CHAPTER ONE

INTRODUCTION

1.0 Background of the study

Education is an essential part of life which children cannot do without and goals for education are shaped and dictated by society Owens and Millsaps, (2001). There is no doubt that there is a general agreement that every child should study Mathematics as it is regarded by most people as essential (Cockcroft, 1982).

The Zambian high school education curriculum consists of subjects such as History, Geography, Civic Education and Mathematics of which some are core subjects. Amongst them is Mathematics, which is a very useful subject for most vocations and higher specialized courses of learning. As a result, there is always a greater pressure on learners to succeed in Mathematics than there is in any other school subject as is the case with England and Wales (Cockcroft, 1982). It can be argued that any person who is ignorant in Mathematics would be at the mercy of others and would be easily cheated. Despite the perceived usefulness of Mathematics, there have been repeated failures in the subject by many learners in Zambia (Nkhata, 1996).

Policy makers and educators are always concerned about improving the teaching and learning of Mathematics. The United Nations Educational, Scientific and Cultural Organization (UNESCO, 1995), under the World Survey of Education, states that although educators and other specialists have continued to evaluate the teaching of particular subjects, special attention has been focused on improving the teaching of Mathematics.

Probably it can be argued that it would be difficult, or perhaps impossible, to live a normal life in many parts of the world, including Zambia, without making use of Mathematics. Mathematics, however offers a different but complementary perspective in terms of how learners make sense of the world around them. The Ministry of Education (MoE) also attaches great importance to Mathematics as it is compulsory not only in the high school curriculum but also in many higher institutions of learning. In the National Policy Document on Education (MoE, 1996), stated that one of its major tasks in relation to high school education is to concentrate its efforts on improving achievement in Mathematics.

The Ministry of Education (MoE, 1996) concerns were the poor performances in Mathematics that was overwhelmingly evident in Grade Twelve final examination results year in year out. The MoE (1996) stated that one worrying aspect about the current high poor school performance which required comment was the achievement level that was far from satisfactory, especially in the area of Mathematics. It was further pointed out that the overall unsatisfactory performance in school certificate was attributed to a large extent to poor performance in Mathematics. With these concerns in mind and in an effort to improve Grade Twelve examination results in Mathematics, the Ministry of Education, in conjunction with donors and other stakeholders, started conducting programmes such as Strengthen Mathematics, Sciences and Technology Education (SMASTE) and Teacher Education through the Teacher Education Department and donor agencies like the Flemish Office for International Cooperation and Technical Assistance (VVOB). This was because Mathematics would always be an integral part of our daily lives in every aspect of human endeavour. Willombe (2011) urged scientists and researchers not only to present hard-core Mathematics but also to share opportunities and knowledge to transform mathematics education in Zambia and the region (Post News Paper, 2011). During his presentation at Fairmount Hotel in Livingstone at the official opening of 2011 Southern African Mathematics Association (SAMSA) conference whose theme was `The Role of Mathematical Sciences in Sustainable Development', he stated that Mathematics was the key to all branches of science as well as a cornerstone of high technology and the symbol of civilization. As a result, Zambia wanted to promote mathematics research and teaching in an effort to bring them up to the world level of the 21st century education.

The Ordinary level syllabus in Mathematics consists of a number of topics such as, transformation, algebra, statistics and earth geometry (CDC, 2004). Some of these topics contribute to a high level of overall poor performance in Mathematics. Of particular interest about this study is Earth Geometry, which was taught in secondary schools, but was removed from the syllabus in 1980's and was re-introduced in 2004. Larson etal (1995) defined geometry as a branch of Mathematics that studies the shapes of objects, their sizes, properties and relationships. It was closely connected to other branches of Mathematics such as algebra, logic, probability and trigonometry. The learning of geometry helps learners develop the skills of visualisation, critical thinking, intuition, perspective, problem- solving, deductive reasoning and logical argument (Hoyles and Jones, 1998). Geometry originated from the

ancient practice of earth measurement, the building of pyramids and the observation of patterns in the movement of the stars applied in navigation.

In spite of the very practical origin of geometry in the investigation of the world, it is also the subject area where the development of abstract reasoning began. Earth geometry was a useful topic in the study of aviation and navigation to mention but a few. It also enables learners to mathematically locate places, calculate distances and to determine time differences on the earth's surface (CDC, 2004).

However, according to the Examination Council of Zambia, Mathematics Examiners' report (ECZ 2008:50), `questions on statistics and geometric graphs were fairly well handled by most learners, while questions on earth geometry, trigonometry and transformation were poorly done'. It can be noted from the above discovery, that the questions which were poorly done were all related to geometry. Besides that, the 2006 ECZ Examiners' report also showed that although some questions were poorly answered, the question on Earth Geometry (Question 9) was very poorly done by most learners (ECZ, 2006). The emphasis (very poorly done) was the concern of the examiners. This prompted the examiners to advise the Zambia Association of Mathematics Education (ZAME) to address issues in Earth Geometry and linear programming (ECZ, 2006). This was done in an effort to improve learners' performance in earth geometry and eventually Mathematics. In the same vein, this would help teachers to equip themselves with the necessary skills in order for them to teach the topics mentioned above and others effectively. To this effect, the MoE through schools are conducting programmes such as the Continuous Professional Development (CPD) and SMASTE to address concerns in topics such as Earth Geometry and how best it could be taught. The concerns came to light after a cross examination of learners' responses to questions on Earth Geometry and Linear Programming among other topics (ECZ, 2006). Therefore, it could be argued that Earth Geometry among other topics contributes to poor performance in Mathematics. This study aimed at establishing the perceptions on the factors that contribute to poor performance in Earth Geometry.

1.1 Statement of the problem

The Zambian high school curriculum has undergone various changes from the colonial period to date. It consists of different subjects such as: English Language, History, Civic Education,

Geography, Mathematics, Commerce and Accounts. It has a small number of core subjects which include Mathematics. One of the aims and objectives of the MoE on high school education according to Educating our Future (MoE, 1996), is to promote the extensive knowledge and accurate understanding of chosen areas in Mathematics. The MoE expresses concerns over the poor performance in Mathematics as seen in Grade Twelve examination results at the end of every year. For instance, one-third (⅓) of boys and two-thirds ($^2/_3$) of girls registered total failure in 'O' level Mathematics in the years since 1987 (MoE 1996). The Zambian syllabus 'D' Mathematics comprises topics such as Transformation, Vectors, Earth Geometry and Algebra among others. Although there are many topics in the syllabus, the academic performance of pupils in the areas of Earth Geometry seems to be poorer than in any other topic (ECZ, 2006:38-39). In view of this, the study sought to investigate the perceptions of teachers and pupils on the factors contributing to poor performance in Earth Geometry at school certificate level.

1.2 Purpose of the study

The purpose of this study was to investigate the perceptions of teachers and pupils on the factors that contributed to poor performance in Earth Geometry at school certificate level.

1.3 Research objectives

The following were the objectives of the study:

- To determine the teaching approaches in Earth Geometry.
- To establish the challenges teachers encounter in teaching Earth Geometry.
- To establish the challenges pupils face in learning Earth Geometry.
- To determine the sex that performs better in Earth Geometry.

1.4 Significance of the study

The study was important as the results would enhance the effectiveness of teaching and learning of earth geometry, which would subsequently contribute to the improvement in the pass rate in Mathematics. This study was one of its kinds in that apart from the general factors that contributed to poor performance in Mathematics, there has been no study which focussed on the perceptions of teachers and pupils on the performance in Earth Geometry. Hence the findings of this study would provide insight of the challenges that teachers and learners encounter in teaching and learning of Earth Geometry respectively. This would also

enable teachers and learners alike to derive not only satisfaction but also confidence in the teaching and learning process respectively.

It was also hoped that the information obtained from the study would be of use to stakeholders in the MoE for interventions and programmes to be put in place in order to improve performance in earth geometry. The findings derived from this study would also be of use to the stakeholders in Teacher Education Department (TED) and the Curriculum Development Centre (CDC), for assessment and evaluation purposes of the Earth Geometry topic. The results from the study may be an eye opener to the Teacher Training Colleges in order for them to evaluate the content provider at their institutions. The study would also contribute to the existing Mathematics literature base.

1.5 Limitations of the study

In this study, one of the limiting factors was the restriction of the study to only eighteen (18) high schools on the Copperbelt, which may not give a comprehensive picture on the study. Moreover, there was also the constraint of some teachers who expressed unwillingness to answer the questionnaires as they were asking to be paid in return. However, with time and persuasion, the teachers accepted to answer the questionnaires though data collection was considerably delayed.

1.6 Operational definition of terms

For the purpose of this research study, the following terms were used.

- **´Ordinary` level Mathematics** refers to Mathematics which is compulsory in the Zambian high school curriculum. It is a broad field of study in which properties and interactions of objects are examined. It is an extremely rich and diverse set of tools, terminologies and approaches ranging from purely abstract to utilitarian.
- **Earth Geometry** in the study refers to the size, shape and position of two and three dimensional figures. In geometry one explores the spatial sense and geometric reasoning. It is concerned with the location of places, the calculation of distances and determination of time differences between places on the Earth's surface.

1.7 Theoretical frame work

According to English (2002), it is argued that the attempt to develop a comprehensive theory that describes how students learn specific mathematics domain was rather rare in the field of mathematics education. This was supported by Wilson (1993), who stated that no one theory of learning completely describes how students acquire mathematical understanding. However, this research was influenced by the theory of Piaget (2001) whose early work identified four stages of cognitive development namely: the sensorimotor, the preoperational, the concrete operational and the formal operational (Brainerd, 1978). Besides that, the study was also influenced by the Van Hiele (1999) model which suggests that learners advance the levels of thought in geometry. Van Hiele (1999) characterized these levels as: visual, descriptive, abstract and formal deduction (Usiskin, 1982).According to his model, it is not possible for learners to bypass a level. However, this research focused on high school learners who frequently move between the concrete operational stage and formal stage when faced with learning new skills, concepts and principles. At this stage of learning Earth Geometry, learners need experiences that incorporate concrete operations and abstraction .Piaget's theory centers on the process of assimilation and accommodation of information into the schema of the learners (Brainerd, 1978).The theory stresses the importance of human interaction and physical manipulation in the acquisition of knowledge. On the other hand, the model suggests that the teaching of geometry should be sequential and that no level should be bypassed. Many teachers, however, inappropriately believe they are applying Piaget's theory when they merely show objects to learners instead of letting them manipulate the objects and make their own mathematical connections. Earth geometry is one area of Mathematics which requires models in teaching it in order to help learners establish and interpret mathematical connections. The theories demands that teachers should provide concrete models in their instruction in Earth Geometry and the sequential order must be followed to ensure that no level is skipped in teaching Earth Geometry.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Introduction

This chapter reviews the related literature on the teaching and learning of geometry, and also highlights some factors that contribute to poor performance in this component of Mathematics.

2.2 The Nature of Geometry

Geometry is open to many different approaches. It appeals to our visual, aesthetic and intuitive senses (Jones, 2002). These aspects and considerations tend to make geometry a demanding topic to teach satisfactorily. Since we live on a 3-Dimensional world, much of our experience is through visual stimulus, meaning the ability to interpret visual information is fundamental to human experience. Battista (1999) and Lappan (1993) stated that Geometry plays an important role in primary and secondary school mathematics curricula in Malaysia and other countries. They further stated that geometry provides a rich source of visualization for understanding arithmetical, algebraic, and statistical concepts. According to Atiyah (2001; 50) claims that understanding and making sense of the world is a very important part of what it means to be human. Atiyah (2001) argued that spatial intuition or spatial perception is an enormously powerful tool not only for things that were obviously geometrical but even for things that were not. According to Volderman (1998) geometry provides a more complete appreciation of the world we live in, since it is a major part of our synthetic world such as architecture and virtually everything humans have created. It can also be stated that geometry enables students to analyse characteristics of two and three dimensional shapes and develop mathematical arguments about relationships, specify location, describe special relationships, use visualization and geometric modeling to solve problems (NCTM, 2000). New developments in computing technology mean that the 21st century is one era where spatial thinking and visualization will be vital. Geometry teaching demands that teachers should make it a point to display visual aids to enable pupils make interpretations and draw conclusions.

Of the range of theoretical work concerned with geometrical ideas, that of Piaget and of Van Hiele were probably the most well known (Jones, 2002). The Piagetian work had two major themes. The first was that our mental representation of space was not perceptual "reading off" of what was around us. We build our representation of the world through progressively reorganizing our prior active manipulation of the environment. This suggests that for learners to understand geometry, they should manipulate objects and relate them to the environment. The second theme was that geometric ideas follow a more definite logical order than historical. Piaget (2001) stated that the progressive organization of geometric ideas in children follows a definite order and this order is more experiential than it is the historical development of geometry.

But Van Hiele (1999) suggested that learners advanced through levels of thought in geometry which were characterized as visual, descriptive, abstract and formally deductive. According to his model, it was not possible for learners to bypass a level. The evidence available suggested that all types of geometric ideas appear to develop overtime, becoming increasingly integrated and synthesized (Hoyles and Jones, 1998). Poor performance in geometry may be as a result of the manner in which it was taught, where logical sequence was not followed and the skipping of the Van Hiele model. This demands that care must be taken when teaching geometry. No doubt, teachers must create striking classroom displays, suspend geometrical models and involve pupils in making models, to get them decide on definitions and then to let them explore the logical consequences. According to Ben- Chairn et al (1989) visualising cross sections of solids is very difficult for learners lacking ample prior concrete experiences with solid objects. Due to the limited geometric experiences learners may not have enough opportunities to develop and exercise their spatial thinking skills for effective geometry learning and hence resulting in poor performance.

2.3 Methods of Teaching Geometry

Many teachers in schools have tried different methods and programmes to make learners understand geometry, sometimes with success and sometimes not (Chakerian, 1972).The tendency by most teachers to teach geometry by informing learners of the properties associated with planes or solid shapes and then completing the exercises contributes to poor performance in geometry. Such an approach entails that little is attempt made to encourage thinking and reasoning skills in learners such as solving non- routine problems and deriving

proof (Hoyles and Jones, 1998). This approach posed problems to both teachers and learners, and both began to dread geometry. Teachers became frustrated because their poor conceptual understanding led to learner's poor geometry achievement. It could be argued that to teach geometry effectively to learners of any grade, age or ability, it was vital to ensure that learners understood the concepts and the logical steps that were involved rather than learners solely learning rules. Kalejaiye (2000) states that poor performance in geometry is as a result of teachers who do not involve learners in their teaching and that they had adopted the rote learning style. The way geometry was taught where, there seemed to be no connection between class work and real situations, may have contributed to poor performance as learners did not see its relevance. In view of this, the programmatic document; the 1989 *Curriculum and Evaluation Standards for School Mathematics* (NCTM, 2000) recommended that geometric topics be introduced and be applied to real world situations whenever possible. However, this did not imply that immersing learners in real world situations automatically led to geometrical understanding (Schwartz, 2008). It is argued that hands-on activities were a popular way to establish a connection between instruction and real-life. This was so because the challenge of geometry instruction was to elevate the learners' experience with the real-world objects to the level of Mathematics. Overall, research on the teaching and learning of geometry indicated that physical experience, especially the physical manipulation of shapes was important to all ages, and that a wide variety of geometrical experiences were necessary in order for learners to gain firm understanding of geometry.

In many geometry classrooms today, teachers merely introduced learners to facts about geometry and then drilled them with concepts in deductive reasoning (Mullis, 2000). Learners were seldom given the opportunity to discover and conceptualise geometry on their own. Hoyles and Jones (1998) argue that although the deductive method is central to Mathematics and intimately involved in the development of geometry, providing a meaningful experience for learners at school appeared to be difficult. Research shows that learners fail to see a need to distinguish forms of mathematical reasoning such as explanation, argument, verification and proof (Jones, 2002). Another reason advanced for learners' poor performance was because of the teaching methods which concentrate much on calculation rather than problem solving and proof which encouraged critical thinking (Yeo, 2000).

In Malaysian schools, for example, geometry was usually taught using mainly the textbooks, the chalkboard and occasionally the compass and protractor (Mullis etal, 2000). Sometimes teachers used geometric kits to show the different geometric solids mentioned in the syllabus. However this teaching approach did not seem to help many students as evidenced by poor geometry performance at Form Two level (Mullis et al, 2000) and Form Five (Malaysia: Ministry of Education, 1996). When compared to that in high performing countries, the mathematics curriculum in Malaysia lacked emphasis on teaching approaches that encouraged thinking and reasoning skills such as communicating mathematically, solving non- routine problems, deriving proofs and projects. Though this represents an overall picture of mathematics instruction, it could be inferred to the teaching of geometry. Noraini (1998) insisted that geometry instruction needed to encourage more non-routine problem solving activities such as geometric puzzles and problems based on real-life situations to enhance geometric thinking skills. Geometry instruction also needed to be designed to encourage more interactions between teachers and learners to enhance mathematical communications. According to Van Hiele (1999) optimal geometry learning was achieved when students developed their thinking and reasoning skills.

2.4 Lack of proof and proving in earlier school years

It is no longer a secret that high school geometry with its formal (two-column) proof was considered difficult and detached from practical life, because of the teaching methods employed. It can be argued that the poor performance in earth geometry by the learners at a high school was a manifestation of the type of geometry taught in lower grades. Lack of proof in geometry in earlier school years has greatly contributed to poor performance at a higher level. Battista and Clements (2000) state that it was even worse that most teachers at primary level did not teach even the `impoverished' geometry, which meant that most learners reached high school level with a low Van Hiele way of understanding, hence making it difficult for learners to understand the topic. This was because learning geometry required formal deduction at a level that a typical high level geometry was taught. Battista and Clements, (2000), noted that poor performance in geometry was due, in part, to the elementary school geometry which focused on recognizing and naming of geometrical shapes. To remedy this situation, they suggested that geometry at primary level should involve the study of objects, motions and relationships in a spatial environment. This meant that the learners' first experiences with geometry should emphasize the informal study of

physical shapes and their properties and have (teachers) as their primary goal the development of learners' intuition and knowledge about their spatial environment. Subsequently experiences should involve analyzing and abstracting geometric concepts and relationships in increasing formal settings. Although the Van Hiele (1999) model was not a perfect one but based on other research, it seemed to model the progress of geometrical thinking. It could be easier for learners to learn geometry at a high level if they encountered informal "proofs" in earlier school years where they were required to justify their statements and reasoning. This of course would not be on such formal level as it was at a higher level but simply a mind set for learning and teaching geometry, where mathematical statements and truths were justified (Chakerian, 1972). It could be argued that a lot of geometry taught in primary school did not foster pupils to higher level of geometrical thinking. As a result, they experienced a lot of difficulties at a high level, hence the poor performance. The concern from Malaysian Ministry of Education (2000) was that most of the geometry problems at primary level were of the type: calculate the area\ circumference\perimeter of the figure. There was nothing much about proving and analyzing concepts. Given that children experience life on a solid planet in a 3D world and that much of this experience is sensed through visual stimuli, it was vital to give geometry appropriate consideration at the primary level. The learning of geometry can be built on the naturally acquired spatial sense. Guiding children to reflect on the characteristics and regularities of their spatial experience could easily lead to the development of the basic concepts of geometry such as straight lines, curved lines and 3D shapes. This is so because geometry is primarily about grasping the space, in which the child lives, breathes and moves. This is the space the child must learn to know, explore and conquer in order to live, breathe and move better in it (Freudenthal, 1973).

2.5 Lack of understanding of geometry concepts

According to Van Hiele's (1999) model, a learner's geometrical understanding progresses through various levels (visual, descriptive, abstract/relational and formal deduction) which cannot be skipped. It could be argued that with the poor performance in earth geometry, most of the learners enter high school with low Van Hiele level of understanding. As a result, they hardly understood concepts. When learners recalled their geometry experience, many of them recalled it not only as unpleasant but they often also recall the difficulties that they experienced in learning geometry. These two facets go hand in hand, and when learners found it difficult or impossible to understand an area of study, they typically resorted to rote

memorization, which is unacceptable. Strutchens, Harris and Martin (2001) stated that learners learnt geometry by memorizing geometric properties rather than by exploring and discovering the underlying properties. They further argued that geometry knowledge learnt in this way limited and superficial. Eventually the learners found it difficult to apply the limited geometry knowledge in problem solving. This lack of understanding often discouraged learners, leading to poor performance in geometry. According to the reports (ECZ, 2006), most of the questions on earth geometry were either poorly or very poorly done by most learners due to lack of understanding of concepts and definitions. In the 2004 ECZ Examiner's report (ECZ, 2004) it is stated that most learners were not able to sketch the globe, given latitudes and longitudes. In most cases, the learners interchanged the latitudes and longitudes. Besides that, the ECZ Examiner's report (2006:38) stated that "question 9 on Earth Geometry was very poorly done, Pupils, interchanged figures, latitude, and longitude and had wrong angles". This was a demonstration of the lack of understanding of the definitions and concepts. Learners' responses also showed that they did not understand how to calculate the angle of either the difference in latitude or longitude respectively. For instance the ECZ Examiners report (2008:50) indicated that "question 10 on earth geometry was poorly done by most pupils. Learners could not get the correct difference in latitude; some just lifted 30° and others 60°". For instance, to find the difference in latitude between 30ºN and 60ºS, most learners found either 30° or 60° instead of finding the sum. The responses from the learners depicted learning through memorization or through the use of the transmission method which translated into little or no learning at all. One of the factors that made geometry learning difficult was the geometry language which involved specific terminology which was unique and needed particular attention and understanding before it could be used meaningfully. Bishop (1986) and Lappan (1999) stated that the misuse of geometry terminology could lead to misconceptions of geometric knowledge. According to the Third International Mathematics and Science Study- Repeat (Battista, 1999), of which Malaysia was one of the countries in the analysis of geometry and geometry related questions, it was observed that pupils performed well in straight forward questions concerning geometry concepts but in questions requiring higher thinking skills the performance was poor (Malaysia: Ministry of Education, 2000).

Although the Van Hiele (1999) levels are useful in describing learners' geometric concepts development, it remained uncertain how well the theory reflected children's mental

representations of geometric concepts development. Various problems have been identified with the specification of the levels. Particular problems included the labelling of the lowest level as `visual' when visualization is demanded at all levels, and the fact that learners appeared to show signs of thinking from more than one level in tasks that were the same or different, in different contexts.

2.6 Summary

The review of literature on geometry indicates that it appealed to our visual, aesthetic and intuitive senses. As a result, it played an important role in primary and secondary school curricula in many countries. Teachers have tried different approaches to make learners understand geometry sometimes with success and sometimes not (Chakerian, 1972). It was also noted that the tendency by most teachers to teach geometry by informing learners of the properties of shapes and then completing exercises contributed to the poor performance in geometry. It is argued that geometry instruction must be designed to encourage more interactions between teachers and learners and also to encourage hands-on activities in order to enhance mathematical communications. It was also revealed that most geometry taught at primary schools was impoverished as a result learners experienced difficulties in learning geometry at the secondary level. It was further indicated that the poor performance in geometry was partly as a result of the lack of understanding of geometric concepts which has its own language and terminologies. It was also shown that the lack of visualising of 3D figures on the part of the learners resulted into poor performance in geometry.

However, no studies to my knowledge have focused on poor performance in Earth Geometry in Zambia and in particular, on the Copperbelt region. This study, it is hoped, will determine the perceptions on the factors that might contribute to poor performance in earth geometry at school certificate level on the Copperbelt Province.

CHAPTER THREE

METHODOLOGY OF THE STUDY

3.1 Introduction

This chapter presents the research methods which were employed in the study. The chapter begins with research design, target population, sampling procedure, research instruments, data collection instruments, pilot study and ends with data analysis.

3.2 Research design

The study employed both qualitative and quantitative techniques as methods of collecting and analysing data. This was so because any method used on its own has limitations and biases which could be minimized greatly by the use of mixed methods (Creswell, 2003). Quantitative and qualitative research methods provide different perspectives and each has its limitations. However, the overall research design of this study is qualitative. As such, limitations of one method can be off-set by the others' strengths.

It follows, therefore that, the researcher used quantitative method in order to establish the magnitude of the problem at hand which was complimented by use of qualitative approach to establish the extent of the problem. For example, the researcher had to use a quantitative research tool, the questionnaire, in order to find out how many teachers and students faced challenges in teaching and understanding Earth Geometry respectively. Whereas the extent of the problem was checked by conducting interviews with a strategic interactive approach and open questions in order to make an accurate analysis. Subsequently, the research relied on a research strategy that was flexible and interactive.

3.3 Target population

The target population comprised of grade twelve learners on the Copperbelt Province. However, the researcher also included teachers of mathematics and specialists from ECZ and CDC as informants on the subject.

3.4 Sample

The sample comprised ninety (90) grade 12 learners, seventy-two (72) teachers of mathematics (who had at least taught a grade 12 classes) and two (2) mathematics specialists from ECZ and CDC. The learners and teachers were from Kitwe, Chingola, Luanshya, Ndola, Mufulira and Kalulushi districts of the Copperbelt Province.

3.5 Sampling procedure

The study used probability sampling called Simple Random Sampling (SRS), so that the selection of elementary units depended purely on chance and no personal bias was involved, (Sharma,1983). White (2005) also stated that the probability random sampling technique ensures that every element in the sampling frame has an equal chance of being included in the sample. The sample of six districts on the Copperbelt Province was drawn from a total of nine districts. The names of the districts were numbered from one to nine on the cards and these were mixed thoroughly, and then six cards were drawn one after the other which constituted the sample. For each district, three high schools were selected randomly using the lottery method where the names of schools in the district were written on identical slips of paper that were folded and mixed well. Three slips were selected at random one after the other with replacement. This was repeated for the other districts until the eighteenth, the desired number of schools was attained. Five learners were selected per school using the systematic sampling procedure where the names of pupils were arranged in order, (alphabetically using registers). A sample of five was obtained by taking every sixth member of the population. This was repeated for the other schools until a total of ninety learners were selected. Also a sample of four teachers was selected from each school. These were teachers of Mathematics who had at least taught a grade twelve class. The selection was based on seniority, thus the first four teachers from each school were selected with reference to the number of years taught. This procedure was repeated with all schools until a total of seventy-two teachers were achieved. The sample also included the Mathematics subject specialist at ECZ and at CDC. The named respondents assisted the researcher to obtain more data on earth geometry as to when and why the topic was removed and later re-introduced. The selection of the informants (teachers of mathematics, ECZ and CDC specialists) was purposive sampling as it was a specific group to assist in providing information.

3.6 Research instruments

The data were collected using the following instruments: questionnaires, interviews and document analysis.

The questionnaire for teachers was used to collect information on whether they had learnt Earth Geometry at the institutions they had attended and to find out the difficulties they experienced and the approaches that they used in teaching Earth Geometry. The data collected was both qualitative and quantitative. The questionnaires for learners collected data on their experiences in learning Earth Geometry. The data collected was both quantitative and qualitative.

Interviews with the ECZ and CDC Mathematics subject specialists availed data on the factors that led to the removal and reintroduction of earth geometry in the syllabus. Data was also collected from previous records of learners' performance and their difficulties in learning Earth Geometry.

3.7 Data collection procedure

a) Questionnaire

The questionnaires were self administered to participants (learners and teachers). The researcher waited for the participants to complete the task of filling in and then submitted them to the researcher. The questionnaires consisted of both structured and open-ended questions. The respondents were also asked to tick one of the five provided options in the appropriate column, which gave the researcher information on how the participants rated the topic and how they were taught. This was useful because participants indicated their choices freely.

The questionnaires were distributed to both learners in Grade Twelve learners and teachers of Mathematics between the period of November 2009 and June 2010.

b) Interviews

The researcher conducted face to face interviews with informants at ECZ and CDC. These were also conducted between November 2009 and June 2010. The interviews involved

generally open-ended questions that were few in number (6) and intended to elicit views and opinions from the informants. The researcher took notes during the process.

c) Documents

The researcher analysed public documents, such as ECZ Examiners' reports, journals and newspapers. The advantages of analysing documents were that they were accessed at a time convenient to the researcher and it saved the researcher time and the expense of transcribing.

3.8 Pilot study

The pilot study was conducted at two schools in Chingola District on the Copperbelt Province. The results from the two schools showed that the instrument was idea to be used in the study as it indicated consistency in terms of how learners answered the questions.

3.9 Data analysis

The qualitative information that was obtained from the questionnaires, interviews and documents was analysed and was put into themes. On the other hand, quantitative data was analysed through the use of statistical tools such as frequency tables, pie charts and bar charts (Huberman, 1994). The researcher made an interpretation of data analysis which included description, analysing data and drawing conclusions about its meaning personally and theoretically.

3.10 Ethical consideration

The ethical issues of research were applied to all phases of the research process. The researcher defined the purpose of the study which was explained to participants so that they understood the need for them to be involved in the research. The researcher respected the participants, informants and the research sites by obtaining permission before conducting the research from the school managers. The researcher also dissociated names (of places and individuals) from responses during the coding process and used aliases for individuals and places to protect their identities. The participants were assured of confidentiality by not writing their names or identity on the questionnaires. The researcher did not use the language or words that were biased against persons because of gender, sexual orientation, racial or ethnic group, disability or age (Cresswell, 2003). The participants were also assured of

confidentiality as the information obtained would be used strictly for academic purposes only.

CHAPTER FOUR

PRESENTATION OF FINDINGS

4.1 Introduction

The chapter discusses the findings of the research from the questionnaires and interviews undertaken in order to investigate the factors that contributed to learners' poor performance in Earth Geometry in the selected schools of Kitwe, Mufulira, Ndola, Chingola, Kalulushi and Luanshya districts of the Copperbelt Province.

4.2 Findings from the learners

4.2.1 Sex of Respondents: Figure 1 shows the proportion of learners according to gender.

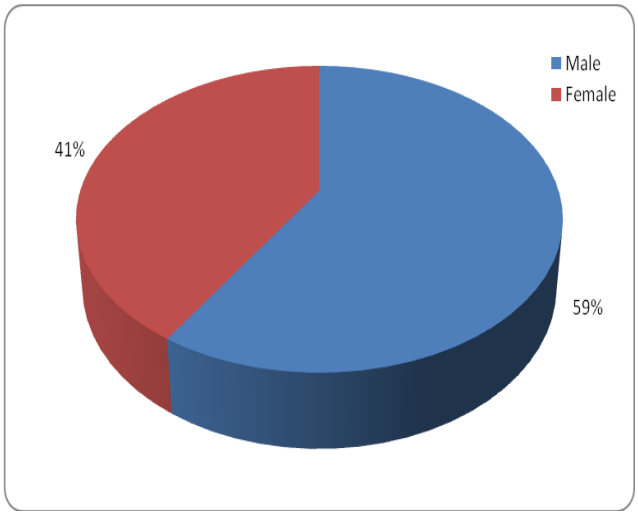

Figure 1: Learners' gender

It can be noted from Figure1 that the majority in the study, 53 (59.0%) were males while 37 (41.0%) were females.

4.2.2 Learners' ability in learning Earth Geometry by gender.

The learners were asked, whether they had difficulties in learning Earth Geometry. Their responses are presented in Figure 2.

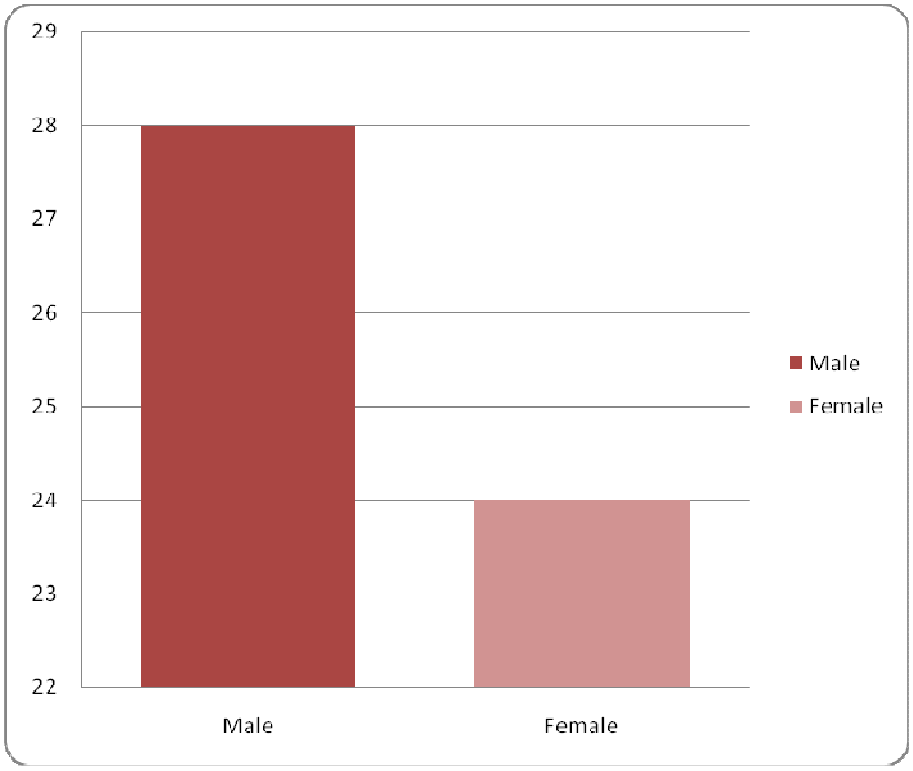

Figure 2: Responses of learners' on whether they had learning difficulties in Earth Geometry by gender

Out of the 90 learners, 52 indicated that they had difficulties in learning Earth Geometry of which the majority 28 (54.0%) were male learners and the remaining 24 (46.0%) were female learners.

The learners were further asked to state the difficulties they encountered in learning Earth Geometry. Table 1 shows the difficulties that learners encountered in learning Earth Geometry.

4.2.3: Difficulties that learners encountered in Earth Geometry.

Table 1 below shows the frequency of difficulties stated by learners in learning Earth Geometry.

Explanation	Frequency	Percent
Never learnt the topic	4	3.5
Calculation of distances on the great circle	24	21.0
Location of points on the globe	21	18.3
Calculation of speed	23	20.0
Calculation of distance between two points	18	15.7
Identifying diagrammatically opposite sides	15	13.0
Converting minutes to degrees	7	6.0
Nautical miles	3	2.6
Total	**115**	**100.0**

Table 1: Difficulties that learners encountered in Earth Geometry

It can be noted from Table 1 that out of the 115 responses, a comparatively larger number of responses, 24 (21%) stated that they had difficulties in calculating distances on the great circle. These were seconded by 23 (20.0%) responses which indicated that they had difficulties in calculating speed. There were also 21 (18.3%) responses that indicated that they had difficulties in locating the points on the globe. Further 18 (15.7%) of the learners' responses indicated that they had difficulties in calculating the distance between two points while 15 (13.0%) of the responses indicated that they had difficulties in identifying diagrammatically opposite sides.

The learners were also asked to explain possible causes of the difficulties they encountered in learning Earth Geometry. The respondents gave various reasons. Table 2 gives the details.

Explanation	Frequency	Percent
Teachers did not express themselves fully on the topic	17	14.9
Too many formulas to memorise	11	9.6
Lack of seriousness by some teachers	22	19.3
Cant visualise sketch in 3D	5	4.4
Lack of application	9	7.9
Poor explanation by the teachers	14	12.3
Teachers were not well qualified to teach grade 12	12	10.5
Topic not well covered	3	2.6
Language not well understood	15	13.1
Not knowing the formulas	4	3.5
Female teachers did not know how to teach	2	1.8
Total	**114**	**100.0**

Table 2: Learners' suggested reasons for the difficulties they encountered in learning Earth Geometry

Table 2 shows that the learners' suggested reasons for the difficulties they encountered in learning Earth Geometry. Out of the 114 responses, 22 (19.3%) of the responses showed that the teachers lacked seriousness, as a result, learners faced difficulties in learning Earth Geometry. The lack of seriousness implied the reluctance and the lack of commitment on the part of the teachers in teaching Earth Geometry effectively as compared to other topics. Besides that, 17 (14.9%) of the responses indicated that teachers did not express themselves fully when teaching Earth Geometry. Table 2 further revealed that 15 (13.1%) of the responses indicated that they had difficulties in learning Earth Geometry because its language was too difficult to understand. This was followed by 14 (12.3%) responses which showed that they had difficulties because of the teachers' poor explanation on the topic. Moreover, 12 (10.5%) of the responses indicated that they had difficulties in learning Earth Geometry because the teachers were not qualified to teach Grade 12.

4.2.3 Responses of learners that had fewer difficulties in learning Earth Geometry

Figure 3 shows the responses of learners who had less difficulty in learning Earth Geometry.

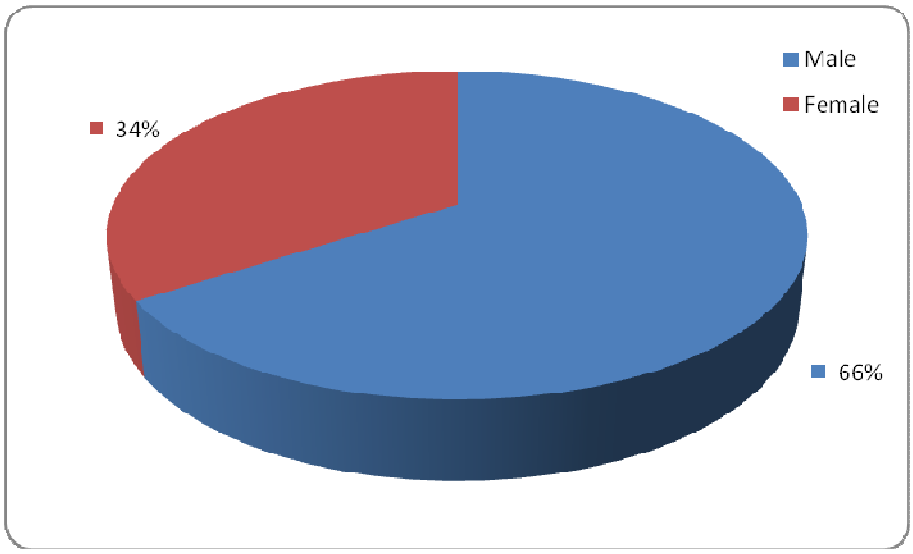

Figure 3: Learners' responses that had fewer difficulties in learning Earth Geometry by gender

Figure 3 shows that out of the 38 respondents who had fewer difficulties in Earth Geometry, 25 (66.0%) were male learners and 13 (34.0%) were females.

4.2.4 Learners views on the use of teaching aids by teachers in Earth Geometry

The learners were asked to indicate their views on whether teachers used teaching/learning aids or not in teaching Earth Geometry.

Table 3 shows the views of learners on whether or not teachers used teaching/learning aids in teaching Earth Geometry.

Response	Frequency	Percent
Strongly agree	11	12.0
Agree	26	29.0
Uncertain	7	8.0
Disagree	28	31.0
Strongly disagree	18	20.0
Total	**90**	**100.0**

Table 3: Learners' responses on whether teachers used teaching/learning aids in Earth Geometry

Table 3 shows the views of the learners on whether teachers used teaching/learning aids or not in Earth Geometry. Of the 90 respondents, 11 (12.0%) strongly agreed that teachers did not use the teaching aids, while 26 (29.0%) agreed that teachers did not use the aids when teaching earth geometry. Further more 28 (31.0%) of the respondents disagreed with the notion that teachers did not use teaching aids while 18 (20.0%) strongly disagreed. It was also noted that 7 (8.0%) of the respondents were uncertain about teachers use of teaching aids in Earth Geometry.

4.2.5 Learners' perceptions on how teachers approach Earth Geometry.

The respondents were asked to indicate their views on the supposition that teachers of Mathematics tended to make the topic difficult to comprehend.

Table 4 shows the views of learners that teachers of Mathematics tended to make the topic difficult to understand.

Response	Frequency	Percent
Strongly agree	32	36.0
Agree	25	28.0
Uncertain	7	8.0
Disagree	15	17.0
Strongly disagree	11	12.0
Total	**90**	**100.0**

Table 4: Learners' views on whether teachers of Mathematics make Earth Geometry difficult to understand

Of the 90 learners, slightly over a third, 32 of them (36.0%) strongly agreed while 25 (28.0%) agreed that teachers of Mathematics tended to make the topic difficult to comprehend. Besides 7 (8.0%) learners were uncertain. Also 15 (17.0%) and 11 (12.0%) learners disagreed and strongly disagreed respectively that teachers tended to make the topic difficult.

4.2.6: Learners' views on the use of Mathematics text books by teachers

The learners were asked of the views on the teachers' dependence on the text book when teaching Earth Geometry. Table 5 shows the responses of learners on whether or not the teachers depended on text books when teaching Earth Geometry.

Response	Frequency	Percent
Strongly agree	32	36.0
Agree	22	24.0
Uncertain	11	12.0
Disagree	14	16.0
Strongly disagree	11	12.0
Total	**90**	**100.0**

Table 5: Learners' views on teachers' dependence on text books when teaching Earth Geometry

From Table 5 a large number of learners, 32 (36.0%) indicated that they strongly agreed that teachers depended on text books when teaching Earth Geometry while 22 (24.0%) agreed that

teachers depended on text books. Further more, it was also shown that 14 (16.0%) and 11 (12.0%) of the learners disagreed and strongly disagreed respectively with the view that teachers depended on text books when teaching Earth Geometry. Another 11 (12.0%) of the learners were uncertain about the notion.

4.2.7: Learners' views on the language of Earth Geometry

Learners were asked on whether or not the language used in Earth Geometry was difficult to understand. Table 6 shows the views from the learners.

Response	Frequency	Percent
Strongly agree	17	19.0
Agree	19	21.0
Uncertain	6	7.0
Disagree	29	32.0
Strongly disagree	19	21.0
Total	**90**	**100.0**

Table 6: Learners' views on whether Earth Geometry language was difficult to understand

Table 6 shows that out of 90 learners, 17 (19.0%) strongly agreed that Earth Geometry language was difficult to understand while 19 (21.0%) of them agreed that the language was difficult to understand. Also 29 (32.0%) and 19 (21.0%) learners indicated that they disagreed and strongly disagreed respectively. Further more, 6 (7.0%) of the learners indicated that they were uncertain about the language in Earth Geometry being difficult.

4.2.8: Learners' views on the connection of Earth Geometry to real-life

Respondents were asked to indicate their views on whether Earth Geometry was not connected to real life situations. Table 7 shows their responses.

Response	Frequency	Percent
Strongly agree	24	27.0
Agree	16	18.0
Uncertain	7	8.0
Disagree	20	22.0
Strongly disagree	23	26.0
Total	**90**	**100.0**

Table 7: Learners' views on whether Earth Geometry was not connected to real-life

As can be noted from Table 7, 24 (27.0%) of the respondents strongly agreed that Earth Geometry was not connected to real- life situations. Besides, 16 (18.0%) of the respondents agreed with the view that Earth Geometry was not connected to real- life. However, 7 (8.0%) of the respondents were uncertain as to whether or not Earth Geometry was connected to real-life. It was also found that 20 (22.0%) of the respondents disagreed while 23 (26.0%) of them strongly disagreed with the view that Earth Geometry was not connected to real-life situations.

4.2.9: Learners' views on whether there was memorization in learning Earth Geometry

Table 8 shows the views of learners whether there was a lot of rote learning in Earth Geometry.

Response	Frequency	Percent
Strongly agree	24	27.0
Agree	30	33.0
Uncertain	11	12.0
Disagree	19	21.0
Strongly disagree	6	7.0
Total	**90**	**100.0**

Table 8: Learners' views on whether learning Earth Geometry involved memorization

According to Table 8, 24 (27.0%) and 30 (33.0%) of the respondents strongly agreed and agreed respectively that there was a lot of memorization in learning Earth Geometry while 11

(12.0%) were uncertain. On the other hand, 19 (21.0%) and 6 (7.0%) of the respondents disagreed and strongly disagreed respectively with the view.

4.2.10: Learners' views that Earth Geometry was too abstract

The respondents were asked on whether or not Earth Geometry was too abstract. Table 9 shows the responses from the learners.

Response	**Frequency**	**Percent**
Strongly agree	24	27.0
Agree	29	32.0
Uncertain	11	12.0
Disagree	21	23.0
Strongly disagree	5	6.0
Total	**90**	**100.0**

Table 9: Learners' views that Earth Geometry learning was too abstract

The study found out that out of 90 respondents the majority were in agreement with the view that Earth Geometry was too abstract. As evidenced in Table 9, 29 (32.0%) of the learners agreed with the view that Earth Geometry was too abstract while 24 (27.0%) of the learners strongly agreed. 11(12.0%) were uncertain while 21(23.0%) and 5(6.0%) of the learners disagreed and strongly disagreed respectively.

4.3 Findings from the teachers

4.3.1 Teachers' gender

Figure 4 below shows the gender of teachers in the study.

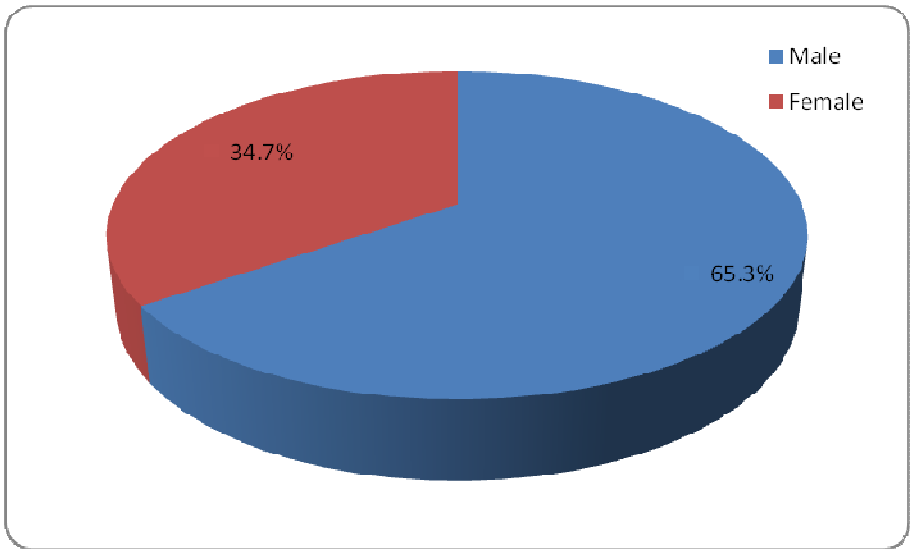

Figure 4: Teachers' gender

Figure 4 shows that the majority, 47 (65.3%) were males while 25 (34.7%) were females.

4.3.2 Institution of learning

Teachers were asked to indicate the institutions where they did their teacher training. Figure 5 shows the responses.

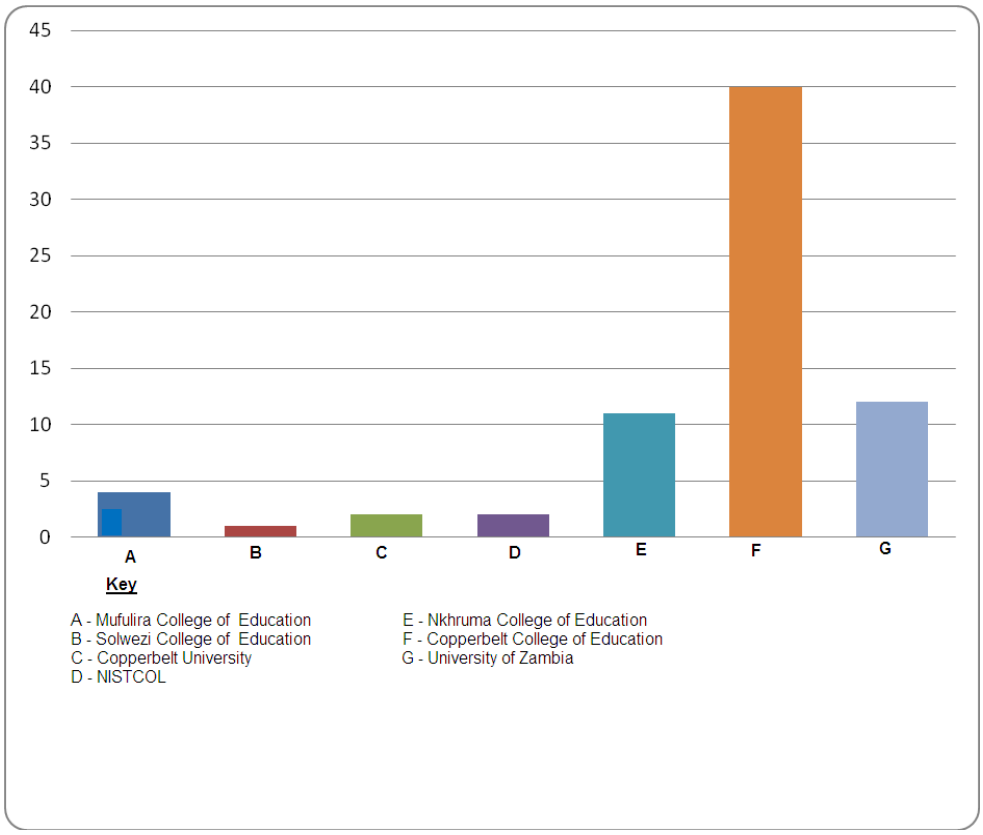

Figure 5: Institution of learning where respondents attended

As depicted from Figure 5, more than half 40 (55.6%) of teachers were trained at the Copperbelt Secondary Teachers College and the least, 2 (1.4%) were trained at Solwezi College of Education.

4.3.3 Teachers' professional qualifications

Respondents were asked to indicate the highest professional qualifications they had attained and the following emerged as shown in Figure 6.

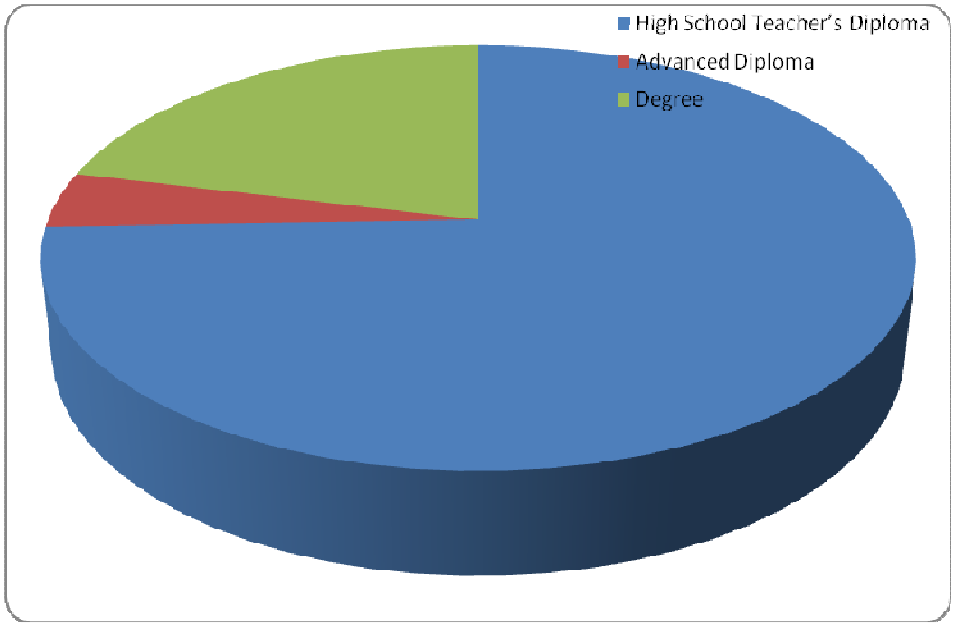

Figure 6: Teacher's highest professional qualification

Figure 6 shows that the majority of the teachers 58 (80.6%) out of 72 had a high school diploma as their highest professional qualification, 2 (2.8%) teachers had an advanced diploma and 12 (16.7%) teachers had a university degree.

4.3.4 Earth Geometry learning at the institution trained

Teachers were asked to indicate if they had learnt Earth Geometry at the institutions where they were trained. Out of 72 teachers, 28 (38.9%) indicated that they had learnt Earth Geometry, while 44 (61.1%) of them indicated that they had never learnt Earth Geometry.

4.3.5 Did you face difficulties in learning Earth Geometry at the institution where you were trained?

Out of the 28 teachers who had learnt earth geometry at their institutions, 12 (42.9%) indicated that they had had difficulties in understanding Earth Geometry while 16 (57.1%) stated that they had not had difficulties in understanding the topic.

4.3.6 Difficulties that teachers faced in learning earth geometry at the institution attended

The 12 teachers who indicated that they had faced some difficulties in learning Earth Geometry at their institutions of training also indicated the difficulties they had faced. Table

10 shows some of the difficulties that teachers had encountered in learning Earth Geometry at their institutions of training.

Difficulties	Frequency	Percent
To find distance along the circle of latitude and great circle	3	10.3
Identifying great and small circles	5	17.2
Challenge of associating it with mensuration	2	6.9
Calculating the shortest distance	12	41.4
Deriving the nautical mile concept	4	13.8
Location of places on the globe	3	10.3
Total	**29**	**100.0**

Table 10: Difficulties teachers encountered in learning Earth Geometry at the institution attended

From Table 10, all the 12 teachers representing 41.4% of responses indicated that they had difficulties in calculating the shortest distance through the poles. This was followed by 5 (17.2%) teachers who indicated that they had difficulties in identifying the great and small circles.

4.3.7 Approaches that teachers used in teaching Earth Geometry

The teachers were asked to indicate the approaches they used in teaching earth geometry; these are shown in Table 11.

Approach	Frequency	Percent
Lecture	33	33.3
Problem Solving	15	15.2
Discussion	51	51.5
Total	**99**	**100.0**

Table 11: Approaches used by teachers in teaching Earth Geometry

From Table 11, 51(51.5%) responses from the teachers indicated that they used discussion method in teaching Earth Geometry while 33(33.3%) of the responses from the teachers showed that they used the lecture method in teaching Earth Geometry. Besides that, 15(15.2%) responses from the teachers stated that they used problem solving in teaching Earth Geometry.

4.3.8 Teachers' views on suitable approaches used to teach Earth Geometry

Teachers were also asked to indicate the most suitable approaches used to teach Earth Geometry. Table 12 shows the responses.

Approach	**Frequency**	**Percent**
Lecture	31	43.1
Problem Solving	12	16.6
Discussion	29	40.3
Total	**72**	**100.0**

Table 12: Suitable approaches used to teach Earth Geometry

From table 12, it can be noted that the majority 31(43.1%) of the teachers stated that the lecture method was a suitable approach in teaching Earth Geometry while 29(40.3%) of them indicated that the discussion approach was the most suitable in teaching Earth Geometry. Besides that, 12(16.6%) of the teachers stated that problem solving was the most suitable approach in teaching Earth Geometry.

4.3.9 Use of teaching/learning aids by teachers in teaching Earth Geometry

Teachers were asked to indicate how often they used teaching/learning aids in their instruction in Earth Geometry. The study revealed that out of 72 respondents the majority 42 (58.3%) of the teachers used teaching aids very often in their instruction in Earth Geometry, while 27 (37.5%) of the teachers indicated that they sometimes used teaching aids in teaching Earth Geometry. Only 3 (4.2%) of the teachers indicated that they rarely used teaching aids in teaching of Earth Geometry.

4.4.0 The challenges faced by teachers in teaching Earth Geometry

Teachers were asked to indicate the challenges they faced in teaching Earth Geometry. Table 13 shows the responses.

Challenge	Frequency	Percent
Explaining the centre of the earth	3	3.4
Negative attitude of learners in Earth Geometry	5	5.6
Lack of teaching resources and books	22	24.7
Difficult to apply Earth Geometry in real-life	3	3.4
Explaining the earth as a spherical object with a smooth surface	7	7.9
Location of places on the globe	4	4.5
Finding distance a long circle of latitudes and longitudes	13	14.6
Explaining angles of latitude and longitude	11	12.4
Lack of prerequisite knowledge in learners	4	4.5
Explaining the shortest distance via the poles	6	6.7
Explaining time difference	2	2.2
Defining longitudes and latitudes	4	4.5
Deriving the radius of the circle of latitude	5	5.6
Total	**89**	**100.0**

Table 13: Challenges faced by teachers in teaching Earth Geometry

Table 13 shows that out of the 89 responses, 22 (24.7%) of them indicated that they lacked teaching resources and books. This was followed by 13 (14.6%) of the responses which indicated that they had the challenge of finding the distance along the circle of latitude and longitude. It was further revealed from Table 13 that 11 (12.4%) of the responses indicated that they had the challenge of explaining to the learners how to find the angles of latitude and longitude.

4.4.1 Measures to address the challenges faced by teachers in teaching Earth Geometry

The teachers were asked to suggest ways to address the challenges they faced in teaching earth geometry. Table 14 shows some suggested measures that teachers should under take in order to address the challenges.

Measure	Frequency	Percent
Introducing the topic at basic level	6	9.0
Intensifying CPD meetings	8	11.9
Use of the globe and suitable teaching aids	34	50.7
Teaching prerequisite knowledge	10	14.9
Teachers in-depth knowledge of Earth Geometry	9	13.4
Total	**67**	**100.0**

Table 14: Measures of addressing the challenges in Earth Geometry

Table 14 shows that most teachers' responses 34 (50.7%) suggested that the use of the globe and suitable teaching aids to be among the solutions to some challenges they faced in teaching Earth Geometry. This was followed by 10 (14.9%) responses which indicated that teaching of pre-requisite knowledge would also help to alleviate the challenges. Other measures were; the introduction of the topic at basic school level which had 6(9.0%) of the responses, intensifying CPD meetings on earth geometry with 8(11.9%) of the responses and the need for in-depth knowledge on the topic on the part of the teacher which had 9(13.4%) of the responses.

4.4.2 The challenges that learners faced in learning Earth Geometry from the teachers' perspective.

The teachers were asked to state the challenges which pupils faced in learning earth geometry. Table 15 shows the challenges that pupils encountered in Earth Geometry, from the teachers' perspective.

Challenge	Frequency	Percent
Calculating the shortest distance	6	6.3
Sketching and plotting of points	17	17.7
Finding angle of latitude and longitude	12	12.5
Calculating distance between two points	16	16.7
Visualising 3D figures	11	11.5
Differentiating small circles and great circles	5	5.2
Memorisation as opposed to understanding	11	11.5
Lack of text books	2	2.1
Understanding nautical miles and calculation of speed	16	16.7
Total	**96**	**100.0**

Table 15: Challenges of learners in learning Earth Geometry from the teachers' perspective

Table 15 shows that most of the teachers stated that the learners had a challenge of sketching and plotting the points on the globe which had 17 (17.7%) responses. It was also stated that the learners had the challenge of calculating the distance between two points which had 16 (16.7%) of the responses. It can also be noted from the table that the challenge the pupils had which had also 16 (16.7%) responses was the challenge of understanding nautical mile and calculation of speed. It was further noted that 12 (12.5%) responses indicated that the pupils had the challenge of finding the angle of latitude and longitude. This was followed by the challenges which had 11 (11.5%) equal responses of visualising 3D figures and memorisation as opposed to understanding which pupils had according to the teachers' perspective.

4.4.3 Teachers' suggestions on measures of addressing the challenges faced by learners in learning Earth Geometry

With reference to Table 16, teachers were asked to suggest the possible solutions to the challenges that learners faced in learning Earth Geometry. Table 16 shows the measures required in addressing challenges learners faced in the learning of Earth Geometry from the teachers' perspective.

Measure	Frequency	Percent
Cutting down on rote learning	4	2.6
Learner involvement in the Earth Geometry	16	10.3
Introduction of basic Earth Geometry at junior level	4	2.6
Intensifying the use of teaching aids	23	14.8
Questions to involve problem solving and proofs	15	9.7
Clear explanation on the concepts	3	1.9
Thorough explanation on nautical mile	11	7.1
The use of variety of approaches	6	3.9
Motivation towards Earth Geometry	37	23.9
Geography to be compulsory subject	5	3.2
Teaching prerequisite topics	14	9.0
Teachers to be resourceful	2	1.3
Workshops and seminars on Earth Geometry	15	9.7
Total	**155**	**100.0**

Table 16: Measures required to overcome the challenges that learners faced in learning Earth Geometry from the teachers' perspective

Regarding Table 16 about measures to address the challenges that learners encountered in learning Earth Geometry from the teachers' perspective, most of the responses 37(23.9%) suggested the need to motivate learners in learning Earth Geometry in addressing some of the challenges. This was followed by 23(14.5%) of the responses which suggested that intensifying the use of teaching aids could be one of the measures to address the challenges encountered by the learners. Among other measures were the teaching of prerequisite knowledge and involving problem solving questions and proofs in their instruction of earth geometry which had 14(9.0%) and 15(9.7%)of the responses respectively.

4.4.4 Teachers' views on the gender of learners having most difficulties in learning Earth Geometry

Teachers were asked to indicate the sex of learners that faced difficulties the most in learning Earth Geometry. The study showed that out of 72 respondents the majority, 56 (77.8%) indicated that female learners faced difficulties the most while 16 (22.2%) of the respondents

indicated that both male and female learners had difficulties. There were no respondents that indicated that the male learners only had difficulties in learning Earth Geometry.

4.4.5 Teachers' explanation of the difficulties learners faced in learning Earth Geometry

The study also sought to find out from the teachers the reasons why the learners had difficulties in the learning of Earth Geometry. Table 17 shows the responses from the teachers.

Reason	Frequency	Percent
Lack of concentration, commitment and interest	9	9.9
Learners give up so easily	12	13.2
Girls had a negative attitude towards the topic	26	28.6
Girls do not like challenging work	11	12.1
Both girls and boys had a negative attitude towards Earth Geometry	6	6.6
Failure to visualise 3D figures	17	18.7
Recently re-introduced so difficult to understand	3	3.3
Girls are lazy	3	3.3
Teachers did not learn the topic when trained	4	4.4
Total	**91**	**100.0**

Table 17: Showing reasons why learners faced the difficulties in Earth Geometry from the Teachers' perspective

Table 17 shows the teachers' explanation of the difficulties learners faced in learning Earth Geometry. From Table 17 , it can be noted that most of the teachers indicated that female learners had difficulties in learning Earth Geometry because of their negative attitude and this totaled 26 (28.6%) of the responses. It was also shown that learners had difficulties in learning Earth Geometry because they had difficulties in visualising 3D figures which was represented by 17 (18.7%) of the responses. Besides, some teachers felt that the learners gave up easily in learning Earth Geometry and some felt that female learners did not like challenging work which was represented by 12(13.2%) and 11(12.1%) of the responses respectively.

4.4.6 Teachers' views on whether or not Earth Geometry should remain in the syllabus.

It was found that out of 72 teachers, 65 (90.3%) of them indicated that Earth Geometry should continue to be in the syllabus while 7 (9.7%) teachers stated that Earth Geometry should be removed from the syllabus.

4.4.7 Teachers' views on teaching and re-introduction of Earth Geometry in the syllabus

Table 18 shows the views of teachers on teaching and re-introduction of Earth Geometry in the syllabus.

View	Frequency	Percent
Enabled learners and teachers to think critically	10	9.3
Good knowledge of the earth and its measurements	4	3.7
Location of towns	11	10.0
Understanding world time differences	14	13
It was relevant for future studies such as navigation	32	29.6
It relates to real-life situations	16	14.8
Enabled the calculation of distances between places	6	5.6
Application was difficult	5	4.6
No impact in the learners	2	1.9
Learners can learn it in Geography	1	0.9
Difficult to explain to the pupils	4	3.7
Syllabus was too big for the inclusion of Earth Geometry	3	2.8
Total	**108**	**100.0**

Table 18: Teachers' views on teaching and re-introduction Earth Geometry in mathematics syllabus

From Table 18, the responses indicated that some teachers were in support of the re-introduction of the topic in the syllabus while others were not in support of the idea. Nonetheless, most of the responses were positive on the topic stating that the topic was

relevant for some future studies, such as navigation which had 32(29.6%) of the responses. Among other positive responses were that the topic enabled learners to understand world time differences bearing in mind that the world was a global village and that it was also important because it was related to real-life situations which had 14(13.0%) and 16(14.8%) of the responses respectively. On the other hand, some teachers felt that there was no need to re-introduce the topic in the syllabus. Some of the reasons advanced were that the topic was difficult to apply to real- life situations and that it was difficult to explain to the learners These took 5(4.6%) and 4(3.7%) of the responses respectively.

4.5 Findings from interviews with ECZ and CDC Specialists

The responses below were from the interview conducted with the specialists from ECZ and CDC. When asked when and why Earth Geometry was removed from the syllabus, the specialist from CDC responded:

> ``*Iam not very sure of the year, but around the early 1980's. The major reason for removing it was that teachers were finding difficulties in teaching it. As you know most teachers did not learn it at school or college''.*

Furthermore, when the specialist was asked why Earth Geometry was re-introduced in 2004, the response was:

> ``*As CDC we thought of reviewing the curriculum and we saw the need to re-introduce Earth Geometry as it is used in other studies such as navigation''.*

When a specialist from ECZ was asked when and why Earth Geometry was removed from the syllabus, his response was similar to the one by the CDC specialists. When asked why it was removed from the syllabus, the specialist's response was:

> ``*For us, we were very happy that Earth Geometry was removed because you know why? It gave both teachers and pupils problems. Again I was very sad when it was re-introduced''.*

The specialist from ECZ was asked to state the challenges that learners encountered in Earth Geometry. The responses were:

> ``*Pupils failed to visualize, even to draw the sketch, to locate places and to calculate distances. You should check the Examiners Grade 12 mathematics report and you will find that most questions on Earth geometry are poorly done''.*

The specialists were also asked about the challenges teachers encountered in teaching Earth Geometry, the response was:

> ``*Teachers had difficulties in teaching Earth Geometry because they never learnt at school and at college. So you find that the difficulties are transferred to the pupils''.*

When the specialists were further asked on the measures to be put in place to address the challenges in teaching/ learning Earth Geometry, one of the specialists responses were:

> ``*You know what, a teacher is supposed to be above the subject. There is need for teachers to conduct workshops in schools on Earth Geometry. There is also need to introduce the topic in educational colleges. Teachers should also involve pupils in making models''.*

From the interview with the ECZ and CDC specialists, it was evident that both teachers and learners were affected by the level of difficulty of Earth Geometry.

CHAPTER FIVE

DISCUSSION OF RESULTS

5.1 Discussion of the findings.

This chapter discusses the findings of the study which sought to establish the factors contributing to poor performance in Earth Geometry at school certificate level in selected schools on the Copperbelt Province. The following were the objectives of the study: to determine the teaching approaches in Earth Geometry; to establish the challenges teachers encounter in teaching Earth Geometry; to establish the challenges learners face in learning Earth Geometry and to determine the gender disparities in performance in Earth Geometry.

5.2 Teaching approaches in Earth Geometry

According to Table 11, the study revealed that most of the teachers used the Discussion approach in teaching Earth Geometry which was followed by the Lecture and the Problem Solving approach respectively. The study further showed that the Lecture approach was the most suitable in teaching Earth Geometry which was followed by the Discussion and Problem Solving approach respectively. It was noted that the Problem Solving approach was not much used by the teachers in teaching Earth Geometry of which it would have helped in developing learners' to come up with mathematical arguments about relationships which eventually would help in solving some of the challenges that encountered in learning Earth Geometry. Although most of the teachers indicated that they used the Discussion approach in teaching Earth Geometry, this was not collaborated by the learners who indicated that the teachers depended on textbooks in teaching Earth Geometry (Table 5). This meant that learners were not involved in the learning process. Moreover, the discussion approach entails that learners should posses some knowledge in order for to be involved in the discussion otherwise it yielded poor results. Even though textbooks provided valuable support for teachers in Malaysia in their preparation of work, Yeo (2000) and Fuys (1988) in Singapore and the United States respectively indicated that textbooks provided little opportunities for learners to explore their geometric thinking. In Malaysian schools where geometry was taught using mainly textbooks never helped many learners as evidenced by the poor geometry performance (Mullis, 2000).

With reference to Table 12, most of the teachers indicated that the Lecture approach was most suitable approach in teaching Earth Geometry. The problem with this approach was that it did not involve the learners; therefore it did not achieve the intended outcomes. Besides the Lecture approach was regarded as the fundamental ingredient of classroom work (Cockcroft, 1982), Yeo (2000) argued that there was need to change the traditional mode of instruction to one that was more rewarding for both teachers and learners. The problem with the lecture approach was a tendency by teachers who taught geometry to inform learners rather than to involve them in the learning process. Even in many classrooms today, teachers introduce learners to facts about geometry and then drill them with concepts in the deductive reasoning (Mullis, 2000). This meant that learners were seldom given an opportunity to discover and conceptualise on their own, which discouraged the learners in the learning process. This was to the more reason why most of the learners (Table 8) felt that there was memorization in learning Earth Geometry which they resorted to after the failed to understand the concepts which probably yielded poor results.

Geddes and Fortunato (1993) claimed that quality of instruction was one of the greatest influences of the learners' acquisition of geometry knowledge. Strutchens (2001) advised that instruction in geometry should emphasise hands-on explorations, developing geometric thinking and reasoning, making conjectures and carrying out geometric projects.

According to the study, it was revealed that most teachers used the Lecture and Discussion approach in their instruction in Earth Geometry which did not yield the intended results as learners continued to perform poorly in Earth Geometry (ECZ, 2006). Although there was no specific approach in teaching Earth Geometry, there was need to use approaches that gave learners an opportunity to investigate and discover Earth Geometry. There was also need to encourage model construction, non-routine activities and hands-on activities to enhance geometry thinking (Noraini, 1998). It can be argued that the teaching of Earth Geometry should not be confined to a specific approach as noted in the study but should include opportunities for the learners to discover, explore and make mathematical conclusions of which problem solving approach could be involved in teaching Earth Geometry.

5.3 Challenges of teaching Earth Geometry

According to Table 10, the study revealed that some teachers encountered difficulties in learning Earth Geometry at the institution trained. Some of the difficulties were calculating the shortest distance between points, identifying great and small circles and finding the distance along the circle of latitude and great circle. In comparison with Table 13 on the challenges encountered by teachers in teaching Earth Geometry of which some were lack of teaching resources and books, finding distance along circles of longitudes and latitudes and explaining the angle of latitude and longitude were similar to the challenges they (teachers) encountered at the institution trained. It can therefore be argued that the difficulties that teachers encountered when trained were passed on to the classroom. The major source of the difficulties that teachers encountered in teaching Earth Geometry was the institution of training. In this case it was important that those tasked with the responsibility of teacher training institutions should address the challenges encountered by the teachers to avoid their reoccurrence in the classroom which did not help in improving the performance in Earth Geometry. In line with this finding, the ECZ mathematics examiners' report (ECZ, 2006) advised ZAME to address the challenges encountered by teachers in teaching Earth Geometry because of the poor performance which was noted at the end of the year in school certificate results. This was the case as questions on Earth Geometry were either poorly done or very poorly done by most learners (ECZ, 2006) because of the challenges that teachers encountered in teaching Earth Geometry.

However, on the question whether Earth Geometry should continue to be part of the syllabus despite the challenges teachers encountered in teaching Earth Geometry, the responses (4.4.6) showed that 65 of the teachers were of the view that Earth Geometry should remain in the syllabus and gave their reasons in support of their view (Table 18) while 7 of the teachers indicated that Earth Geometry should be removed from the syllabus and in support of their view advanced some reasons that the syllabus was already too wide for coverage for the inclusion of Earth Geometry. With the majority of the teachers in support that Earth Geometry should remain in the syllabus, it meant the need for teachers to prepare fully in understanding Earth Geometry before they could deliver to the learners. It can be noted that much of the challenge in making the teaching of Earth Geometry a success rested on the teachers. However, teachers of mathematics must have strong geometry knowledge and reasoning skills themselves in order to help learners meet their expectations in terms of

performance in Earth Geometry. There was need for the teachers to be knowledgeable about the content and their expectations in teaching Earth Geometry.

It was also noted from Figure 5 that out of the 72 teachers who participated in the research, 58 (80.6%) of them were diploma holders, 2(2.8%) of the teachers had an advanced diploma while 12 (16.7%) of the teachers had a university degree. In line with the National Policy on Education (MOE, 1996), it could be argued that most of the teachers were not qualified to teach in high schools and that partly explains the learners' poor performance in Earth Geometry. Although university graduates never learnt Earth Geometry at the institution, they were able to assimilate the content in Earth Geometry because of the content they were taught at the institution. Though this does not suggest that degree holders are better teachers than diploma holders, but there was need for future research to consider which of the two makes a better qualified teacher to teach in a high school.

5.4 Challenges of learning Earth Geometry

The study revealed several challenges that learners encountered in learning Earth Geometry as shown in the Tables 1 and 15. Among the challenges were difficulties in sketching the points, calculating the distance between two points and along the great circle and also the difficulties in finding the angles of latitude and longitude. It was interesting to note that the challenges that learners encountered in learning Earth Geometry were similar to the challenges that teachers encountered in teaching Earth Geometry. As a result, it could be argued that the challenges which learners faced in learning Earth Geometry were passed on to them by the teachers. These same challenges by the learners were noticed when they sat for the final school certificate examination. For instance, in the ECZ mathematics examiners' report (ECZ, 2004), it was noted that learners were not able to sketch the globe given the latitudes and longitudes, and that in most cases they interchanged them. This showed that the learners lacked the understanding of the concepts which was supposed to be developed by the teacher who also lacked the adequate knowledge on the subject. These challenges on the learners might continue if the challenges of the teachers were not addressed.

It was important also to note that many concepts in geometry required learners to perceive the objects and identify their properties by comparing them with the previous experiences. Hershkowitz (1989) also argued that visualisation was a necessary tool in geometry concept formation. In comparison with the approaches that teachers used in teaching Earth Geometry

in the study, there was little help for the learners to develop the idea of concept formation. Teachers needed to use approaches that could stimulate logical thinking and formation of concepts. Kor (1995) recommended more visual activities in the classroom to help learners understand geometric concepts. The challenges that learners encountered of failing to sketch the globe, interchanging latitudes and longitudes and failing to calculate distance between points demonstrated the lack of concepts understanding. It could therefore be helpful for learners if geometry lessons could be carried out with hands-on activities. By being able to ``touch-see-do'' and interacting with the objects of their learning could learn geometry in a more imaginative and successful way (Bishop, 1983). This view was supported by Gardner in Campbell and Dickson (1996). In his Theory of Multiple Intelligences, Gardner suggested that some learners were kinesthetically inclined, meaning that they learn best when actively involved with the objects on their learning. In this case, geometrical concepts require visual interpretations as many geometry problems were presented in a two-dimensional format.

However, what was shown from the study on the challenges that learners encountered was that most of the learners had a problem of understanding geometry language. Bishop (1986) stated that geometry language was a pertinent problem with many learners and this was their weakness. It could be argued that Earth Geometry has its own terminologies which must be understood before an attempt to solve a problem. Misuse of geometry terminology could lead to misconceptions of geometric knowledge and consequently failure to solve problems leading to poor performance (Lappan, 1999). It was this same Earth Geometry language which was supposed to be adequately be explained to the learners by the teachers to avoid the misconceptions which unfortunately were not done as the findings indicated that the same teachers had difficulties in teaching Earth Geometry. Besides, some of the teachers had difficulties in understanding Earth Geometry when they did their training. From the ECZ mathematics examiners' report (ECZ, 2004), it was evident that geometry language especially in the comprehension of geometry terms plays a very important role in learning and understanding of geometric concepts (Clements, 2001). The problem was that when learners failed to grasp the concepts they resorted to memorization. Strutchens (2001) argued that geometry learnt by memorizing geometric properties rather than by exploring and discovering the underlying properties was limited, superficial and short-lived. Although most of the challenges encountered by the learners were passed on by the teachers, it was noted

that both teachers and learners had challenges in teaching and learning Earth Geometry respectively.

5.5 Performance by gender in Earth Geometry

According to Figure 2, out of the 52 learners who had difficulties in learning Earth Geometry, 28 (54.0%) of the learners were male while 24 (46.0%) of the learners were female. This finding was contrary to that of the 72 teachers in the study of which 56 (77.8%) of the teachers indicated that female learners had the most difficulties in understanding Earth Geometry while 16 (22.2%) of the teachers indicated that both male and female learners had difficulties in understanding Earth Geometry. According to the findings in the study, it can be noted that both male and female learners had difficulties in learning Earth Geometry regardless of the gender which had the most difficulties. It was important also for the teachers not to put to mind that a particular gender had the most difficulties in learning Earth Geometry. Instead, they should consider that both male and female learners had the ability to learn and understanding Earth Geometry. In the case that a particular gender experienced that most difficulties, it was their duty to find ways of motivating that gender.

However, according to Malpass, O'Neil and Hocevar (1999), there was a significant increase in achievement in mathematics among gifted or high scoring learners. To the contrary, Halat (2006) noted that a considerable decrease in recent years in the difference in the mean scores between male and female learners. Besides Halat (2006) found no difference in the acquisition of the Van Hiele levels between male and female learners. On the other hand, Kadiri (2004) argued that available literatures had not been able to identify a single direction of difference in performance between male and female learners subject to the inequalities in their physiological structure. Although most researchers had found males performing better than females (Fennema and Sherman, 1978) especially on higher order knowledge, a few saw females out- performing males while some others established on significant difference. In this study, it was found that both male and female learners had difficulties in learning Earth Geometry regardless of the levels of difficulty.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

This chapter concludes the study and makes some recommendations based on the findings of the study.

6.2 Conclusion

The study established that teachers mostly used the lecture and discussion methods in teaching Earth Geometry. The study further found that both teachers and learners had challenges in teaching and learning Earth Geometry respectively, which ranged from inadequate knowledge of the topic on the part of the teachers to lack of resources in order to teach effectively. It was established that teachers did not get adequate support in the area of geometry (Earth Geometry) in their teacher preparation programmes. Thus, they went into the field with the same challenges that they had when they were pupils themselves in school. Teachers found it hard to explain or introduce some concepts in Earth Geometry to learners (e.g. finding the distance along circle of latitude and longitude, explaining angles of latitude and longitude and how to find the shortest distance via the poles, etc.)

The study further found the challenges learners had in learning Earth Geometry. The challenges they faced were; poor grasp of Earth Geometry concepts, inability to visualize objects in three dimensions, comprehending the language or geometry terms used in geometry in general. The challenges faced by learners (according to them) were caused by poor teaching by their teachers of mathematics; they also felt overwhelmed by the formulas.
It was also established that for either sex both learners, irrespective of gender, encountered difficulties in learning Earth Geometry. However, it was indicated from the learners' point of view that male learners had the most difficulties than female learners. While from the teachers' point of view it was indicated that female learners had the most difficulties than male learners.

6.3 Recommendations

In view of the findings and conclusions, the following recommendations are proposed:

- The Ministry of Education through the Curriculum Development Centre should introduce the basics of Earth Geometry in the syllabus at junior level. The inclusion of the topic at junior level would help in laying a better foundation for the high level.

- Teachers' colleges should provide content which is wider than the school syllabus to equip would be teachers with content to handle new inclusion of topics such as Earth Geometry.

- Workshops/seminars on Earth Geometry for teachers should be conducted in order to enhance the in-depth knowledge on the topic to enable them teach with confidence.

- The Ministry of Education through the schools should provide teaching aids / resources in Earth Geometry to enhance effective teaching.

- The teachers of mathematics should utilize visual stimulus such as manipulation of objects (using the model), which might considerably facilitate development of geometric thinking skills.

Areas of future research

From the findings of this research, this researcher proposes that future research be focused on finding out the impact of teacher professional qualification in teaching Earth Geometry mathematics successfully.

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APPENDICES

Appendix A

THE UNIVERSITY OF ZAMBIA
SCHOOL OF EDUCATION

QUESTIONAIRE FOR TEACHERS IN HIGH SCHOOLS

Dear Respondent,

I am a post- graduate student at the University of Zambia pursuing a Master of Education Degree in Mathematics Education. I am carrying out a research as the fulfillment of my masters' programme.

The questionnaire is anonymous and no answers will be considered correct or wrong. All answers will be kept strictly confidential. The results of the research will be purely for academic purpose only. I therefore, request you to feel free and answer as accurately and honestly as possible.

Thanking you in anticipation.

TEMBO OLIVER FREDSON (student)

Section A

1. Sex:……
2. School:……
3. Qualification:……..

Section B

Instruction: Write your answers in the answer spaces provided. In some questions put a tick (✓) in the box that is appropriate to your response.

4. At which institution where you trained? …….....
5. Did you learn Earth Geometry at the institution?

Yes	
No	

6. If your answer is yes, did you face any difficulties in understanding it?

Yes	
No	

7. If your answer is yes, what difficulties did you face?
   ……..
   ……..
   ……..
8. When teaching Earth Geometry, what approach/ method do you use?
   ……..
   ……..
9. Which approach/ method do you find most suitable in teaching Earth Geometry?
   ……..
   …….

10. How often do you use teaching/ learning aids in Earth Geometry lessons?

Very often	
Sometimes	
Rare	

11. What challenges did you face in teaching Earth Geometry?

……

……

……

12. How best can you address the challenges in 11?

……..

……..

……

13. What challenges do your pupils face in learning Earth Geometry?

……

……

……

14. How best can you address the challenges in 13?

……

……

……

15. What sex of pupils seems to have most difficulties in learning Earth Geometry?

Male	
Female	

16. Suggest reasons to your response in 15.

……

……

……...

17. How best can you address the responses in 16?

……

……

……

18. Do you feel earth geometry should still remain in the syllabus?

Yes	
No	

19. If Yes/ No, state the reasons below.

……

……

……

Appendix B

THE UNIVERSITY OF ZAMBIA
SCHOOL OF EDUCATION

QUESTIONAIRE FOR PUPILS IN HIGH SCHOOLS

Dear Respondent,

I am a post- graduate student at the University of Zambia pursuing a Master of Education in Mathematics Education. I am carrying out a research as fulfillment of my masters' programme.

The questionnaire is anonymous and no answers will be considered correct or wrong. All answers will be kept strictly confidential. The results of the research will be purely for academic purpose only. I therefore, request you to feel free and answer as accurately and honestly as possible.

Thanking you in anticipation.

TEMBO OLIVER FREDSON (student)

Section A

Instructions: Write your answers in box and answer spaces provided.

1. Personal Data

   Question 1.1

   Gender

Male	
Female	

   Question 1.2

Grade	

   Question 1.3

School	

   Question 1.4

   Do you face any difficulties in learning Earth Geometry?

Yes	
No	

   Question 1.5

   If your answer in 1.4 is yes, what difficulties do you face?

   ……

   Question 1.6

   Give reasons to your answer in question 1.5

   ……

Section B

2. Your experience and opinion about the teaching and learning of Earth Geometry.

   Put a tick (✓) in the appropriate box that suite your response.

   Example:

   Girls like mathematics. If your answer is Strongly Agree, put a tick underneath as shown below.

Statement	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
Girls like mathematics	✓				

Statement	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
1.Earth Geometry is too abstract					
2.Earth Geometry involves rules					
3.Idon't understand teachers explanation					
4.There too much memorisation in Earth Geometry					
5.I face difficulties in understanding Earth Geometry					
6.Earth Geometry is not connected to real-life					
7.Teachers do not use teaching aids when teaching Earth Geometry					
8.Teachers depend too much on text books					
9.Most teachers make Earth Geometry difficult					
10.I don't perform well in Earth Geometry					
11.Earth Geometry language is very difficult to understand					

Appendix C

INTERVIEW GUIDE FOR CDC AND ECZ MATHEMATICS SPECIALIST

1. Sex…….

2. What is your position in the institution?

3. When was Earth Geometry removed from the syllabus?

4. Why was Earth Geometry removed from the syllabus?

5. Why was Earth Geometry re-introduced in the syllabus in 2004?

6. What challenges do pupils encounter in learning Earth Geometry?

7. What challenges do teachers encounter in teaching Earth Geometry?

8. What solutions should be put in place to address the challenges encountered by both teachers and pupils?