taught through ICM and CIT

This study was a quasi-experimental design consisting of pre-test before intervention and post-test after the intervention with a control group and experimental group. The intervention involved using Instructional Concept Maps (ICM) as the control group used Conventional Instructional Techniques (CIT). Thus, the focus of the study was on effects of concept maps using the topic 'electric current'. The achievement tests consisted of 20 free response style formatted items with a maximum score of 40 marks. The objective was to measure knowledge on concepts of physics, and hence evaluates students' achievement. This was used to help answer the question "does concept mapping strategy improve students' achievement in Electric Current?" A total of 132 students participated in the study, with the experimental and control groups consisting of 66 students each. Three teachers were actively involved in the study as research assistants. These were the regular teachers in the sample schools. The teachers were inducted and continuously briefed and coordinated through the lessons. They also received a set of identical brief notes on concepts in the study topic.

4.1.1 Results of the Pre-test

The students' pre-test scores were used to calculate the mean, standard deviation and the standard error of mean of both the experimental and the control. The mean scores on the pre-test were very close for the two groups indicating the two groups were of equivalent ability in physics (Table 4.1). This is a useful condition for this study design.

Table 4.1 Pre-test Scores for Experimental and Control Groups

			Descriptive statistics			Levene's Test for Equality of Variances	
School	**Group**	**N**	**Mean (Max $\bar{x}$ =40)**	**Std. Deviation**	**Std. Error Mean**	***F***	***p***
A (Boys)	Experiment	33	17.18	4.8118	0.8252	0.0129	0.9100
	Control	33	16.76	5.1783	0.9014		
B (Girls)	Experiment	33	18.79	6.0247	1.0650	0.0609	0.8059
	Control	33	18.36	5.8085	0.9961		

Having confirmed equality of the groups' variances (Levine's test with *p*>.05) as indicated in table 4.1, comparison between the mean scores was carried out using an independent-samples t-test. The *t*-test results showed that the difference was not statistically significant (Table 4.2). Therefore, the two groups in both schools were assumed to be equivalent with respect to their initial knowledge and understanding of physics concepts.

Table 4.2 Independent *t*-test results on initial group differences

		Independent t-test for Equality of Means						
School		**t**	**df**	**Sig. (2-tailed)**	**Mean Diff.**	**Std. Error Diff.**	**95% Confidence Interval of the Difference**	
							Lower	**Upper**
A (Boys)	Equal Variances	0.3447	64.000	0.7314**	0.4242	1.2305	-2.0341	2.8825
	Unequal Variances	0.3447	63.658	0.7314	0.4242	1.2305	-2.0348	2.8832
B (Girls)	Equal Variances	0.2913	64.000	0.7718**	0.4243	1.4568	-2.4860	3.3346
	Unequal Variances	0.2913	63.915	0.7718	0.4243	1.4568	-2.4869	3.3355

**Difference is not statistically significant, *p*>.05

4.1.2 Results of the Post-test

The students' achievements of electric current concepts were investigated for both the experimental and control groups. Table 4.3 shows the descriptive statistics and Levene's test for equality of variances results on difference in students' achievements. The data were obtained immediately after the intervention and therefore this is considered as the immediate learning gain.

Table 4.3 Descriptive statistics results for difference in learning gains

			Descriptive statistics			**Levene's Test for Equality of Variances**	
School	**Group**	**N**	**Mean (Max $\bar{x}$ =40)**	**Std. Deviation**	**Std. Error Mean**	***F***	***p***
A (Boys)	Experiment	33	21.18	5.3060	0.9100	0.4048	0.5269
	Control	33	18.48	4.7112	0.8201		
B (Girls)	Experiment	33	25.03	5.4514	0.9637	1.1255	0.2927
	Control	33	21.91	6.2016	1.0636		

An independent-samples t-test was conducted to compare students' achievement of the learned electric current concepts in ICM and CIT lessons. In boys' school, there was a statistically significant difference in the scores for experimental (M=21.18, SD=5.3060) and control (M=18.48, SD=4.7112) groups at the 5% level of significance; t(64)= 2.1834, p = 0.0327. Similarly, in Girls' school, the immediate mean gain score for the experimental group (M=25.03, SD=5.4514) was high compared to the control group

(M=21.91, SD=6.2016) and the difference is statistically significant at the 5% level, t (64)=2.1715, p=0.0336 based on an equal variance independent *t*-test (Table 4.4).

Table 4.4 Independent *t*-test results for difference in learning gains

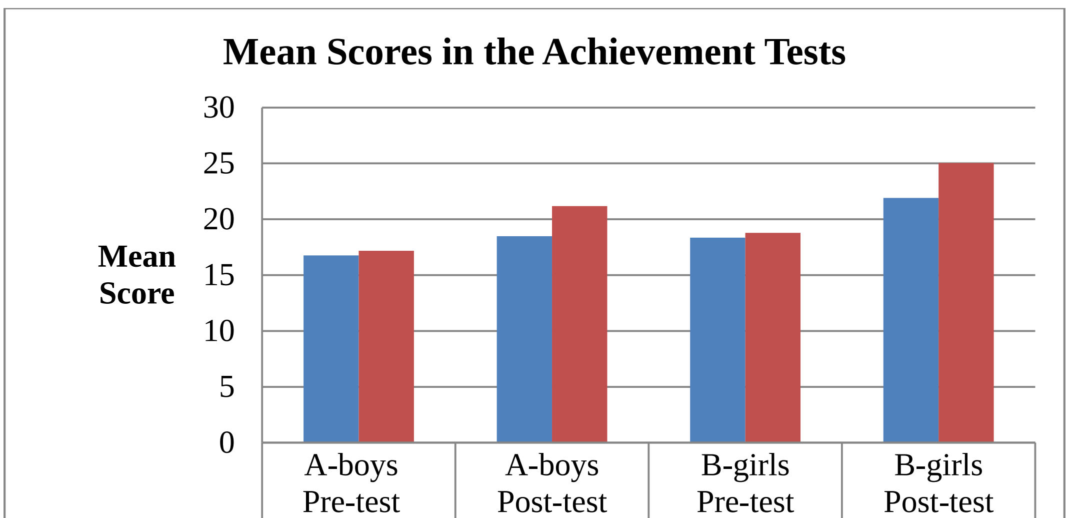
		Independent t-test for Equality of Means						
School		**t**	**df**	**Sig. (2-tailed)**	**Mean Diff.**	**Std. Error Diff.**	**95% Confidence Interval of the Difference**	
							Lower	**Upper**
A	Equal Variances	2.1834	64.000	0.0327*	2.6970	1.2352	0.2294	5.1646
(**Boys**)	Unequal Variances	2.1834	63.116	0.0327	2.6970	1.2352	0.2286	5.1654
B	Equal Variances	2.1715	64.000	0.0336*	3.1212	1.4374	0.2498	5.9926
(**Girls**)	Unequal Variances	2.1715	62.965	0.0337	3.1212	1.4374	0.2480	5.9944

*Difference is statistically significant, $p<.05$

The equal variance independent *t*-test was used after ascertaining that the two groups have similar variances as indicated by the *p*-value for the Levine's test that is greater than 0.05 (Table 4.3). The statistically significant difference in the *t*-test result means that the experimental group was superior to the control group suggesting the benefit of instructional concept maps on learning. Rao (2003) agrees with these results when he stated that concept mapping as an instructional tool had an effect on the achievements of students who also reflected a positive attitude towards concept mapping as an effective teaching strategy.

4.1.3 Comparison of the mean difference between Experimental and Control groups

As can be seen from Figure 4.1, in the pre-test, the mean differences between the experimental and control groups were 0.4242 and 0.4243 for the boys' and girls' school respectively. These differences are not significant thus implying that the two groups were of relatively equal ability at the beginning of the study.



	A-boys Pre-test	A-boys Post-test	B-girls Pre-test	B-girls Post-test
Control	16.76	18.48	18.36	21.91
Experimental	17.18	21.18	18.79	25.03

Figure 4.1: Mean Scores in the Students' Achievement Tests

For the post-test, the mean differences between the two groups were 2.6970 and 3.1212 for the boys' and girls' school respectively. These values are significant and therefore indicate the difference between the experimental and control groups in terms of performance in the post-test. The information on mean performances between the two groups is also displayed in Table 4.1, and Table 4.3.

From these post-test results, it can be seen that experimental group performed better than the control group. Thus, the findings show that concept mapping method improves students' achievement in electric current. This largely indicates the benefit of concept mapping instruction to the learning of physics concepts and is in agreement with previous studies. Novak and Musonda (1991) showed that students taught using concept maps posses more valid science concepts and hold fewer misconceptions compared to students instructed using conventional methods. They further noted that although wide variation existed for both groups, the ICM instructed group consistently scored better. Pankratius (1990) also showed that students who create concept maps during learning perform better than those who do not, and that periodic Concept Mapping is more effective than Concept Mapping just at the end of the unit.

The performance of students in the control group was average and significantly less compared to those of experimental group (Figure 4.1). This showed that they could not demonstrate full understanding of the electric current concepts. These findings are in agreement with Novak, Mintzes and Wandersee (2000) when stated that rote learning occurs when the learner makes no effort to relate new concepts and propositions to prior relevant knowledge his/her possesses and Novak (1998) who said that such information learned by rote in the absence of connections with previously acquired frameworks is largely forgotten.

4.2 Role of Teachers in ICM and CIT Lessons

The primary role of a classroom teacher as an instructor is to plan and implement study lessons in a manner that helps students to develop and relate concepts. A teacher is supposed to teach areas of the curriculum, monitor, evaluate and report students' progress in key learning areas, and implementing strategies to achieve targets related to specific student learning outcomes.

Classroom Observation Schedule (Appendix IX) was used to evaluate various aspects of lesson presentation with regard to teachers' and students' roles. The objective was to assess the role of physics teacher and student in lessons employing concept mapping strategy and conventional instructional techniques. These aspects considered included:-

a) The teacher's choice of teaching method
b) How the teacher prepared the students before using the teaching method
c) Teacher's competence on the use of the methods
d) Reporting or reinforcing key points in the presentation
e) Lesson review by the teacher

Twenty eight lessons were observed, fourteen each for ICM and CIT Lessons. The data obtained were analysed in order to answer the question "what are the roles of teachers in lessons employing concept mapping strategy and conventional instructional techniques?" The responses were as outlined below.

4.2.1 Aspects of Role of Teachers in ICM and CIT Lessons

The teaching strategies observed during COS included lecture, note taking (dictating notes), question-answer method, demonstration, laboratory experiment, discussion, problem solving (for numerical concepts), assignment, and concept mapping. These teaching strategies/methods were then classified as teacher centered, interaction, and leaner centered (Table 4.5 Item 3). The findings show that not many teaching strategies used by teachers are learner centered. From the findings, it can also be said that teachers rarely plan for activity-based lessons.

Table 4.5 Teaching Strategies/Methods used in ICM and CIT Lessons

		Teacher centered	Interaction	Leaner centered
COS Item 3	Classify the teaching strategy/method	• Lecture • Demonstration • Note taking	• Question-Answer • Discussion • Assignment • Problem solving	• Experiment • Concept mapping

The findings reflect the outcome of a baseline study conducted by SMASSE project technical team in 1998 that showed teaching methodology as a major contributing factor for poor performance in physics (Waititu and Orado, 2009). Despite the focus on INSET for teachers to improve their teaching practices, these results still show how unprepared teachers are in the case of SMASSE's ASEI-PDSI implementation programme in Kenya and illustrates that perhaps efforts to train teachers on the implementation of ASEI-PDSI approach need to be stepped up.

However, the teachers gave a number of reasons for their choice of these teaching strategies. The reasons included size of the class, students' ability, suitability of a method, wide syllabus content, teacher's effort to encourage teacher-student interaction, and to help students acquire and retain the desired knowledge and skills.

Within the constructivist framework, a role of the teacher is to provide learners with flexible learning tools as opposed to routine procedures (Duffy, 1993), and to provide the necessary scaffolds for the learners to make progress. At times these scaffolds are the teacher providing information and the necessary support; at others it is the materials and processes that act as scaffolds (Vygotsky, 1978).

Table 4.6 shows that there was no major difference between ICM and CIT lessons in the manner in which the teachers prepared the learners before using a specific teaching strategy. It can be seen that in 71.4% of the ICM lessons observed, the teacher "adequately" prepared the students before using a given strategy. This was 7% close (64.3%) to CIT lessons observed in which the teacher "adequately" prepared the students before using the chosen strategy (COS Item 4). This could be because teachers tend to choose teaching strategies/methods they are competent in.

Table 4.6 Teacher's ability to prepare Students for a Strategy and Review of Lesson Presentations

Observed teacher aspect	Percentage rating per scale									
	Not at all		A little		Fairly adequately		Adequately		A great deal	
	ICM	CIT	ICM	CIT	ICM	CIT	ICM	CIT	ICM	CIT
COS Item 4	0	0	7.1	7.1	14.3	21.4	**71.4**	64.3	7.1	7.1
COS Item 6	0	14.3	0	14.3	14.3	64.3	**71.4**	7.1	14.3	0

The findings summarized in table 4.6 also revealed that the majority (64.3%) of teachers in CIT lessons "fairly adequately" reviewed the lessons. This is unlike in ICM lessons where the teachers "adequately" reviewed the lessons in 71.4% of the lessons observed (COS Item 6 and Figure 4.2). This is possibly because the constructed concept maps gave a summary of the concepts learned during the lesson and made it easy or conditioned the teachers to review the lessons.

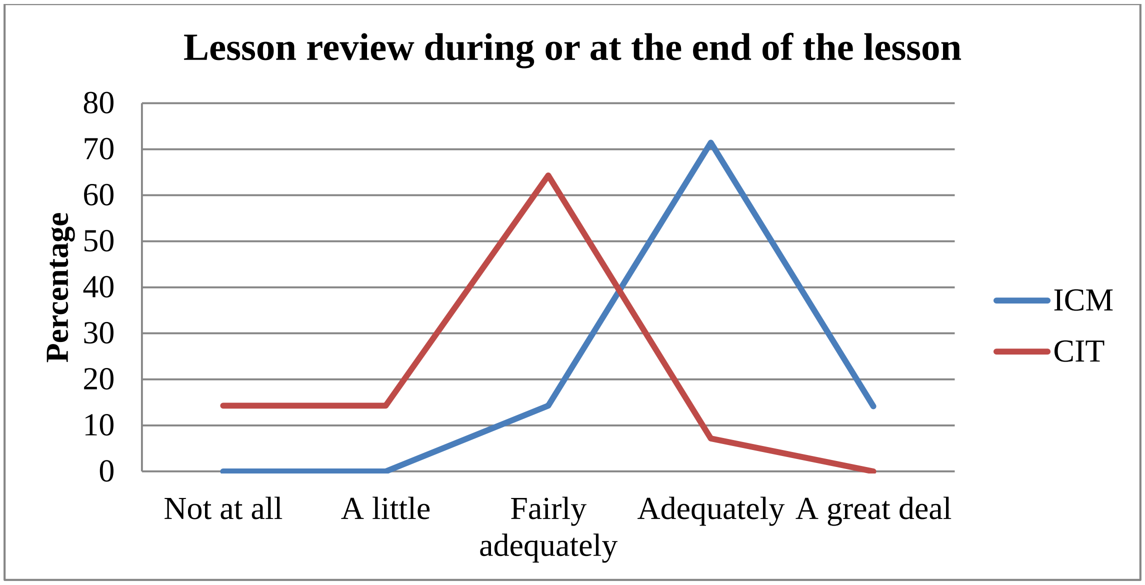


Figure 4.2: Lesson review by the teacher during or at the end of the lesson

Another area of interest was teacher competence in using various teaching methods. As table 4.7 shows, teacher's competence on the use of specific strategies/methods was rated "good" at 64.3% and 57.1% for ICM and CIT lessons respectively. This could be a confirmation that teachers settle for strategies they are competent in. It was observed that the teachers for the experimental groups did not find difficulty in integrating concept mapping strategy with their regular teaching strategies/methods.

Table 4.7 Teacher's Competence on the use of Teaching Strategies

Observed teacher aspect	Percentage rating per scale									
	Very poor		Poor		Average		Good		Very good	
	ICM	CIT	ICM	CIT	ICM	CIT	ICM	CIT	ICM	CIT
COS Item 7	0	0	0	0	28.6	21.4	**64.3**	57.1	7.1	21.4

Eighty five point seven percent (85.7%) of the students in ICM lessons reported that "the teacher reported/reinforced key points in the presentation" immediately. Fifty seven percent of students in CIT lessons reported that the teacher responded to key points "at appropriate breaks" (Table 4.8 and figure 4.3). This could have been possible because the level of teacher-student and student-student interaction in ICM lessons is relatively high and that immediate response is necessary in the process of constructing the concept maps.

Table 4.8 Teacher's Report/Reinforcement of Key points

Observed teacher aspect	Percentage rating per scale								Mean and SD			
	Immediate		At appropriate breaks		Later after presentation		Withheld key points		Mean		Std. Dev	
	ICM	CIT	ICM	CIT	ICM	CIT	ICM	CIT	ICM	CIT	ICM	CIT
COS Item 5	**85.7**	28.6	7.1	57.1	7.1	14.3	0	0	3.79	3.14	0.56	0.64

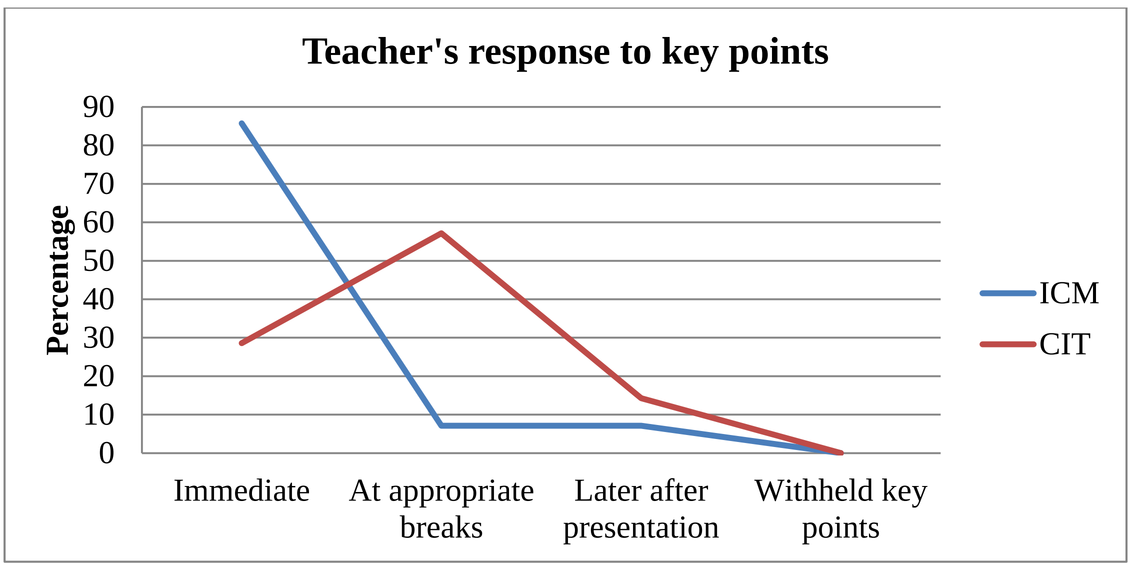


Figure 4.3: Teachers' report/reinforcement to key points in the presentation

4.3 Role of students in ICM and CIT Lessons

Classroom Observation Schedule (COS) was used to evaluate the;

a) level of students' participation in the lesson

b) level of students' interaction with the teaching resources

c) level of students' interaction with each other

d) use of question and answer

e) students' ability to answer conceptual questions

These aspects were assessed using a five point Likert scale; not at all, a little, fairly adequately, adequately, and a great deal. The coding formulation gave 5-points for a 'great deal' and 1-point for a 'not at all' for the five statements. During observation of the lessons, the researcher would rate each aspect according to its application in that lesson. A total of twenty eight lessons were observed, fourteen each for ICM and CIT Lessons. The data obtained was analysed in order to answer the question "what are the roles of students in lessons employing concept mapping strategy and conventional instructional techniques?

4.3.1 Role of students in ICM Lessons

The students' roles were evaluated using a five level rating scale (Figure 4.4 and Figure 4.6). Learners participated "a great deal" (78.6%) in the ICM lessons that were observed. Thus, the use of ICM had a positive effect on students' willingness to be actively engaged in the learning process.

In 78.6% of the lessons, learners were "adequately" allowed to interact with the learning resources. However, the groups' concept maps differed significantly in the structure (or organization) of their representations, replicating the findings of De Simone and Schmid (1998). Some had the more traditional appearance of hierarchical maps, while others included more cyclical patterns. Groups also varied in their ability to represent the text-based knowledge accurately, though overall they were successful at analyzing the relevant content. That is, they were able to identifying main concepts and group them across the sub-topic.

Students interacted with each other “a great deal” in 57.1% of the lessons. This was possibly because learners were directly involved in the construction of the concept maps and the teachers only served to assist them. The ICM lessons were, therefore, characterized by high involvement of the student and encouraged collaborative learning, an instructional strategy that is characterized by structured group work that supports various forms of thoughtful discussion and dialogue amongst group members (Abrami, Chambers, Poulsen, De Simone, d'Apollonia, and Howden, 1995).

Cooperative learning, a specific form of collaboration, has been found to enhance achievement and productivity significantly more than competitive or individual learning structures. Equally impressive is the positive impact that team learning has on student attitudes about learning, affect, and self-concept (Johnson and Johnson, 1994).

In lessons that were observed, the majority (64.3%) of students asked questions or sought guidance “a great deal” and were able to answer conceptual questions “adequately” (71.4%). The rating of all students’ aspects as observed is shown in figure 4.4.

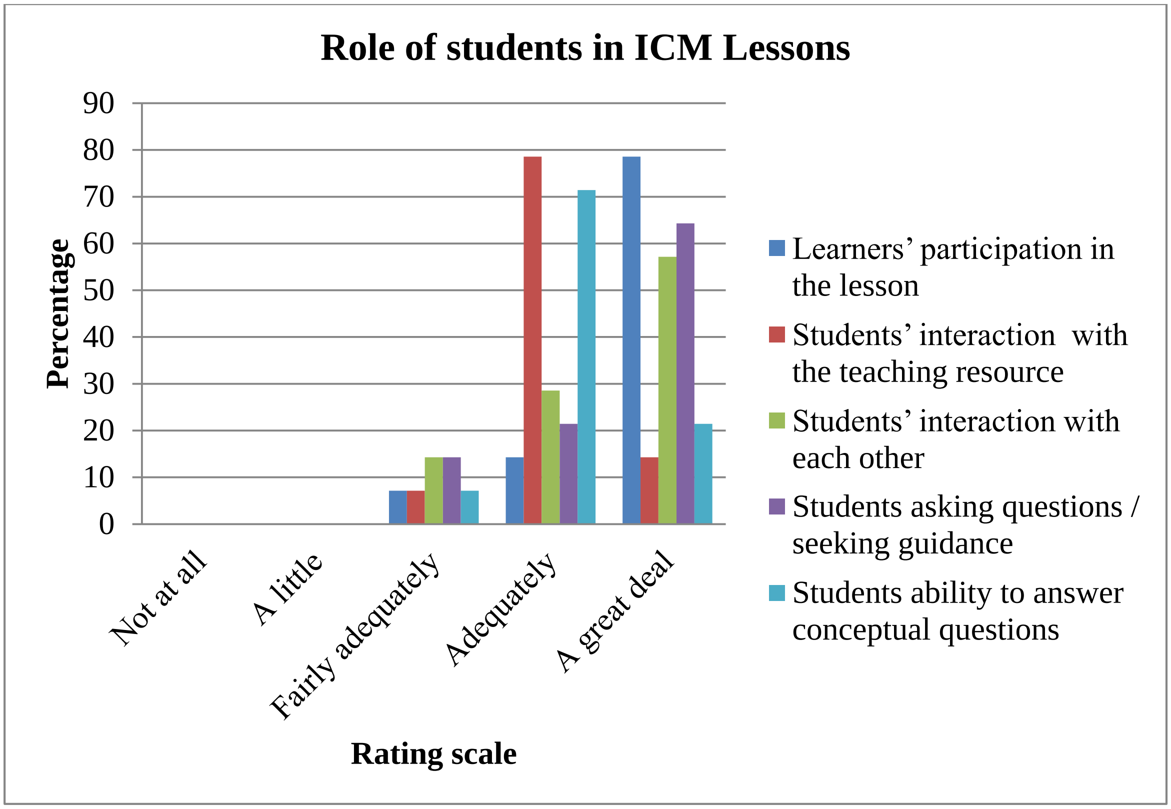


Figure 4.4: Role of students in ICM Lessons

4.3.2 Role of students in CIT Lessons

Figure 4.5 shows that in 50.0% of the CIT lessons observed, learners were given time to participate in the lessons "a great deal". They were also allowed to interact with learning resources "adequately" (57.1%). Students interacted with each other "fairly adequately" (57.1%) during the CIT lessons observed. Thus, the CIT lessons were characterized by average involvement of the student. This was possibly because students' participation, interaction with learning resources and with each other is only limited to question-answer sessions, discussion, teacher guided problem solving sessions and during experiments which are in themselves not adequate. This type of learning is classified as passive learning. The students accept the information at face value without questioning or discussing its merits or fallibilities.

It was however noted that students "fairly adequately" asked questions or sought guidance in 57.1% of the CIT lessons observed. Similarly, students were "fairly adequately" able to answer conceptual questions (64.3%).

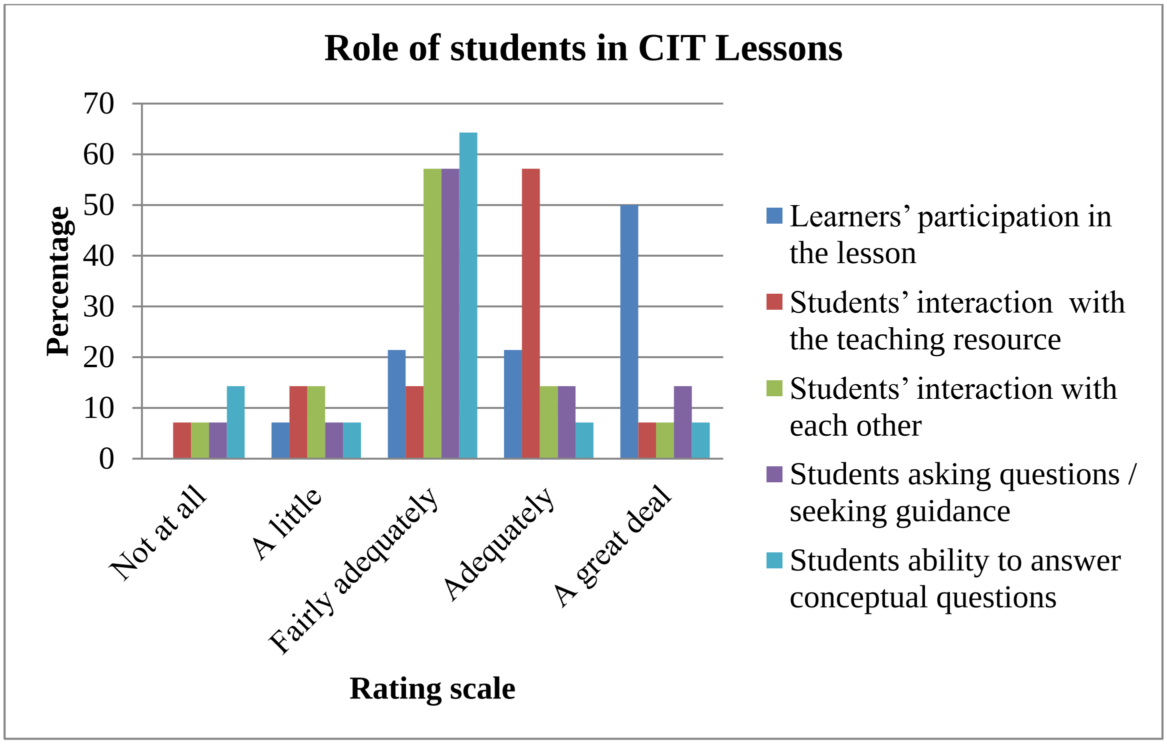
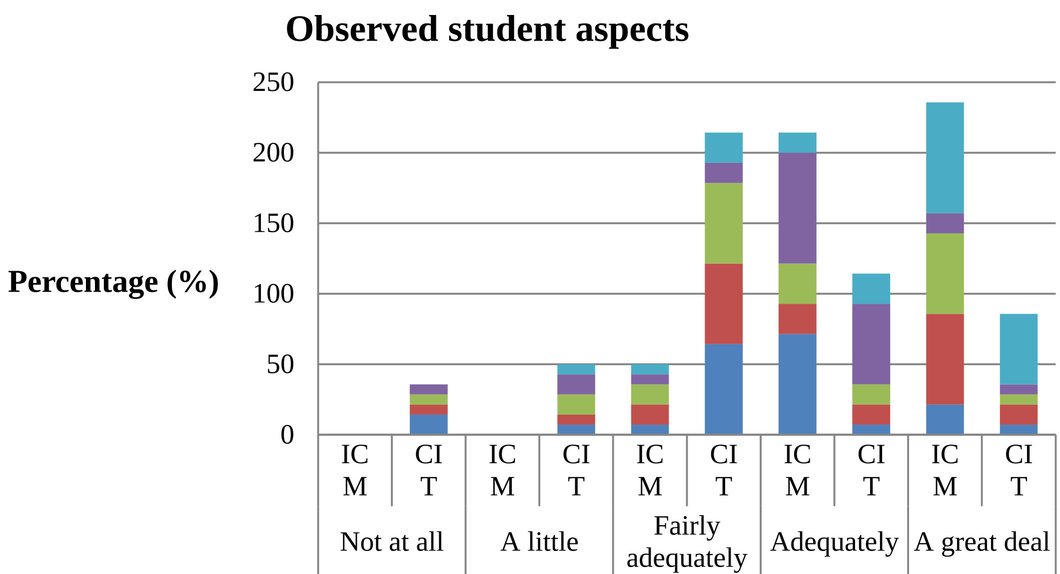


Figure 4.5: Role of students in CIT Lessons

4.3.3 Comparison of students' Role in ICM and CIT Lessons

As can be observed in figure 4.6, in both ICM and CIT lessons, the majority (78.6% and 50.0% respectively) of students participated in the lessons "a great deal". However, the level of participation was 28.6% slightly high in ICM lessons. Students' interaction with the teaching resources in both the lessons was also rated as "adequate" with 78.6% level of interaction for ICM lessons and 57.1% level of interaction for CIT lessons. Thus, students' interaction with the teaching resources was marginally high in ICM lessons by 21.5%. This observation agrees with the findings that in traditional classes, teachers deliver lessons for the majority of the class time and there is little opportunity for student input through discussion or experiential exercises (Stewart-Wingfield and Black, 2005).

On students' interaction with each other, 57.1% of the ICM lessons observed revealed that learners were able to interact with each other "a great deal" as opposed to 57.1% of CIT lessons where learners were able to interact with each other "fairly adequately". It was also observed that in 64.3% of ICM lessons, students asked questions or sought guidance "a great deal". This was unlike in 57.1% of CIT lessons in which students "fairly adequately" asked questions or sought guidance. In 71.4% of ICM lessons, students ability to answer conceptual questions was adequate compared to 64.3% of CIT lessons in which students were "fairly adequately" able to answer conceptual questions. Comparison of students' aspects observed in ICM and CIT is summarized in figure 4.6 and table 4.6.



	Not at all ICM	Not at all CIT	A little ICM	A little CIT	Fairly adequately ICM	Fairly adequately CIT	Adequately ICM	Adequately CIT	A great deal ICM	A great deal CIT
Learners' participation in the lesson	0	0	0	7.14	7.14	21.43	14.29	21.43	78.57	50
Students' interaction with the teaching resource	0	7.14	0	14.29	7.14	14.29	78.57	57.14	14.29	7.14
Students' interaction with each other	0	7.14	0	14.29	14.29	57.14	28.57	14.29	57.14	7.14
Students asking questions / seeking guidance	0	7.14	0	7.14	14.29	57.14	21.43	14.29	64.29	14.29
Students ability to answer conceptual questions	0	14.29	0	7.14	7.14	64.29	71.43	7.14	21.43	7.14

Figure 4.6: Rating of Students' Role in ICM and CIT Lessons

Table 4.9 Summary of Roles of Students in ICM and CIT Lessons

	Observed student aspect	*n* ICM	*n* CIT	Mean (Max $\bar{x}$ =5.00) ICM	Mean (Max $\bar{x}$ =5.00) CIT	Std. Dev ICM	Std. Dev CIT
1	Learners' participation in the lesson	14	14	4.71	4.14	0.59	0.99
2	Students' interaction with the teaching resource	14	14	4.07	3.43	0.46	1.05
3	Students' interaction with each other	14	14	4.43	3.00	0.73	0.93
4	Students asking questions / seeking guidance	14	14	4.50	3.21	0.73	1.01
5	Students ability to answer conceptual questions	14	14	4.14	2.86	0.52	0.99

n – Respondents, Maximum mean $\bar{x}$ = 5.00

From the mean values obtained, it can be seen that the ICM lessons obtained high mean rating in all aspects of student roles observed as compared to ICT lessons. This shows that students in the experimental lessons were more actively involved in the learning process compared to those in the control lessons. This may be attributed to the nature of ICM instruction which compel students' involvement in the lesson in the aspects assessed.

4.4 Challenges encountered by Teachers and Students in ICM and CIT Lessons

Teachers often experience challenges not only in the content they teach, but also in the way they teach. These challenges affect their effort to make teaching consistently effective despite the inherent complexity of the classroom. Student questionnaire (SQ) was used to identify the various challenges encountered by physics teachers and students when using concept mapping strategy and conventional instructional techniques. The data obtained was used to answer the question "what are the challenges encountered by physics teachers and students when using concept mapping strategy as compared to those using conventional instructional techniques?"

The challenges the study set out to assess using SQ (Appendix X) included: teacher's level of organization (Item 1); the lesson time management (Item 2); teacher-student interest and enthusiasm (Items 3, 4, 5); clarity, respect, tolerant, and fairness by the teacher (Items 6, 7); lesson planning (Items 8, 9, 10, 11, 12, 13, 14, 15); use of instructional materials (Item 16); teacher-student interaction and communication (Items 17, 18); classroom management (Item 19); teacher's use of questioning and answering (Item 20); teacher audibility (Item 21); and overall atmosphere created during the lesson

(Item 22). Tables 4.5 and 4.6 show a summary of data, a descriptive analysis of the students' response. The students' responses are summarized in table 4.7 and table 4.8.

4.4.1 Challenges Encountered by Teachers and Students in ICM Lessons

In 50.0% of ICM lessons in boys' school (Table 4.10, Item 1), students strongly agreed that the teacher was well organized during lesson presentation as compared to 53.1% of ICM lessons in girls' school (Table 4.11, Item 1). The majority (67.7% and 64.3% for girls' and boys' schools respectively) of respondents "agree" that the lesson time was efficiently used. This could be because the use concept mapping is an effective time management and reading method. Concept mapping does not take any more time than any other method that actively organizes material. One of the challenge could be the students are used to a receiver role and not a producer role. The producer role is the only way for active thinking and cooperative learning.

Most students (92.9% and 50.1% for boys' and girls' schools respectively) "agree" or "strongly agree" that the teacher was interested in the class, was enthusiastic about what he/she taught, and stimulated their interest on the lesson. These findings mirror the teacher's role of facilitating learning. Showing enthusiasm is one way to motivate students to achieve the academic goals established for the topic. Of all the variables in the motivation equation, enthusiasm is one for which the teacher has the greatest control, takes the least amount of time, and can have an immediate and visible impact on student motivation.

Most participants in the boys' school in ICM lessons "agree" or "strongly agree" that the teachers explained the lesson material clearly, and that the teacher was respectful, tolerant and fair to them during the lesson presentation. However, the mean rating by students in girls' school was average (2.91). In 51.6% of the lessons, the students "agree" that the teachers explained the lesson material clearly while in 34.3%, the students "agree" that the teacher was respectful, tolerant and fair to them during the lesson presentation (Table 4.10 and Table 4.11, Items 6 and 7). Novak and Heinze-fry (1990) stated that concept mapping appeared to enhance clarity of learning, integration and retention of knowledge.

Table 4.10 Time management, interest, enthusiasm, clearity, respect and tolerance in Boys' ICM lessons

ITEMS	**Percentage rating per Scale**					**Respondents**
	SA	**A**	**N**	**D**	**SD**	***n***
Q1	50.0	46.4	0.0	3.6	0.0	28
Q2	**32.1**	**64.3**	0.0	3.6	0.0	28
Q3	53.6	39.3	7.1	0.0	0.0	28
Q4	50.0	35.7	14.3	0.0	0.0	28
Q5	42.9	50.0	3.6	3.6	0.0	28
Q6	42.9	53.6	3.6	0.0	0.0	28
Q7	50.0	46.4	3.6	0.0	0.0	28

Table 4.11 Time management, interest, enthusiasm, clearity, respect and tolerance in Girls' ICM lessons

ITEMS	**Percentage rating per Scale**					**Respondents**
	SA	**A**	**N**	**D**	**SD**	***n***
Q1	25.0	53.1	15.6	0.0	6.3	32
Q2	**12.9**	**67.7**	12.9	6.5	0.0	31
Q3	6.3	43.8	34.4	3.1	12.5	32
Q4	34.5	31.0	24.1	3.5	6.9	29
Q5	16.7	30.0	10.0	33.3	10.0	30
Q6	19.4	51.6	16.1	12.9	0.0	31
Q7	12.5	34.4	9.4	18.8	25.0	32

On lesson planning as evaluated by items 8 to 15 (Table 4.12 and Table 4.13), most students were in agreement that the teachers presented the lesson well. In 42.9% of the ICM lessons (Table 4.12, Item 16), the students "strongly agree" that the instructional materials assisted them understand the lesson better. Also, 48% of students in ICM lessons in girls' school "strongly agree" or "agree" that there was good teacher-student interaction and communication, and that the teacher reacted well to situations that arose during the lesson (Table 4.13, Items 17 and 18). More boys (96.4% and 89.3%) "strongly agree" or "agree" with these statements (Table 4.12, Items 17 and 18).

Table 4.12 Lesson planning, use of Instructional materials, Interaction and communication in Boys' ICM lessons

ITEMS		Percentage rating per Scale					Respondents
		SA	**A**	**N**	**D**	**SD**	***n***
Lesson planning	**Q8**	53.6	35.7	7.1	3.6	0.0	28
	Q9	17.9	57.1	14.3	10.7	0.0	28
	Q10	51.9	44.4	0.0	0.0	3.7	27
	Q11	63.0	29.6	0.0	7.4	0.0	27
	Q12	32.1	32.1	32.1	3.6	0.0	28
	Q13	39.3	42.9	17.9	0.0	0.0	28
	Q14	39.3	46.4	3.6	7.1	3.6	28
	Q15	42.9	46.4	3.6	7.1	0.0	28
Q16		**42.9**	39.3	10.7	3.6	3.6	28
Q17		**50.0**	**46.4**	3.6	0.0	0.0	28
Q18		**53.6**	**35.7**	3.6	7.1	0.0	28

Table 4.13 Lesson planning, use of Instructional materials, Interaction and communication in Girls' ICM lesson

ITEMS		Percentage rating per Scale					Respondents
		SA	**A**	**N**	**D**	**SD**	***n***
Lesson planning	**Q8**	25.0	43.8	12.5	3.1	15.6	32
	Q9	32.3	19.4	19.4	19.4	9.7	31
	Q10	34.4	40.6	15.6	9.4	0.0	32
	Q11	43.3	50.0	3.3	3.3	0.0	30
	Q12	12.9	58.1	16.1	6.5	6.5	31
	Q13	9.4	50.0	18.8	6.3	15.6	32
	Q14	31.3	25.0	6.3	15.6	21.9	32
	Q15	15.6	40.6	28.1	12.5	3.1	32
Q16		21.9	34.4	0.0	18.8	25.0	32
Q17		**18.8**	**21.9**	6.3	25.0	28.1	32
Q18		**15.6**	**25.0**	21.9	15.6	21.9	32

Many students in ICM lessons in boys' school "agree" or "strongly agree" that the classroom was well managed, questioning and answering method used appropriately, and that there was a pleasant overall atmosphere created during the lesson, aspects that most students in ICM lessons in girls' school rated as below average (Table 4.14 and 4.15, Items 19-22).

Table 4.14 Classroom management, use of Questioning and Answering, and appropriate voicing in Boys' ICM lessons

ITEMS	Percentage rating per Scale					Respondents
	SA	A	N	D	SD	*n*
Q19	40.0	44.0	12.0	4.0	0.0	25
Q20	50.0	46.4	3.6	0.0	0.0	28
Q21	57.1	32.1	10.7	0.0	0.0	28
Q22	44.0	52.0	4.0	0.0	0.0	25

Table 4.15 Classroom management, use of Questioning and Answering, and appropriate voicing in Girls' ICM lessons

ITEMS	Percentage rating per Scale					Respondents
	SA	A	N	D	SD	*n*
Q19	6.3	37.5	25.0	18.8	12.5	32
Q20	12.9	25.8	19.4	19.4	22.6	31
Q21	35.5	45.2	9.7	9.9	0.0	31
Q22	25.0	18.8	12.5	18.8	25.0	32

4.4.2 Challenges Encountered by Teachers and Students in CIT Lessons

In CIT lessons, 76.7% of students in girls' school "strongly agree" or "agree" (30% and 46.7%) that the teacher was well organized during lesson presentation (Table 4.17, Item

1). A similar percentage of the students “strongly agree” or “agree” (20% and 56.7%) that the lesson time was sufficiently managed (Table 4.17, Item 2). In boys’ school, 65.5% of students “strongly agree” or “agree” that the teacher was well organized while 68.9% of students “strongly agree” or “agree” that the lesson time was sufficiently used (Table 4.16, Items 1 and 2).

Teachers are major source of stimulation for the subject content and the overall tone of their classroom. Therefore, it is important for a teacher to model the behavior he or she wants to see the students display. If the teacher appears bored and uninterested in the lesson, the students will most likely respond to that negative energy and apathetic attitude by duplicating it. Being excited about the content, presenting the information and activities in an organized and interesting way, and showing a genuine interest and enthusiasm in teaching will go a long way in maintaining student attention. These ideas were established by the research findings.

Over 60% of the students in CIT lessons “strongly agree” or “agree” that the teacher was interested in the class, was enthusiastic about what he/she taught, and stimulated their interest on the lesson. Similarly, over 70% of the students in CIT lessons agreed that the teachers explained the lesson material clearly, and that the teacher was respectful, tolerant and fair to them during the lesson presentation.

Table 4.16 Time management, interest, enthusiasm, clarity, respect and tolerance in Boys' CIT lessons

ITEMS	Percentage rating per Scale					Respondents
	SA	A	**N**	**D**	**SD**	***n***
Q1	48.3	17.2	13.8	6.9	**13.8**	29
Q2	**31.0**	**37.9**	10.3	**13.8**	**6.9**	29
Q3	30.0	40.0	20.0	0.0	10.0	30
Q4	30.0	30.0	33.3	0.0	6.7	30
Q5	41.4	34.5	6.9	3.5	13.8	29
Q6	40.0	36.7	10.0	10.0	3.3	30
Q7	56.7	30.0	3.3	0.0	10.0	30

Table 4.17 Time management, interest, enthusiasm, clarity, respect and tolerance in Girls' CIT lessons

ITEMS	Percentage rating per Scale					Respondents
	SA	A	**N**	**D**	**SD**	***n***
Q1	**30.0**	**46.7**	13.3	10.0	0.0	30
Q2	**20.0**	**56.7**	20.0	3.3	0.0	30
Q3	33.3	33.3	23.3	6.7	3.3	30
Q4	33.3	26.7	33.3	6.7	0.0	30
Q5	30.0	23.3	16.7	13.3	16.7	30
Q6	17.2	44.8	17.2	13.8	6.9	29
Q7	20.0	50.0	16.7	13.3	0.0	30

The students for CIT lessons in boys' school were of the opinion that lesson presentation was well done. At least 70% of these students "strongly agree" or "agree" with the statements in items 8 to 15 (Table 4.18 and Table 4.19). However, only 51.7% of the students in boys' school think that the lesson objectives were followed as outlined in the class at the beginning of the lesson (Table 4.18 Item 9) and only 55.2% of them think the lesson material was well covered in the amount of time given. 27.5% of these students "disagree" or "strongly disagree" with this opinion (Table 4.18 Item 15). According to students for CIT lessons in girls' school, lesson presentation was well done, but the level of agreement was less compared to boys' school. Slightly over 50% of all of them agreed with the statements in items 8 to 15 (Table 4.19). Only 36.7% of the students "strongly agree" or "agree" that there was a good summary to the lesson during or at the end of the lesson (Table 4.19 Item 14). Only 10.7% of the students strongly disagreed that the lesson objectives were covered as outlined in the class at the beginning of the lesson, 17.9% of them disagreed with the statement (Table 4.19 Item 9).

On the use of instructional materials, 69% of girls and 73.3% of boys "strongly agree" or "agree" that instructional materials assisted them to understand the lesson. However, 17.3% of girls and 16.7% of boys "disagree" or "strongly disagree" with this view better (Table 4.18 and Table 4.19, Item 16). Most boys in CIT lessons agreed that there was good teacher-student interaction and communication, and the teacher reacted well to situations that arose during the lesson (Table 4.18 and Table 4.19, Items 17 and 18). Less than 50% of the girls' students agreed with these statements.

Table 4.18 Lesson planning, use of Instructional materials, Interaction and communication in Boys' CIT lessons

ITEMS	Percentage rating per Scale					Respondents
	SA	A	**N**	**D**	**SD**	***n***
Q8	26.7	53.3	3.3	6.7	10.0	30
Q9	**27.6**	**24.1**	17.2	20.7	10.3	29
Q10	33.3	36.7	16.7	10.0	3.3	30
Q11	41.4	41.4	6.9	0.0	10.3	29
Q12	33.3	36.7	16.7	3.3	10.0	30
Q13	33.3	50.0	3.3	3.3	10.0	30
Q14	36.7	36.7	16.7	6.7	3.3	30
Q15	**27.6**	**27.6**	17.2	**10.3**	**17.2**	29
Q16	**33.3**	**40.0**	10.0	6.7	10.0	30
Q17	66.7	13.3	10.0	0.0	10.0	30

Table 4.19 Lesson planning, use of Instructional materials, Interaction and communication in Girls' CIT lessons

ITEMS	Percentage rating per Scale					Respondents
	SA	A	**N**	**D**	**SD**	***n***
Q8	23.3	33.3	20.0	16.7	6.7	30
Q9	25.0	32.1	14.3	**17.9**	**10.7**	28
Q10	13.3	36.7	26.7	20.0	3.3	30
Q11	37.9	41.4	10.3	6.9	3.5	29
Q12	10.3	37.9	34.5	13.8	3.5	29
Q13	31.0	27.6	20.7	20.7	0.0	29
Q14	**16.7**	**20.0**	20.0	23.3	20.0	30
Q15	27.6	37.9	6.9	20.7	6.9	29
Q16	**34.5**	**34.5**	13.8	13.8	3.5	29
Q17	28.6	21.4	14.3	28.6	7.1	28

The majority (over 75%) of students in CIT lessons in boys' school "strongly agree" or "agree" that the classroom was well managed, questioning and answering method used appropriately, and that the teacher used an appropriate voice for the classroom situation, aspects that students in CIT lessons in girls' school "strongly agree" or "agree" with at total percent of 40%, 51.7% and 93.3% respectively (Table 4.20, Items 19, 20 and 21).

Table 4.20 Classroom management, use of Questioning and Answering, and appropriate voicing in Boys' CIT lessons

ITEMS	Percentage rating per Scale					Respondents
	SA	A	**N**	**D**	**SD**	***n***
Q18	43.3	43.3	10.0	0.0	3.3	30
Q19	40.0	43.3	3.3	6.7	6.7	30
Q20	53.3	26.7	13.3	3.3	3.3	30
Q21	48.3	34.5	6.9	0.0	10.3	29
Q22	58.6	20.7	10.3	0.0	10.3	29

Table 4.21 Classroom management, use of Questioning and Answering, and appropriate voicing in Girls' CIT lessons

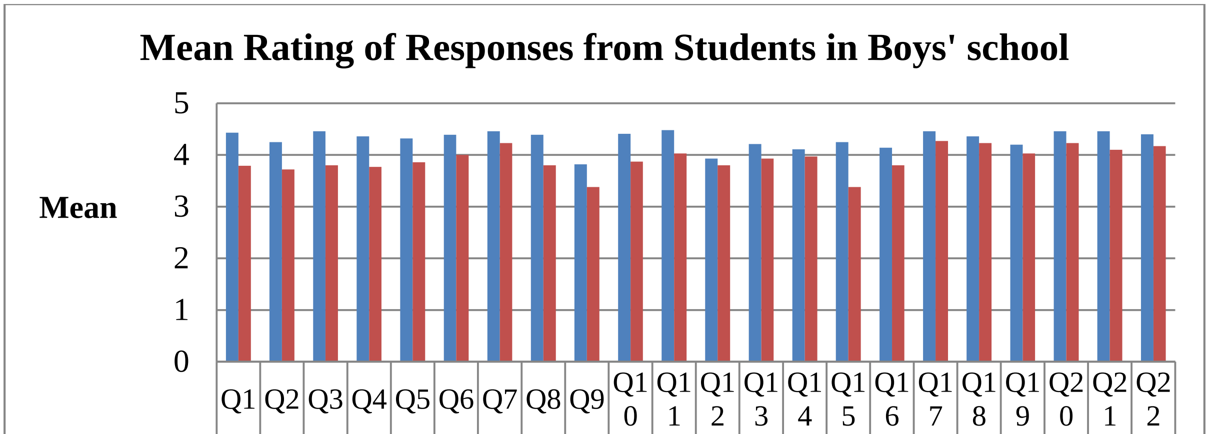
ITEMS	Percentage rating per Scale					Respondents
	SA	A	**N**	**D**	**SD**	***n***
Q18	17.9	28.6	35.7	14.3	3.6	28
Q19	16.7	23.3	30.0	16.7	13.3	30
Q20	20.7	31.0	24.1	13.8	10.3	29
Q21	60.0	33.3	3.3	0.0	3.3	30
Q22	23.3	26.7	26.7	10.0	13.3	30

4.4.3 Comparison of Challenges Encountered by Teachers and Students in ICM and CIT Lessons

It was noted that while most students viewed the teacher as well organized during lesson presentation, a few did not. Notably, 13.8% of male students in CIT lessons strongly disagreed that the teacher was well organized (Table 4.16, Item 1). There is also a minority (6.3%) of female students in ICM lessons that perceived the teacher as not organized (Table 4.11, Item 1). On lesson management, 96.4% of boys and 80.6% of girls in experimental lessons “strongly agree” or “agree” that the lesson time was well managed (Table 4.10, Item 2 and Table 4.11, Item 2). This is as compared to 68.9% of boys and 76.7% of girls in control lessons (Table 4.16, Item 2 and Table 4.17, Item 2). There was however 20.7% of male students in CIT lessons who “disagree” or “strongly disagree” (13.8% and 6.9%) that lesson times were not efficiently used (Table 4.16, Item 2).

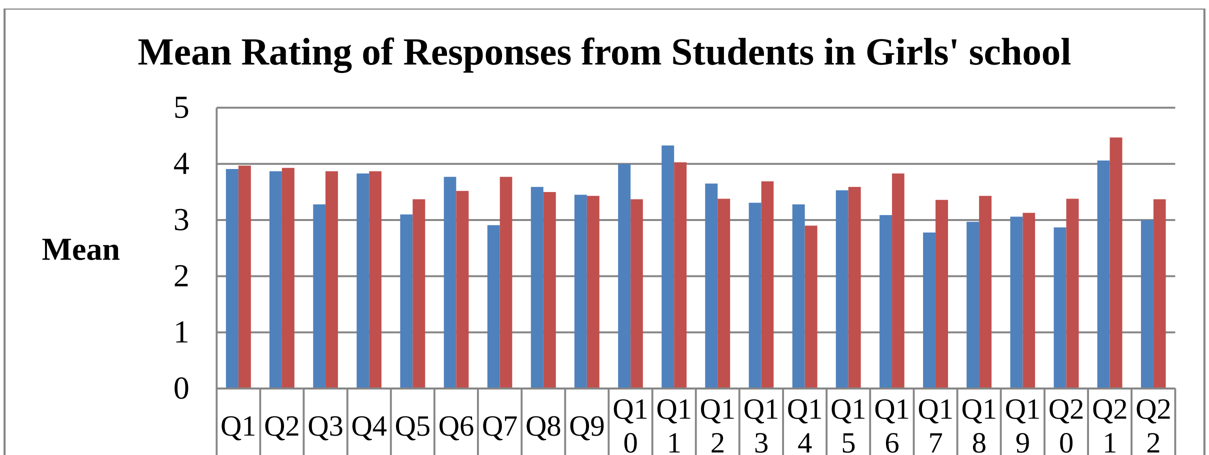
The teachers interest in the class, his/her enthusiasm about what he/she taught and the teachers ability to stimulate students interest on the lesson were evaluated by items 3, 4 and 5 (Appendix X), and were characterized by high mean rating for both the ICM and CIT lessons (Figure 4.7 and Figure 4.8). This shows that irrespective of the strategy or method the teachers were using, they were still able to stimulate and sustain students’ interest on the lessons. These means were however significantly high for ICM lessons compared to CIT lessons in boys’ school. This could be attributed to use of concept mapping as it is the main influencing variable in ICM lessons.

It was also established through items 6 and 7 (Figure 4.7 and Figure 4.8) that most students believed that the teachers explained the lesson material clearly, and were respectful, tolerant and fair to them. This confirms that in both the ICM and CIT lessons, the teachers were professional and mature in their handling of the classroom duties.



	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22
Mean ICM	4.4	4.3	4.5	4.4	4.3	4.4	4.5	4.4	3.8	4.4	4.5	3.9	4.2	4.1	4.3	4.1	4.5	4.4	4.2	4.5	4.5	4.4
Mean CIT	3.8	3.7	3.8	3.8	3.9	4	4.2	3.8	3.4	3.9	4	3.8	3.9	4	3.4	3.8	4.3	4.2	4	4.2	4.1	4.2

Figure 4.7: Mean Rating of Students' Responses in Boys' school



	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22
Mean ICM	3.9	3.9	3.3	3.8	3.1	3.8	2.9	3.6	3.5	4	4.3	3.7	3.3	3.3	3.5	3.1	2.8	3	3.1	2.9	4.1	3
Mean CIT	4	3.9	3.9	3.9	3.4	3.5	3.8	3.5	3.4	3.4	4	3.4	3.7	2.9	3.6	3.8	3.4	3.4	3.1	3.4	4.5	3.4

Figure 4.8: Mean Rating of Students' Responses in Girls' school

A lesson plan is the instructor's road map of what students need to learn and how it will be done effectively during the lesson presentation. Lesson presentation was evaluated by items 8 to 15 (Figure 4.7 and Figure 4.8). The meaning rating indicated that majority of students were of the agreement that the lessons were well planned with an exception of mean rating for girls' school where students in CIT lessons were somewhat neutral (Item 14) as to whether there was a good summary to the lesson during or at the end of the lesson.

On the use of instructional materials, the students agreed in equal measure as to whether there was good use of instructional materials. They could not clearly tell if the instructional materials assisted them to understand the lesson better. This could be because teachers are experiencing difficulty on the use of various instructional materials even after adequately preparing for the lesson.

As to whether there was good teacher-student interaction and communication and if the teacher reacted well to situations that arose during the lesson as rated by items 17 and 18, most students in boys' school "agree" or "strongly agree". However, girls' schools were characterized by low mean rating. This shows that most students were either neutral or disagreed that there was good teacher-student interaction and communication.

Classroom management, teacher's use of questioning and answering, and appropriate speaking voice for the classroom situation were rated with means above four by students in boys' school. On the contrary, students in girls' school rated these aspects with means of about 3.00 (Figure 4.7 and Figure 4.8, Items 19, 20 and 21). The majority of students in both groups rated the overall atmosphere created during the lesson above four (Item 22). This shows that all students strongly agreed that there was a pleasant overall atmosphere created during the lesson. That is, the learning situation was comfortable, cheery, and open so everyone felt free to talk and was inviting to both the students and the teacher.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

This chapter presents a summary of the research findings, conclusions made in accordance with the research results, recommendations based on these research findings and suggestions for further research in education.

5.1 Summary

In this section, a summary of the findings of this study is presented under the following subheadings: Comparison of performance between the experimental and control group; Role of Teachers in ICM and CIT Lessons; Role of students in ICM and CIT Lessons; and Challenges Encountered by Teachers and Students in ICM Lessons.

5.1.1 Comparison of performance between the experimental and control groups

This section provides an answer to the question; "Does concept mapping strategy improve students' achievement in Electric Current?"

The mean scores on the pre-test were very close for the experimental and the control groups. In the boys' school, the means were 17.18 and 16.76 while in girls' school, the means were 18.79 and 18.36 for experimental and control group respectively. A *t*-test result showed that the difference is not statistically significant at 0.05 significance level and 95% confidence level (interval).

On the contrary, the mean scores for post-test were not similar for the two groups. In the boys' school, the means were 21.18 and 18.48 while in girls' school, the means were

25.03 and 21.91 for experimental and control group respectively. A *t*-test result showed that the difference is statistically significant at a significant level of 0.05 based on an equal variance independent *t*-test.

The data on the post-test were obtained immediately after the intervention and therefore is considered as the immediate learning gain. The statistically significant difference in the *t*-test result means that the experimental group obtained larger learning gain compared to the control group. Instructional concept maps therefore improve students' achievement in physics.

5.1.2 Role of Teachers in ICM and CIT Lessons

This section provides an answer to the question; "What are the roles of teachers in lessons employing concept mapping strategy and conventional instructional techniques?" The data used was obtained using classroom observation schedule.

The study set to assess the role of teacher as an instructor/facilitator. These involve planning and implementing the curriculum with a broad view of achieving educational goals of a nation. The aspects assessed included choice of teaching strategy, effectiveness of the strategy and teachers' competence on the use of the strategy, highlight of key points and lesson review for important concepts.

From the findings, teaching strategies commonly employed are teacher centered or interactive, and rarely learner-centered. The study established that other than national examinations oriented experiment (practical), teachers rarely plan activity-based lessons. This shows that the teachers are either "not ready" or are unprepared to implement SMASSE's ASEI-PDSI programme.

Findings revealed that teachers did not find difficulty in using instructional concept maps for the first time. Therefore, it can accurately be said that reasons given by teachers for their choice of teaching strategy cannot prevent them from trying out new strategies which are learner-centered. The reasons included the class size, students' ability, ease of use of the strategies/methods, effort to boost teacher-student interaction, the short time available for syllabus coverage, and their ability to help the students acquire and retain the desired knowledge and skills.

According to the study results, teachers rank high on their ability to prepare the learners before using a specific teaching strategy. The results also show teacher's competence on the use of specific strategies/methods was rated "good". We can therefore argue that teachers choose teaching strategies/methods they are competent in and feel comfortable using, and may not prefer trying out new methods that may be involving at the start.

In the ICM lessons, teachers were able to review the lessons much better than in CIT lessons, giving summary to the lesson during or at the end of the lesson. We can suggest that constructed concept maps gave a summary of the concepts learned during the lesson and made it easy for the teachers to review the lessons. Similarly, in ICM lessons, teachers were able to report/reinforce key points in the presentation immediately. This was unlike in CIT lessons where mostly, teachers reported/reinforced key points at appropriate breaks. This is possibly because the level of teacher-student and student-student interaction in ICM lessons is relatively high and that immediate response is necessary in the process of constructing the concept maps.

5.1.3 Role of students in ICM and CIT Lessons

This section provides an answer to the question; "What are the roles of students in lessons employing concept mapping strategy and conventional instructional techniques?" The data used was obtained using classroom observation schedule.

The study set to assess the role of students as active participants in their learning. By active, this means that students should contribute to classroom discussions by not only answering direct questions posed by the teacher, but answers questions posed by their peers. This again, is not all that the student should do. Students should feel free to ask questions, or express their own ideas about a subject, not only to their teacher, but also their peers. This allows students to construct their own knowledge about their learning, and apply if to their education. These roles encourage positive interdependence, interaction, and student-centered learning. Student-centred learning is focused on each student's interests, abilities, and learning styles, placing the teacher as a facilitator of learning. This classroom teaching method acknowledges student achievement as central to the learning experience for every learner.

The aspects assessed included students' participation in the lesson, and interaction with the teaching resources and with each other, level of questioning, and students' ability to answer conceptual questions. These aspects were assessed using a Likert scale divided into five levels; not at all, a little, fairly adequately, adequately, and a great deal.

From the findings, learners participated "a great deal" in both ICM and CIT lessons. However, the level of participation was high in ICM lessons. Students' interaction with the teaching resource in both the lessons was also rated as adequate. Similarly, students' interaction with the teaching resource is marginally high in ICM lessons. The study further established that students' interacted with each other "a great deal" in ICM lessons and "fairly adequately" in CIT lessons. This could be attributed to the fact that learners in ICM lessons worked in groups, and were directly involved in construction of the concept maps and teachers only served to facilitate the process. This shows that ICM lessons have the students at its centre in an active role and teacher in a passive, instructive role. We can also say that perhaps students' participation in the lessons, and interaction with learning resources and with each other in CIT lessons is only limited to question-answer sessions, discussion, teacher guided problem solving sessions and during experiments which are in themselves not adequate.

The findings revealed that students in ICM lessons asked questions and sought guidance "a great deal". This was unlike in CIT lessons in which students "fairly adequately" asked questions or sought guidance. According to results obtained from ICM lessons, students' ability to answer conceptual questions was adequate. On the other hand, results obtained from CIT lessons revealed that students were "fairly adequately" able to answer conceptual questions. This is because ICM lessons focus on concepts and establishing relationship between and among the concepts. The construction of instructional concept maps is activity-based, student-centered learning.

5.1.4 Challenges Encountered by Teachers and Students in ICM Lessons

This section provides an answer to the question; "What are the challenges encountered by physics teachers and students when using concept mapping strategy as compared to those using conventional instructional techniques?" The data used was obtained using student questionnaire.

The study was designed to identify challenges which included teacher's level of organization, lesson time management, teacher-student interest and enthusiasm, clarity, respect, tolerant, and fairness by the teacher, lesson planning, use of instructional materials, teacher-student interaction and communication, classroom management, teacher's use of questioning and answering, teacher's speaking voice, and overall atmosphere created during the lesson.

Most students were of the opinion that the teachers for ICM and CIT lessons were organized and that lesson time was not efficiently used. The teachers interest in the class, his/her enthusiasm about what he taught and the teachers ability to stimulate students interest on the lesson were characterized by high mean rating for both the ICM and CIT lessons. This shows that irrespective of the strategy or method the teachers were using, they were still able to stimulate and sustain students' interest in the lessons. However, the findings show that use of concept mapping has more positive influence in stimulating students' interest on the lesson.

It was also established that most students believed that the teachers explained the lesson material clearly, and were respectful, tolerant and fair to them. This confirms that in both the ICM and CIT lessons, the teachers were professional and mature in their handling of the classroom duties. The majority of students were also in agreement that the lessons were well planned with an exception of means rating for girls' school where students in CIT lessons were neutral as to whether there was a good summary to the lesson during or at the end of the lesson.

The students for ICM and CIT lessons agreed and disagreed in equal measure as to whether there was good use of instructional materials. They could not clearly tell if the instructional materials assisted them to understand the lesson better. This could be because teachers are experiencing difficulty on the use of various instructional materials even after adequately preparing for the lesson.

Most students in boys' school either agreed or strongly agreed that there was good teacher-student interaction and communication and the teacher reacted well to situations that arose during the lesson. However, girls' schools were either neutral or disagreed that there was good teacher-student interaction and communication. Similarly, the majority of students in boys' school either agreed or strongly agreed that classroom was well managed, the teachers used questioning and answering, and appropriate speaking voice for the classroom situation. On the other hand, students in girls' school were neutral about these aspects.

Finally, most of students "agree" or "strongly agree" that a pleasant overall atmosphere was created during the lessons. That is, the learning situation was comfortable, cheery, and open so everyone felt free to talk and was inviting to both the students and the teacher.

5.2 Conclusions

5.2.1 Specific Conclusions

Based on the study findings, the following conclusions were made. First, given that in the post-test, the mean difference between the two groups was large enough and the equal variance independent-samples t-test confirmed that the difference is statistically significant at 5% level of significance and 95% confidence level (interval), the study concluded that concept mapping instruction has a positive effect on students' achievement in physics.

Secondly, the study concluded that teachers commonly used teacher centered or interactive teaching methods mainly because they are either "not ready" or are unprepared to plan and implement activity-based or learner-centered lessons as advocated by SMASSE's ASEI-PDSI programme. Such activity-based lessons are slightly more involving in terms of time and effort to plan compared to teacher-centered or interactive based lessons. Teachers tend to prefer strategies based on ease of use of the strategies/methods.

Thirdly, instructional concept maps were viewed as a better way of summarizing concepts learned during the lesson thereby making it easy for the lessons to be reviewed and key points reported or reinforced as is required. Fourth, learners' participation is high in student centered learning. The level of students; interaction with the teaching resource and with each other is also high. This translates to active learning and students taking responsibility for their own learning.

Lastly, that the challenges teachers and students encounter during the lessons influence the quality of instruction. These challenges are the same for all teaching strategies/methods. However, most of these challenges are easy to overcome by adopting certain teaching strategies.

5.2.2 Overall Conclusion

This study sets out to determine whether concept mapping instruction benefit students in the learning of electric current concepts in secondary school physics. The findings indicate that students learn better when concept maps are used in the teaching and learning of the concepts and students retain more of what they have learnt in the short-term. The positive effect of teacher and learners' generated concept maps on short-term learning was statistically significant. Therefore, serious considerations should be given to the adoption of concept maps as a teaching and learning tool in the learning of physics with teacher and students drawing the concept maps.

Achievement in science education and in physics in particular can be improved by implementing concept mapping instruction in the teaching of science subjects. This is because ICM is a learner centered strategy that put the students in charge of their learning, and teachers as the facilitators. In general, instructional strategies used by teachers to a great extent determine the performance of the learners. Teachers should make effort to adopt activity based learning in their classroom presentation. The role of teachers and students, and the challenges they face while executing these roles has a positive correlation with the achievement of learners in their area of study. Since these roles and challenges are unique and dynamic, the parties should make concerted effort to always improve and develop.

5.3 Recommendations for implementation

This study brings out a number of possible recommendations for implementation. First, it suggests the integration of concept mapping instruction among other student centered learning with CIT as a way of promoting active learning and empowering learners to take responsibility for their learning.

Second, the study encourage continuous teacher professional development programmes as a way of enabling teachers to interact, share ideas and experiences, learn new ideas, and encourage them to try out different strategies with an aim of enhancing their professionalism. To that end, the government should step up efforts on the implementation of ASEI-PDSI approach.

5.4 Recommendations for further research in science education

This study determined effect of concept mapping instruction on students' achievement in the learning of electric current concepts on short-term. This is because the post-test was administered as soon as the topic was covered and the scores considered immediate learning gain. There is therefore need to determine the effect of concept mapping instruction on students' achievement on long-term. Hence, longitudinal type of study is recommended.

This study focused only on physics. Thus, it would be interesting to find out the effects of ICM in other subjects particularly languages and humanities. This is because performance of learners in other subjects contributes to overall grade awarded to a candidate.

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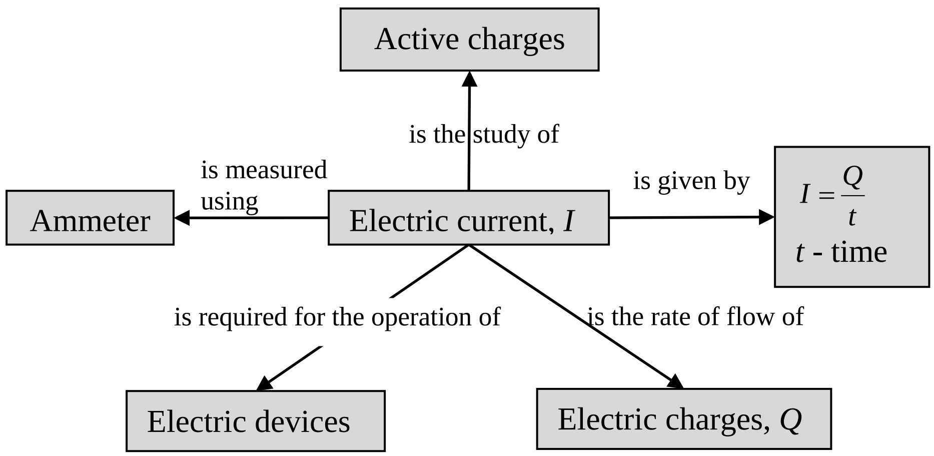
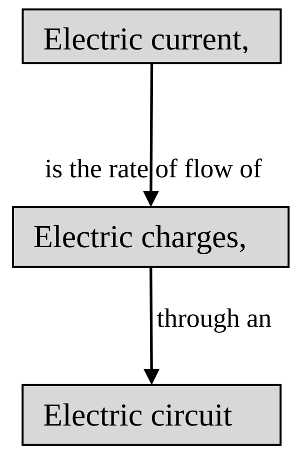
APPENDICES

APPENDIX I

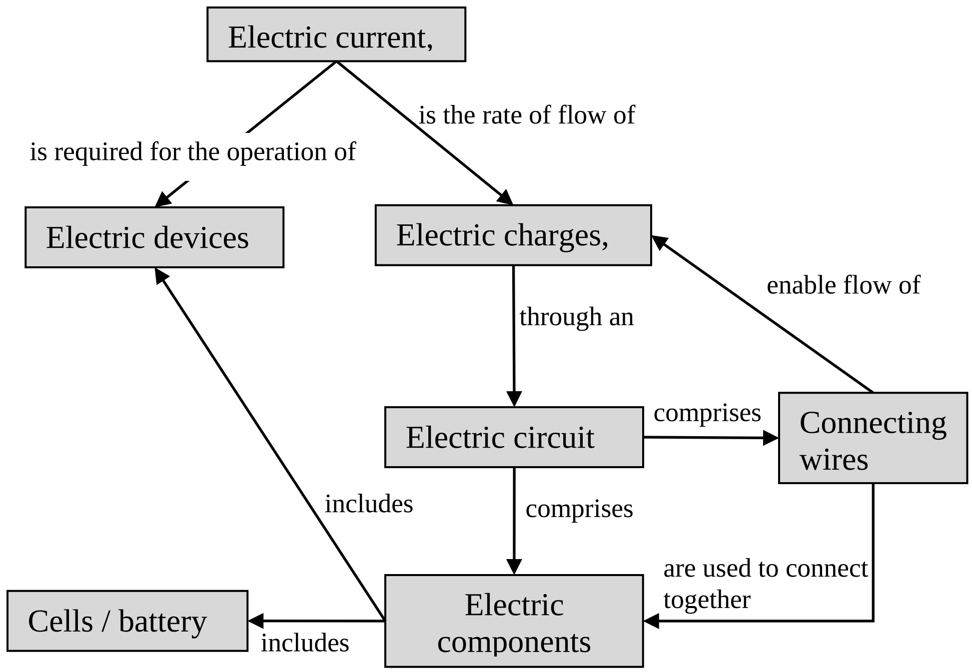
Actual concept maps illustrating the three map structures as proposed by Kinchin (2000) and based on the topic, 'electric current'.



a) Spoke



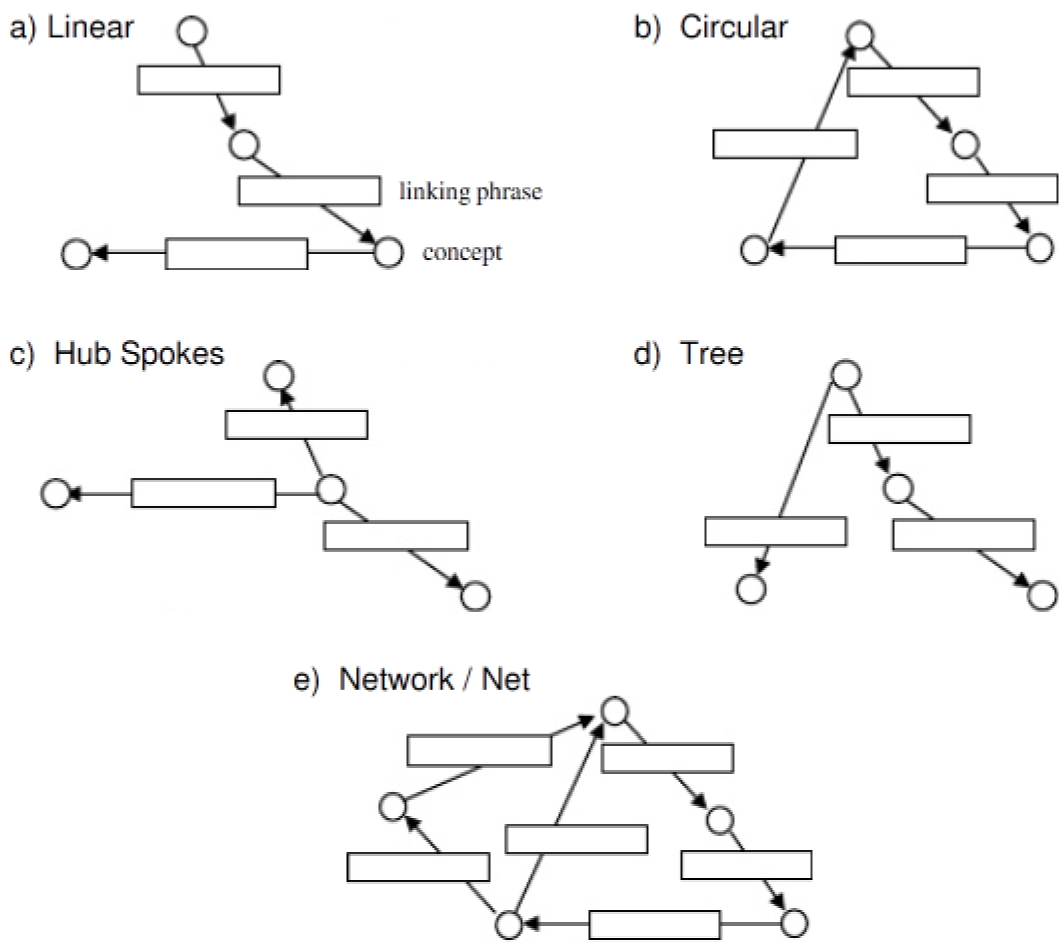
b) Chain



c) Net

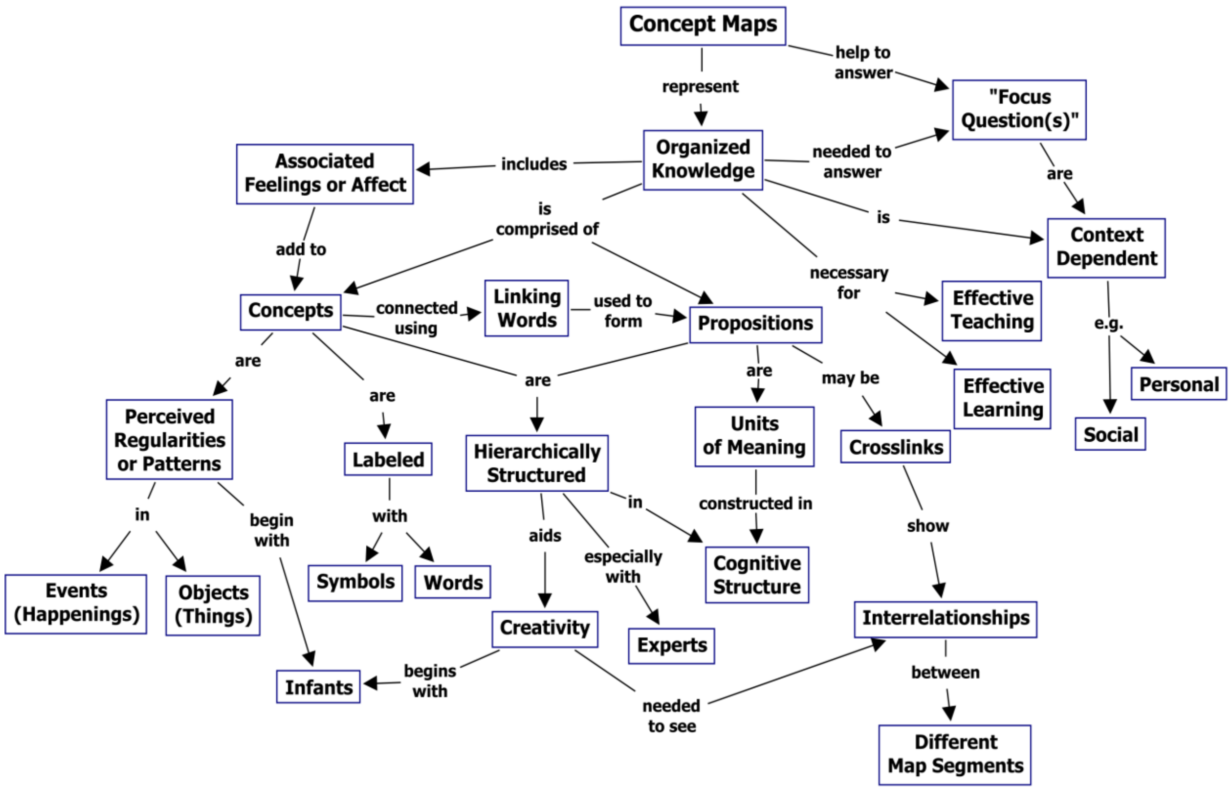
APPENDIX II

CONCEPT MAP STRUCTURES



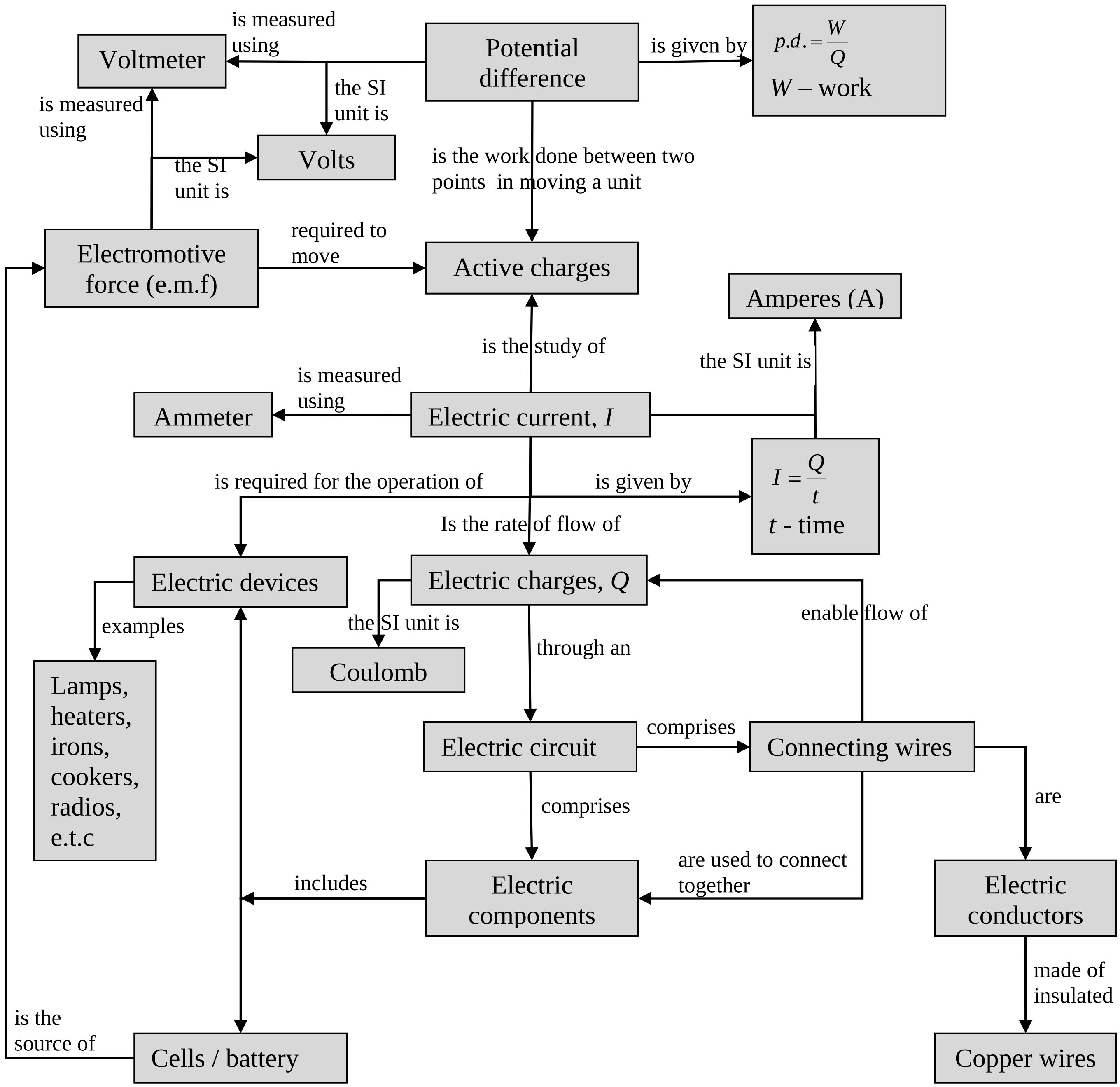
APPENDIX III

A concept map showing the key concepts involved in concept mapping (Novak and Gowin, 1984)



APPENDIX IV

A concept map showing the key concepts involved in sub-topic, 'Electric current and potential difference'.



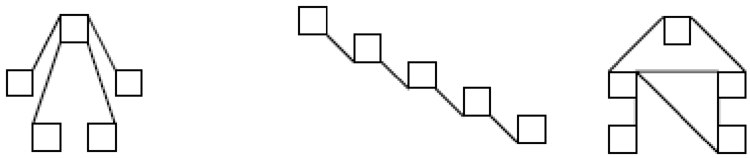
APPENDIX V

SCORING RUBRIC OF THE CONCEPT MAP

Student Name: ___________________________________

1. Map Structure:

   a) Spoke   b) Chain   c) Net



2. Number of Correct Hierarchy levels: _______________

3. Number of Correct Cross-Link: _______________

4. Quality of Propositions

   a) Invalid proposition: ______ x 0 = ____________

   b) Possible relationship: ______ x 1 = ____________

   c) Correct-label proposition: ______ x 2 = ____________

   d) Directional correct proposition: ______ x 3 = ____________

5. Convergence Score = ____________

6. Salience Score = ____________

   Total = ____________

APPENDIX VI

SAMPLING FRAME FOR EXPERIMENTAL AND CONTROL GROUPS

Public Boys' and Girls' Schools in Nairobi County

Boys' Schools		Girls' Schools	
S/No	**Name of Schools**	**S/No**	**Name of Schools**
1	Aquinas High School	1	Buruburu Girls School
2	Dagoretti High School	2	Embakasi Girls Sec School
3	Eastleigh High School	3	Huruma Girls High School
4	Highway High School	4	Kenya High School
5	Jamhuri High School	5	Moi Girls' Nairobi
6	Lenana School	6	Nembu Girls High School
7	Moi Forces Academy	7	Ngara Girls High School
8	Muhuri Muchiri High School	8	Nile Road Girls Sec Sch
9	Mutuini Sec School	9	Our Lady of Mercy Sec Sch
10	Nairobi Milimani Sec School	10	Packlands Arya Girls Sec Sch
11	Nairobi School	11	Pangani Girls' High
12	Ofafa Jericho High School	12	Precious Blood School, Riruta
13	Parklands Boys	13	Ruthimitu Girls' Sec School
14	Pumwani Sec school	14	St. Georges Girls' Sec School
15	St. Teresa's Boys	15	St. Teresa's Girls
16	Starehe Boys Centre	16	Starehe Girls' School
17	Uhuru Sec School	17	State House Girls
18	Upper Hill School		

Source: CDE, Nairobi (2012)

APPENDIX VII

PHYSICS ACHIEVEMENT TESTS (PRE-TEST)

TIME: 1 Hour

NAME…………………………………………… ADM. NO …………………..

SCHOOL …………………………………………. DATE………………………..

Instructions

Answer all questions in this paper

1. State the number of images formed when an object is between two plane mirrors placed in parallel.

   ……………………………………………………………… (2 marks)

2. In a certain pinhole camera, the screen is 10cm from the pinhole. When the camera is placed 6m away from a tree, a sharp image of the tree 16cm high is formed on the screen. Determine the height of the tree.

   Height…………………cm (2 marks)

3. A leaf electroscope A is charged and placed on the bench. Another uncharged leaf electroscope B is placed on the same bench and moved close to A until the caps touch. State and explain what is observed on the leaves of A and B.

   Statement...

   Explanation..

   (2 marks)

4. A polythene rod may be charged by rubbing it with a cloth while being held in the hand but a metal rod cannot be charged in a similar way. Explain why.

   ………………………………………………………………………………………………

   …………………………………………………………………………......

   (2 marks)

5. A boy standing 17m in front of a cliff blows a whistle and hears the echo after 0.5s. Calculate the speed of the sound.

   Speed……………………. m/s (2 marks)

6. State one advantage and one disadvantage of using a convex mirror as a driving mirror in motor vehicles.

   Advantage...

   Disadvantage...

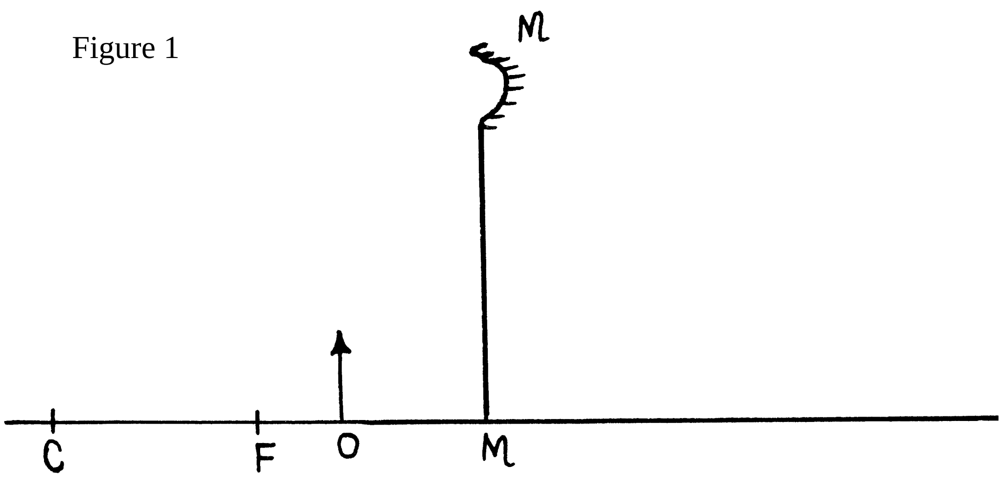
(2 marks)

7. An object of height 20cm is placed 50cm in front of a concave mirror of focal length 30cm. Calculate the position of the image

Position of the image………………….. cm (2 marks)

8. Figure 1 shows an object O in front of a curved mirror M, on the same figure, use rays to locate the image. (2 marks)

Figure 1



9. The current in a circuit is 0.40 A. Calculate the charge, in coulombs, that flows through the circuit during a time of 20 s.

Charge = ...C (2 marks)

10. A student wishes to measure the electromotive force (e.m.f.) of a battery and the potential difference (p.d.) across a resistor.

She has the resistor, the battery. What else does she need?

……………………………………………………………………….. (2 marks)

11. The force on a conductor carrying an electric current in a magnetic field can be varied by changing the magnetic field strength and the magnitude of the current. Name two other factors that can affect the force.

1. ………………………………………………………………………………………

2. ……………………………………………………………………………………

(2 marks)

12. State how each of the **two** defects of a simple cell below can be corrected.

a) Polarization …………………………………………………..
b) Local action………………………………………………….. (2 marks)

13. State **two** advantages of an alkaline accumulator over lead acid accumulator.

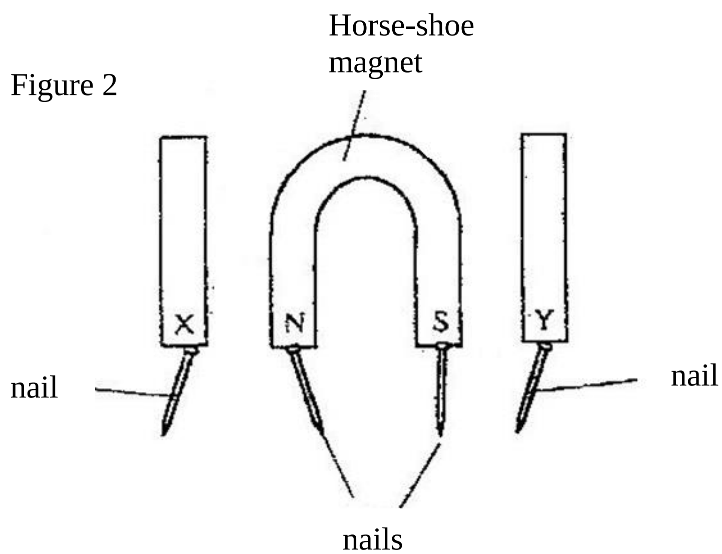
1. ……………………………………………………………………………….

2. ………………………………………………………………………………..

(2 marks)

14. Figure 2 shows a horse – shoe magnet whose poles are labeled and two other magnets near it.

Figure 2



The iron nails are attracted to the lower ends of the magnets as shown.
Identify the poles marked X and Y

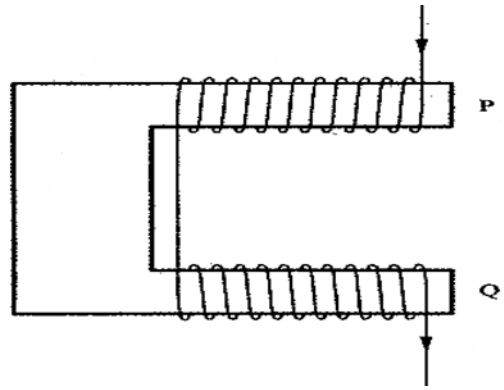
X ……………………… Y…………………………… (2 marks)

15. Explain why soft iron is not used to make permanent magnets.

……………………………………………………………………. (2 marks)

16. Figure 3 shows a diagram of a current-carrying wire wound on a U-shaped soft iron

Figure 3



Draw the magnetic field pattern around P and Q. (2 marks)

17. Figure 4 shows the displacement – time graph for a certain wave

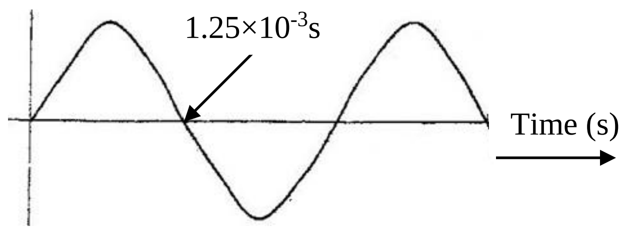


Figure 4

Calculate the frequency of the wave

Frequency…………………….Hz (2 marks)

18. Determine the velocity of light in water given that velocity of light in air is 3.0×10^8 ms^{-1} and the refractive index of water is 1.33

Velocity……………………. m/s (2 marks)

19. Critical angle of a material is 42^0; determine the angle of refraction of light in the material if the incidence angle is 30^0.

Angle of refraction…………………….. Degrees (^{0}) (2 marks)

20. State two conditions under which total internal reflection of light occurs.

1. ……………………………………………………………………………….

2. ………………………………………………………………………………..

(2 marks)

APPENDIX VIII

PHYSICS ACHIEVEMENT TESTS (POST-TEST)

TIME: 1 Hr 20 Min

NAME…………………………………………… ADM. NO …………………..

SCHOOL ……………………………………….. DATE………………………..

Instructions

Answer all questions in this paper

A student designed a small electric heater. The diagram in Fig 1 shows how he used his heater. Use it to answer question 1 and 2.

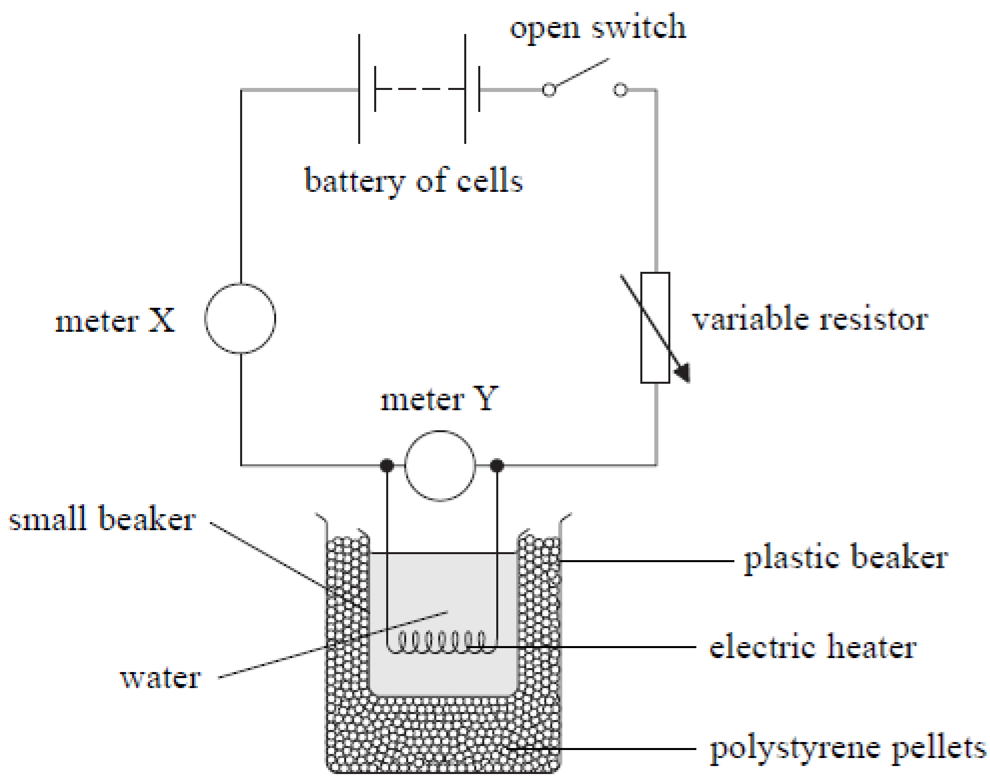
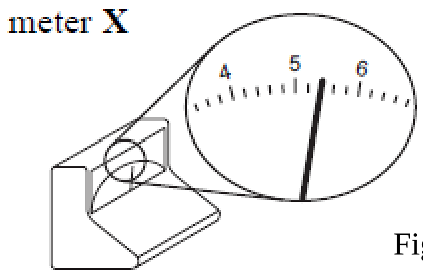


Fig.1

1. Name meter **X** and **Y**

   Meter X............................. Meter **Y**............................. (2 marks)

2. The student closed the switch and noted the readings on meters **X** and **Y**. What is the numerical reading on each meter as shown on the scales in Fig 2?



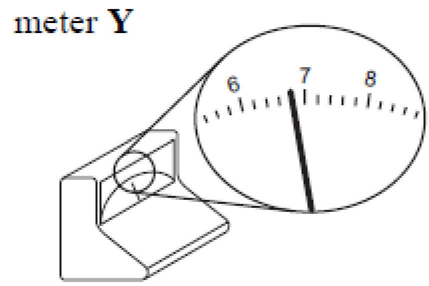


Fig.2

Reading =............................ Reading =............................ (2 marks)

3. Figure 3 shows part of an electrical circuit. The current through the 18Ω resistor is observed to be 2A.

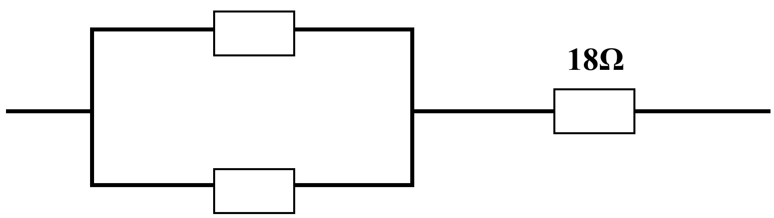


Fig 3

Calculate the value of the current through the 10 Ω resistors.

Current =.................... A (2 marks)

4. A student uses a length of wire as a resistor. He discovers that the resistance of the wire is too small.
To be certain of making a resistor of higher value, what type of a piece of the wire should he use? ………………………………………………………………………………

(2 marks)

5. A wire 7.54 m long has radius of 2.8×10^{-4} m and resistance of 15Ω. Calculate the resistivity of the material of the wire.

Resistivity =.................... Ωm (2 marks)

6. In the circuit on Fig.4, one of the lamps breaks, causing all the other lamps to go out.

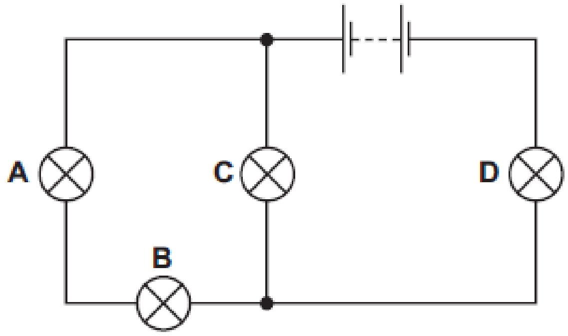


Fig.4

Which lamp breaks? Explain your choice of lamp.

Lamp..

Explanation...

(2 marks)

Fig. 5 shows a low-voltage lighting circuit. Use it to answer question 7 and 8.

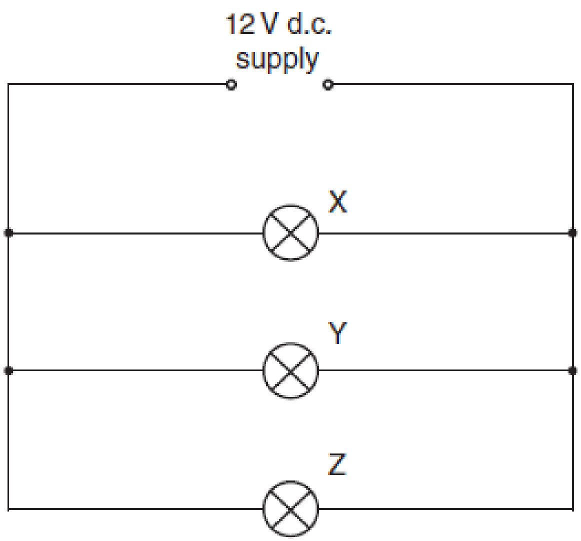


Fig.5

7. (a) In the space below, draw the circuit symbol for a component that would vary the brightness of lamp X.

(b) On Fig. 5, mark with a dot and the letter R where this component should be placed.

(2 marks)

8. The current in lamp Z is 3.0 A. Calculate the resistance of this lamp.

Resistance =.................... Ω (2 marks)

Fig. 6 shows an electric circuit. Use it to answer question 9, 10, 11 and 12.

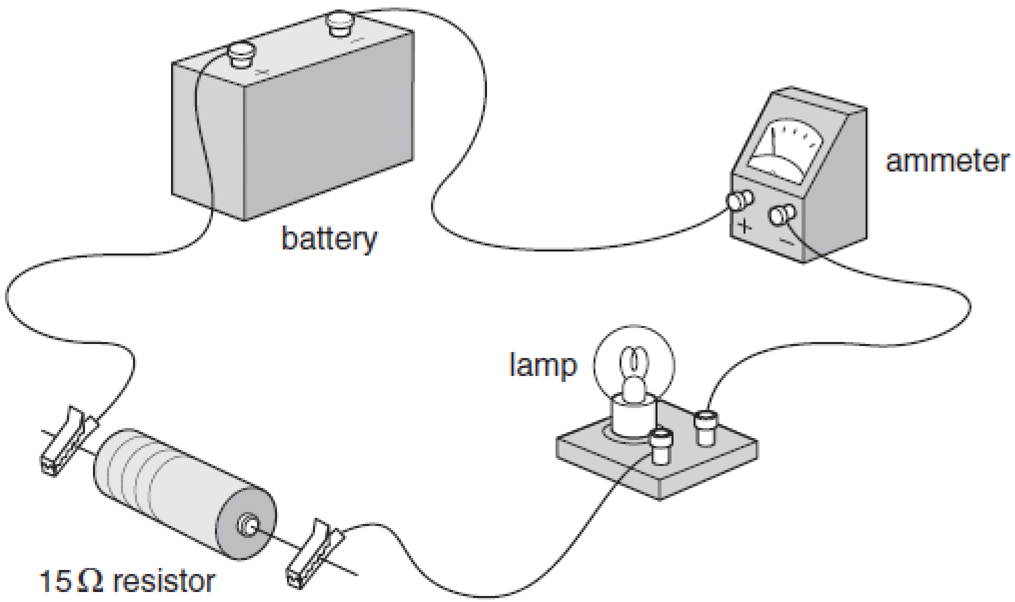


Fig.6

9. The lamp lights, but the ammeter needle moves the wrong way.
   What change should be made so that the ammeter works correctly?
   ....
   (2 mark)

10. The connecting wires are copper wires covered by rubber material.

    State the reason for using rubber material. Explain why copper wires are covered by rubber material.
    Statement..
    Explanation...
    (2 marks)

11. The potential difference across the 15Ω resistor is 6V.
    Calculate the current in the resistor.

    Current =.................... A (2 marks)

12. Another 15Ω resistor is connected in parallel with the 15Ω resistor that is already in the circuit.
    (i) What is the combined resistance of the two 15Ω resistors in parallel?

    Resistance =................... Ω

(ii) State what effect, if any, adding this extra resistor has on the current in the lamp.

....

(2 marks)

13. Cell of e.m.f E volts and internal resistance r ohms is connected to an external resistor R. A current I amperes flows through the circuit. Write and explain an expression relating E, r, R and I.

Expression...

Explanation..
....
....

(2 marks)

It was noted that for the circuit in Fig 7, when the switch is open, the voltmeter gives a reading of 12V, but when the switch is closed the voltmeter drops to 10V and a current of 0.4A flows. Use the information to answer questions 14 and 15.

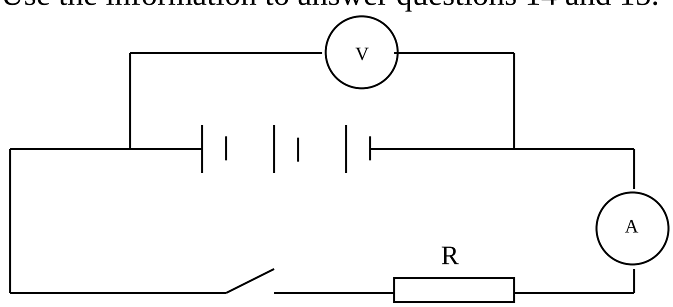


Fig 7

14. Give an explanation for the difference in reading on the voltmeter when the switch is open and when it is closed. (2 marks)

…………………………………………………………………………………………………

……………………………………………………………………………………....

15. Determine the internal resistance of the accumulator (2 marks)

Resistance =.................... Ω

The cell in Fig 8 has an e.m.f of 2.1 V and negligible internal resistance. Use the information to answer questions 16, 17 and 18.

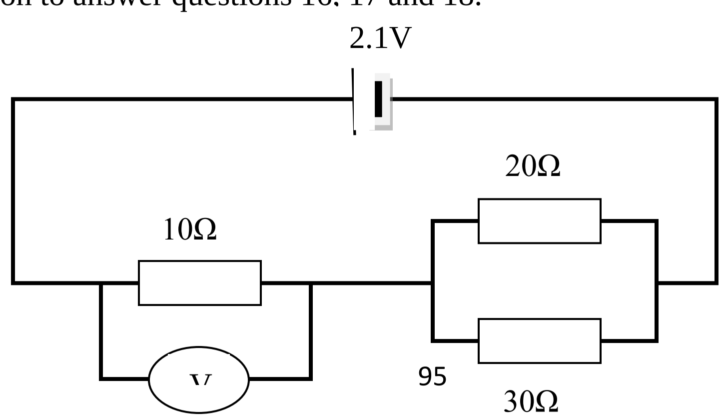


Fig 8

16. Calculate total resistance in the circuit

Resistance =.................... Ω (2 marks)

17. Determine the current in the circuit

Current =.................... A (2 marks)

18. Determine the reading of the voltmeter across the 10 ohms resistor

Voltage =.................... V (2 marks)

19. A student connects a light dependent resistor (LDR) to a battery. The current in the LDR is 0.050A and its resistance is 90Ω in the dark. The LDR is then moved to a position in the light.

Choose words from the box to complete the table. You may use each word once, more than once or not at all.

decrease **increase** **stay the same**	
Effect on …	**It will …**
the resistance of the LDR	
the current in the LDR	

(2 marks)

20. The graph in Fig 9 shows how the current in a filament lamp varies with the voltage across it.

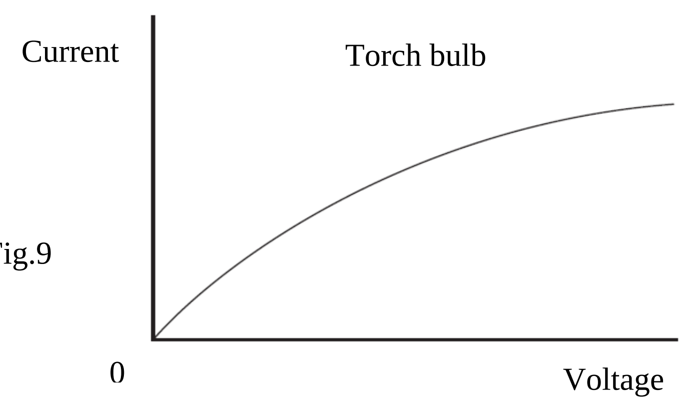


Fig.9

Explain why the graph is not a straight line.

....

....

(2 marks)

APPENDIX IX

CLASSROOM OBSERVATION SCHEDULE (COS)

(To be used by the researcher)

Date ___________________________

Type of School Boys [ ] Girls [ ]

Type of Group Experimental [ ] Control [ ]

PART A: THE TEACHER

1. Does the teacher have a lesson plan? Yes [ ] No [ ]

2. List the teaching strategy/method indicated in the lesson plan
   a) ____
   b) ____
   c) ____
   d) ____

3. Classify the teaching strategy/method as;
   Teacher centered [ ] Interaction [ ] Learner Centered [ ]

4. The teacher prepared the students before using the strategy/method
   Not at all [ ] A little [ ] Fairly adequately [ ]
   Adequately [ ] A great deal [ ]

5. The teacher reported / reinforced key points in the presentation
   Immediate [ ] At appropriate breaks [ ] Later after presentation [ ]
   Withheld key points [ ]

6. The teacher reviewed the lesson
   Not at all [ ] A little [ ] Fairly adequately [ ]
   Adequately [ ] A great deal [ ]

7. Teacher's competence on the use of the strategy/method.

Very good [ ] Good [ ] Average [ ]

Poor [ ] Very poor [ ]

8. Note any other relevant observations made during the lesson

____

____

____

____

PART B: THE STUDENT

Indicate the rating by placing a tick (√) in the appropriate box using the scale below;

a) Not at all 1
b) A little 2
c) Fairly adequately 3
d) Adequately 4
e) A great deal 5

	Students' roles	**1**	**2**	**3**	**4**	**5**
1.	Learners' participation in the lesson					
2.	Students' interaction with the teaching resource					
3.	Students' interaction with each other					
4.	Students asking questions/seeking guidance					
5.	Students ability to answer conceptual questions					

6. Note any other relevant observations made during the lesson

____

____

____

____

APPENDIX X

STUDENT QUESTIONNAIRE (SQ)

NOTE:

- Do not write your **name** anywhere on this questionnaire.
- There is no right or wrong answer.
- Do not tick more than one box for each item in the scale.

Type of School	Boys	[ ]	Girls	[ ]
Type of Group	Experimental	[ ]	Control	[ ]

1. Lesson presentation

   Please rank the following on the scale below to reflect the extent to which you agree with the statements. Please tick (√) your answer in the boxes according to the scale below:

   a) **S**trongly **A**gree - **SA**

   b) **A**gree - **A**

   c) **U**ncertain - **U**

   d) **D**isagree - **D**

   e) **S**trongly **D**isagree - **SD**

	Your feelings on the lesson	**SA**	**A**	**U**	**D**	**SD**
1.	The teacher was well organized.					
2.	The lesson time was efficiently used.					
3.	The teacher was interested in the class.					
4.	The teacher was enthusiastic about what he taught.					
5.	The teacher stimulated my interest on the lesson.					
6.	The teacher explained the lesson material clearly.					
7.	The teacher was respectful, tolerant and fair.					
8.	The objectives of the lesson were clearly stated and understood.					
9.	The lesson objectives were followed as outlined in the class at the beginning of the lesson.					
10.	The lesson was well organized and prepared.					
11.	The lesson was appropriate for our class level.					

12.	The lesson pertained to a definite curriculum or developmental areas.					
13.	There was an attention getting introduction to the lesson.					
14.	There was a good summary to the lesson during or at the end of the lesson.					
15.	The lesson material was well covered in the amount of time given.					
16.	There was good use of instructional materials, i.e. they assisted me to understand the lesson better.					
17.	There was good teacher-student interaction and communication, i.e. all the students were involved in the discussions and activities.					
18.	The teacher reacted well to situations that arose during the lesson.					
19.	The teacher demonstrated good classroom management.					
20.	The teacher used questioning and answering effectively.					
21.	The teacher used an appropriate speaking voice for the classroom situation.					
22.	There was a pleasant overall atmosphere created during the lesson, i.e. the learning situation was comfortable, cheery, and open so everyone felt free to talk and was inviting to both the students and the teacher.					

2. Give any comment(s);

____

____

____

____

Thank you

APPENDIX XI

TEACHER QUESTIONNAIRE (TQ)

This questionnaire aims to gather information on the roles and challenges a teacher faces during instructional process. The information will strictly be kept confidential.

Type of School	Boys	[ ]	Girls	[ ]
Type of Group	Experimental	[ ]	Control	[ ]

1. List the teaching strategies/methods you frequently use in teaching physics
   a) ______________________________
   b) ______________________________
   c) ______________________________
   d) ______________________________

2. Explain why you prefer the strategies/methods listed in 1.
   ____
   ____
   ____

3. The following are some of the aspects of physics learning.
   Indicate the level of agreement of difficulty in teaching the mentioned aspects of physics learning by placing a tick (√) in the appropriate box according to the scale below:

   a) **S**trongly **A**gree - **SA**
   b) **A**gree - **A**
   c) **U**ncertain - **U**
   d) **D**isagree - **D**
   e) **S**trongly **D**isagree - **SD**

	Aspects of physics learning	SA	A	U	D	SD
1.	Knowledge of facts					
2.	Understanding of concepts					
3.	Application of science knowledge					
4.	Creativity and imagination					
5.	Analysis, synthesis and evaluation					
6.	Manipulative skills					
7.	Observational skills					
8.	Data interpretation					
9.	Attitude towards physics					

4. Do you use concept mapping in your teaching? Yes [ ] No [ ]

   Give a brief explanation

   ____

   ____

5. Below are some general statements about use of instructional concept maps.

   Indicate the extent to which you agree or disagree with the statements by ticking (√) in the appropriate box.

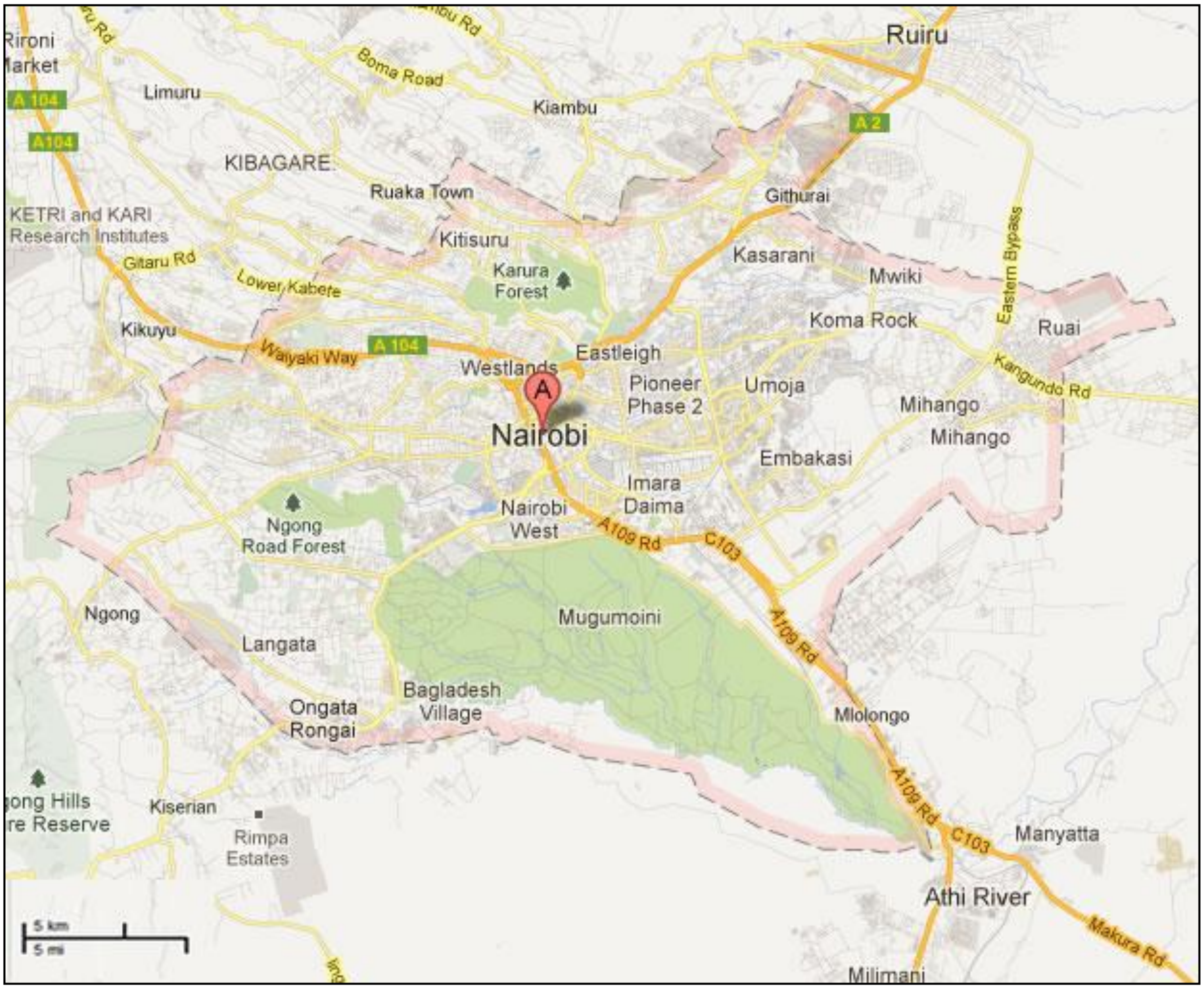
	General statements about use of instructional concept maps	SA	A	U	D	SD
1.	It is easy to construct Concept maps					
2.	Concept maps motivate students					
3.	Use of Concept maps enable students learn concepts much faster					
4.	Concept mapping put too much demand on the teacher's time and energy					
5.	There is need to encourage teachers to use concept mapping					
6.	Concept mapping make learning of physics difficult and unpleasant					
7.	Concept mapping make students like physics					
8.	Use of concept maps do not improve students' performance					
9.	Use of concept maps gives students a chance to show their understanding of concepts learned					
10.	Use of concept maps helps students know the areas they are weak in and those that they are strong in					

6. Give any comment(s) on use of concept maps;

Thank you

APPENDIX XII

MAP OF NAIROBI COUNTY, KENYA



Source: https://maps.google.co.ke/

APPENDIX XIII

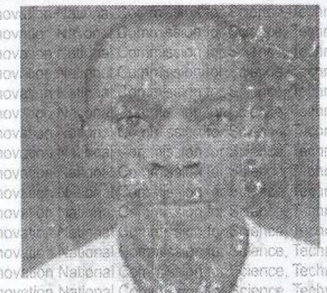
RESEARCH CLEARANCE PERMIT

THIS IS TO CERTIFY THAT:
MR. VINCENT OTIENO WASONGA
of KENYATTA UNIVERSITY, 0-625
NAIROBI,has been permitted to conduct
research in *Nairobi County*

on the topic: ***EFFECTS OF CONCEPT MAPPING INSTRUCTION ON STUDENTS ACHIEVEMENT IN PHYSICS IN PUBLIC SECONDARY SCHOOLS,NAIROBI COUNTY,KENYA.***

for the period ending:
31st December,2013

Permit No : NACOSTI/P/13/0486/379
Date Of Issue : 26th November,2013
Fee Recieved : Kshs ksh1000.oo



....
Applicant's Signature

....
FOR: ***Secretary***
National Commission for Science, Technology & Innovation