

**AN EXPLORATION OF STRATEGIES USED IN THE
TEACHING OF GEOMETRY IN THE SENIOR PHASE**

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**A mini-dissertation submitted in partial fulfillment of the
requirements for the degree of Masters of Education (Mathematics
Education) at the Mafikeng Campus of North West University**

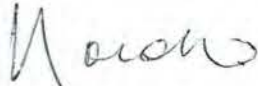
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Declaration

I, *John Bob Kolokoto*, hereby declare that the mini-dissertation for the degree Masters in Education (Mathematics Education) at the University of North West hereby submitted, is my own work and has never been submitted by me for a degree at this or any other university before. All material contained herein has been duly acknowledged.



J.B. Kolokoto

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Dedication

I dedicate this study to my late wife who will always remain a source of inspiration on projects of this nature and to my children, Letlhogonolo and Regomoditswe, for their inspiration and support that made me to keep the midnight light burning against all odds.

ABSTRACT

The unsatisfactory performance of learners in geometry specifically and mathematics in general, as revealed in SACMEQ and TIMMS reports, is an indication of the difficulties experienced by learners in dealing with geometry. In response to many years of learners' challenges with geometry, the South African curriculum must advocate reforms in teaching strategies applied by educators to teach geometry.

The purpose of this study is to understand the challenges that educators face in the teaching of geometry in order to explore and recommend strategies of teaching geometry that will assist educators to improve learners' understanding of geometry in the senior phase. Grade six and nine mathematics results indicate that learners' performance in geometry is of poor standard. This study was conducted in Moses Kotane West Area Office of the North West Province of South Africa. A total number of 35 mathematics educators in 27 middle schools participated in the study by filling in questionnaires. Data were also collected through observation and interview. The constructivism theory provided a theoretical framework for the study. Data collected were analysed by using the Statistical Package for Social Sciences 17.0 (SPSS 17.0) programme and conclusions were drawn.

The study revealed that educators still used traditional methods of teaching in the era of Outcomes - Based Education (OBE) when teaching geometry to learners. Amongst others, teachers do not use the OBE principles such as learner-centred approach, teacher facilitation and integration of knowledge in assisting learners to understand geometry. For most of the participating schools, educators still follow teaching by telling rather than engaging learners in their teaching. Reasons advanced by teachers in sticking to using methods used before the introduction of OBE include lack of pedagogical content knowledge and learner-centred instructional methods. The teachers attribute the use of the traditional teaching methods to lack of proper training and also resistance to change. The study further revealed that the majority of educators' workshops are concentrated on algebra content knowledge and less on strategies that educators should use to teach geometry. In view of the findings in this study, some interactive teaching methods such as problem solving, visualisation and co-operative learning are recommended and could be used for further studies in order to achieve better application of teaching strategies for geometry in our schools.

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ABBREVIATIONS AND ACRONYMS

DoE	Department of Education
GET	General Education and Training
IMAGES	Improving Measurement and Geometry in Elementary Schools
LoLT	Language of Learning and Teaching
MKWAO	Moses Kotane West Area Office
OBE	Outcomes-Based Education
SAQMEQ	Southern and Eastern Africa Consortium for Monitoring Educational Quality
TIMSS	Third International Mathematics and Science Study

CHAPTER 1

ORIENTATION TO THE STUDY

1.1 INTRODUCTION

Euclidean geometry is a vital part of the school curriculum. The intention of this study was to explore and find out about teaching strategies that will improve teaching and understanding of questions of size of lines, angles, surfaces and relative position of figures and the properties of space (Department of Education, 2002a: 1).

The question of how to teach geometry became increasingly problematic as critics from diverse perspectives offered challenges to conventional methods used by educators in the teaching of geometry. Conventional methods, by means of which instructors encouraged the teaching of textbooks through the telling method, made learners not to realise the role that geometry plays in their lives (Davis, 1997: 359). The Conventional approach to teaching involved classes in which teachers adopted a teacher-focused approach which resulted in surface and non-deep approach to learning (Trigwell, Prosser & Taylor, 1999:66). According to Siyepu (2005:421), learners' knowledge of geometry at elementary, middle and high school levels appeared to fall short of what was generally expected at these levels of education. As the writer puts it, "elementary and middle school students are failing to learn basic geometric concepts and geometric problem solving, they are woefully underprepared for the study of more sophisticated geometric concepts and proofs." The conventional approaches to teaching geometry need to change if we are to see an improvement in learners' understanding of geometry.

The study focused on the senior phase and on how educators use different teaching strategies to teach geometry to their learners in order to recommend those suitable for today's classroom situation. It also looked at the work of previous researchers who used qualitative and quantitative methods of data collection to interpret their findings and draw conclusions from the acquired information. The background of the study gives the history of the teaching of mathematics in the country.

1.2 BACKGROUND OF THE STUDY

The unsatisfactory performance of learners in geometry in 2007 showed that a high percentage of South African learners performed poorly in Euclidean geometry. According to the Department of Education 2008 Matric Results Analysis, only a few learners (11174 out of 347000), chose to write the optional paper 3 (geometry) (Department of Education, 2008:5). Of those who wrote the paper in 2007, only 36% actually passed. These results have shown that Euclidean geometry remained problematic. According to Pandor (2006), the 2006 Department of Education Systemic Evaluation Report also revealed that 8 in 10 grade 8 learners did not pass the geometry section of the systemic evaluation assessment task written in 2005. Further analysis of these results indicated that these learners performed more poorly in geometry than in algebra. This is a cause for concern to all those who appreciate the role that geometry plays in a developing country like South Africa.

There appears to be widespread realisation that teaching of mathematics in general, has failed to overcome a number of cognitive barriers to learner understanding (Peterson, 1998). According to McAuliffe (1999), a number of researchers in mathematical education asserted that the instruction in geometry offered in South African schools is inadequate in terms of providing learners with the necessary skills needed to operate at the level of axiomatic thinking required for most high school courses.

According to Mansfeld and Happs (1996), traditional teaching strategies did little to promote understanding of their learners' level of mathematical thought and Mason (2009: 4) specifically states that the inability of many teachers to match instruction with their learners' level of geometrical understanding was a contributing factor to learner failure to promote meaningful understanding of geometry.

Tytler (2002:2) has also noted that the inability of teachers to understand the level of thought of their learners is also applicable to the senior phase of the General Education and Training (GET) Band. The researcher indicated that educators felt frustrated when

explaining a concept in what they thought was the clearest possible way, only to find that on testing these learners, nothing much seemed to have been gained at all.

The study of geometry at the middle school level is made up of the study of two – and three dimensional shapes and their properties and relationships. Through geometry learners learn to reason about and compare objects; to measure attributes of objects; to represent objects through drawings or with coordinates; and to visualize and mentally manipulate geometric objects (Dossey, Giordano, McCrone & Weir, 2002:201).

The study of geometry in the senior phase, that is, from grade 7 to grade 9 needed to provide the foundation for the mathematics which learners are likely to need in pursuing other studies and everyday life experience. In the senior phase, according to Ryan (2003:1), learners tended to respond more positively in algebra interactions than in geometry.

According to Sheil and Kelly (2001), a New Zealand national mathematics test in 1999 found that pupils performed best on items dealing with data and chance, number and algebra and poorest on items with measurement and shape and space. The reason for this performance was that educators placed considerable emphasis on teaching algebra and the areas that received comparatively less emphasis in teaching such as geometry were the content on which learners did relatively poorly.

In addition, the Department of Education reported that the 2007 and 2008 North West Provincial Common Task Assessment (CTA) Moderation Report of the Department of Education indicated a serious decline in the quality of senior phase mathematics results. In 2007, 83% of sampled learners who wrote the grade 9 mathematics paper received a mark between 0% - 29% while in 2008, 98% of sampled learners also received a mark between 0% - 29%. The worst performance was found to be in the geometry section- question 5 (Department of Education, 2009a). This points to problems in the teaching and learning of geometry in schools.

The Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ) (2007) report indicates South Africa's grade 6 learners from poor backgrounds scored eighth position out of 15 participating countries in a mathematics test. The score was considered bad in those tests which were written between 2000 and 2002, when South Africa obtained position 9 out of 14 countries that participated in mathematics. Again, a total number of 97083 South African grade 6 learners in sampled 392 schools wrote the SACMEQ tests in 2007 and 69.5% scored marks between 0%-30% and only 0.6% scored between 80% and 100%. This study also sums up reasons to conclude that South Africa's learners are underperforming in mathematics in general. French (2004:26), expresses the view that performance in mathematics as a whole is a good indication of performance in geometry specifically.

Highlights from TIMMS (2008:13), The Trend in International Mathematics and Science Study (TIMSS) produces reliable cross-national comparison data on mathematics and science achievements. TIMSS assesses achievement in these subjects at grade 4 and 8 among learners in several countries around the world. In 2003, according to Department of Education (2009b:5), 44 countries including South Africa participated in the assessment of their grade 8 learners. South African learners performed below the 466 mark which is the international average by scoring only 264 which was the lowest ranking amongst the 44 countries that participated.

According to Highlights from TIMMS (2008; 13), 36 countries out of a total of 47 scored below the TIMSS scale of 500 for mathematics from grade eight learners. According to the report, mathematics scores for eighth-grade students were higher in 2007 with 11 points compared to 1999.

Table 1. Percentage of TIMSS mathematics assessment: 2007

Content domains	Percent of assessment
Number, data and chance	48
Algebra	30
Geometry	22
Cognitive domains	Percent of assessment
Knowing	38
Applying	41
Reasoning	21

Adapted from: TIMSS (2008:5)

Table 1 indicates that the TIMSS mathematics assessment is designed along two dimensions: the mathematical topics or content domain that learners are expected to learn and the cognitive skills that learners are expected to have developed. The content domains are number, data, algebra and geometry. The cognitive domains in this grade are knowing, applying and reasoning. According to the report, in terms of comparison with other countries, U.S learners in grade eight scored above the TIMSS scale score of 500 for numbers and data and chance. On the other hand, U.S. eighth graders' average score in the geometry domain was on average, worse than the other content domains and lower than the TIMSS scale score.

Evidence concerning South African learners' low performance in mathematics generally, and in geometry specifically, has been drawn, according to Brombacher (2001), from the results of the Third International Mathematics and Science Study-Repeat (TIMMS-R) conducted by the Human Science and Research Council (HSRC) in 1999. The TIMMS-R results indicated that of the 38 countries that participated, South African learner obtained the poorest results in mathematics. The mathematics average score of 275 points out of 800 points was well below the international average of 487 points (Howie, 2001:11). According to Howie (2001:11), South African learners in the TIMMS-R had "considerable difficulty dealing with ... geometry questions and in some cases were successfully distracted by questions testing misconceptions" in geometry.

Siyepu (2005:42) express the view that the weakness of learners' knowledge of geometry is not much different in South Africa. He states that in South Africa "it is well known that on the average, learners' performance in the senior phase geometry is far worse than algebra". It has been asserted that learners who struggle with mathematics, geometry included, did not have an understanding of fundamental concepts that ought to have been in place (Daniels, 2007). This supports the theory that the reason for the lack of good performance in geometry in high school lies in the poor foundation acquired at the intermediate and senior phase level. The poor performance in geometry has been attributed to the dire shortage of qualified mathematics educators, lack of curriculum knowledge, geometry content knowledge and correct geometry teaching strategies by educators (Taylor & Vinjevold, 1999). This is the case in the majority of schools in South Africa.

1.3 THE STATEMENT OF THE PROBLEM

Mathematics results have been poor in the country. A research conducted by the Human Science Research Council in 2007 (Mail & Guardian, 2011:5) which aimed at finding out how teachers' teaching strategies and their application thereof play a role in learners' understanding of the subject, found that inadequately trained mathematics teachers could be the root cause of learners' poor grasp of the subject. Some capacity to train teachers, according to IOL (Independent Online, 2008:1), was lost when 150 teachers colleges were merged and reduced to 25. We thus have more theoretical than practical exposure to class work than methods. The research also found that a large number of learners fail to reach proficiency in mathematics because they are taught by teachers lacking subject matter knowledge. The study also found that the quality of teachers' training was probably a key variable of why learners in other countries, such as Zimbabwe and Tanzania, seem to know more mathematics than learners in South Africa.

The inference is that some mathematics educators currently in South African schools received poor education in terms of content and methods of teaching mathematics, leading to poor qualifications. Improper training also led teachers to select to teach only

“friendly” topics which in most cases excluded geometry. Such poorly qualified teachers passed on their poor education to their learners.

According to the Mail & Guardian (2011:12), the problem of under teaching by teachers is compounded by the fact that the best mathematics learners did not choose to become teachers. The resource pointed out that it was quite likely that students who obtained as low as E (40% - 49%) or F ($33\frac{1}{3}\%$ – 39%) symbols for matric mathematics are the ones who became mathematics teachers, geometry included. The report also indicated that educators’ knowledge is not the only factor that has the biggest influence on learners’ performance but also motivation and the ability of teachers to transfer knowledge. The teachers are also struggling to adapt to Outcomes- Based Education (OBE) despite training.

Adler (2009:1) remarks that poor teaching of mathematics results from educators not being taught mathematical reasoning and so were unable to design and adapt tasks towards purposes that supported mathematical reasoning and critically working with or mediating the development of such in others. In the case of mathematical reasoning, Stacey (2000), asserts that mathematical reasoning, its actuality in curricula texts and classroom practices, remains a challenge in many, if not most, classrooms. Hence, one wonders if such poorly trained teachers have enough curriculum knowledge, pedagogical content knowledge and methods of presentation to teach geometry effectively. Therefore the intention of the research was to find out about strategies that teachers can use to improve the teaching of geometry.

1.4 RESEARCH QUESTIONS

The questions which directed the research are:

- Which strategies do teachers use in teaching geometry?
- Which challenges do teachers face in teaching geometry to their learners?
- What can be done to improve geometry teaching in schools?

1.5 THE RESEARCH AIM

The aim of the research was to find out:

- About strategies teachers use in teaching geometry
- Which challenges do teachers face in teaching geometry to their learners and
- What can be done to improve geometry teaching in schools?

1.6 SIGNIFICANCE OF THE STUDY

Taylor (2009:2) mentions that educators' strategies of teaching geometry were found to be poor because they were not properly trained. The exploration therefore was conducted in order to enhance the teaching and learning of geometry. According to the researcher, most mathematics teachers still use traditional teaching strategies such as telling method in the teaching of geometry. In traditional teaching, mostly surface questions which need ready answers which are not developmental are asked. These questions do not promote investigative thinking. The researcher intended to explore instructional strategies which will be relevant to an Outcome-based classroom in order to improve geometry teaching. The strategies should be based on learner centredness and be problem based.

1.7 DELIMITATIONS

The study was conducted in Moses Kotane West Area Office, a historically disadvantaged area with no former model C schools in the Bojanala District of the North West Province. In some sampled schools, teachers teaching mathematics were under qualified with grade 12 mathematics as their highest qualification in mathematics.

1.8 LIMITATIONS

This study is limited to teaching methods in geometry in schools in the Moses Kotane West Area Office and does not represent instructional practices that represent the whole educational landscape of the country. One shortcoming of this study concerned the number of lessons observed and interviews in each of the participating schools. The involvement of only six schools in classroom observation and interviews particularly limited the scope of this study with regard to the findings. Another contributory factor to the limitation was the time allocated to a teaching period. The majority of schools did not follow the notional time of one hour per period thus educators were rushing to catch up with time.

Educators' knowledge of the syllabus and its theoretical basis were limited as a result of their suspense preparedness in presenting the lessons. Though they had lesson plans, it was in rare cases that the educators confidently taught what they had prepared and thus affected the flow of the presentation. This affected an effective contribution to the research. Lack of discipline in some classrooms had a negative impact to the lesson presented since part of the lesson was used to call learners to order.

1.9 DEFINITION OF TERMS

This section is meant to clarify key concepts used in this study so that readers can understand the context in which these concepts were used. The following key concepts were used in this research as defined below:

- **Geometry**

Geometry as a part of mathematics is concerned with questions of size, shape and relative position of figures and the properties of space, it is part of mathematics that deals with the relationship between lines, angles and surfaces (Macmillan School Dictionary, 2004: 421). According to the Oxford English Dictionary (2005: 374), geometry is also defined as a study of lines, angles, surfaces and solids in mathematics.

- **Outcomes**

According to Spady (1994:2), outcomes are clear learning results that we want students to demonstrate at the end of significant learning experiences. They are not values, beliefs, attitudes, or psychological states of mind. Instead, outcomes are what learners can actually do with what they know and have learned. An outcome is not a score or grade, but the end product that learners are able to carry out.

- **Outcomes-Based Education**

OBE can be defined as an approach in which the curriculum, teaching and assessment are organised around outcomes. In fact, OBE is based on the philosophy that learners should demonstrate the outcomes they have achieved. It is a result-oriented system of education.

- **Senior Phase**

The senior phase is the phase which includes Grades 7, 8 and 9 (previously standards 5, 6 and 7) in the schooling system in the Moses Kotane West Area Office and former Bophuthatswana schools in the North West Province. The schools housing these classes were referred to as middle schools.

1.10 OUTLINE OF CHAPTERS

Chapter 1: Orientation

An introduction and background to the study is given in the first chapter with the aim of leading the reader into the context and scope of the topic in order to provide information to help explain the rationale for the research. Attention is also given to the formulation of the research problem and the research questions. Factors that affect the poor teaching of geometry, limitations and delimitations are also outlined in this chapter.

Chapter 2: Review of the Literature

Literature review contains information which is relevant to the South African situation and schools. The review covers the following areas: theoretical background including Outcomes-based Education constructivism, investigative teaching of geometry and Van Hiele Levels' strategies of teaching geometry, Pestalozzi's method and previous research on the teaching of geometry.

Chapter 3: Research design and methodology

The chapter provides a description of research design and methods used in this study. The study design focuses on population and sample and the research instruments in the form of a questionnaire, interviews and classroom observation. Qualitative and quantitative approaches were used.

Chapter 4: Data Analysis and Interpretation

Data generated from the tools used to gather information on how educators teach geometry is analysed and interpreted

Chapter 5: Discussion, recommendations and conclusion

Findings from the analysed data are discussed, conclusions drawn and recommendations made regarding the approaches that can be used to teach geometry effectively.

1.11 CONCLUSION

The introductory chapter reflects the background of the study, the problem to be investigated and the main purpose of the study. The main focus of the study is to explore strategies that are used to

teach geometry in the senior phase so as to recommend those that will assist educators make learners understand geometry better. The majority of educators still use conventional methods in their classrooms to teach geometry. The chapter proceeded to give the objectives of the study followed by the research questions. Attention was drawn to the significance and delimitation of the study.

The following chapter focuses on existing literature on the teaching of geometry and the constructivist theory which was chosen as the framework of this study.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

A literature review refers to a scrutiny of all relevant sources of information (De Vos, Strydom, Delport & Fouche, 2005:127). An extensive study of various books, newspapers and internet materials were used for data. Sources were scrutinised with the aim of drawing relevant information to determine strategies that can be used to teach geometry effectively. This chapter focuses, amongst others, on

- theoretical background
- Outcomes-Based Education (OBE) and its principles
- approaches, on the teaching of geometry,
- van Hiele's Levels of thought,
- strategies used in the teaching of geometry, and
- previous research.

Van de Walle (2004: 345) has also noted that geometry teaching used to be ignored until late in the year. This was because many educators were not trained and confident with geometry teaching and did not see the importance of teaching it. The traditional strategies of teaching geometry did also not help learners to achieve positive results because the strategies that educators used did not have any connection with the environment in which learners found themselves in and educators taught in order to complete the syllabus. Unfortunately, in this teaching, subject matter was presented as a pre-organised structure. All concepts, definitions and deductions were pre-conceived by the educator from the textbook. Rote learning was the order of the day and teachers and textbooks were the only source of information to which learners could refer and this approach gave rise to a rigidity of learners' responses.

2.2 THEORETICAL BACKGROUND

South Africa has been faced with many educational challenges and changes since 1994. One of the many changes was the introduction of a new curriculum for a democratic South Africa by means of National Curriculum Statement. Botha (2002:361) notes that one of the major challenges was an examination orientation with a major emphasis on rote learning and unimaginative teaching methods. Change is sought to teach mathematics in general and geometry in particular. This chapter deals with a background that will lead in finding strategies for the teaching of geometry for this era.

2.2.1 Outcomes-based education (OBE)

Outcomes-based education, as the foundation of the curriculum in the new South Africa, forms the basis for creating a rewarding curriculum for learners in the senior phase as it strives to enable all learners to achieve to their maximum ability (Rigby, 2001). According to Harlen (2004), the mathematics learning outcomes of the senior phase encouraged a learner-centred and activity based approach to education. For most of these learners, it is important to connect what is being taught in the classroom with the world outside in ways that seek to engage their interest. This is life-long learning which is facilitated by:

- Learning with understanding, which in turn means learning that links with, and uses real life experiences as a basis for reflecting on new phenomena;
- Acquiring learning skills (thinking processes and meta-cognition);
- Building motivation to learn (intrinsic), for example, by offering choice and control; highlighting learning goals and by encouraging collaboration.

According to the Department of Education (2002b:10), OBE considers the process of learning as well as content which are emphasized by spelling out the outcomes to be achieved at the end of the process of teaching. The learning outcomes and assessment standards were designed down from the critical and developmental outcomes which in turn were derived from the Constitution of the Republic of South Africa. According to White (2003:2), the learning outcomes and the assessment standards emphasise participatory, learner-centred and activity-based education. These form the basis of the OBE characteristics, namely, learner-



centred approach, teacher facilitation and integration of knowledge which inform strategies the educators need to use in order to assist learners' understanding of geometry. The paragraphs that follow give an insight into the principles.

2.2.2 Principles of Outcomes-based Education

OBE principles of the Department of Education (1997:18) are organised from a focus on learner exit outcomes and designed downwards to learning unit levels. Spady (1994:30) opines that the principles are powerful factors in creating conditions that enable learners to learn more, to demonstrate higher levels of skills and get credit for their accomplishments. These principles are:

- **Clarity of Focus**

Clarity of focus means that everything that the educators do should be guided by outcomes that they wish learners should to achieve (Department of Education, 1997:5). It implies that educators' initial focus should not be on the established curriculum but on what they want all learners to be able to exhibit successfully. Educators must ensure that learners are clear about the criteria against which they are to be assessed and what they are expected to demonstrate. According to Killen (2000:122), the outcomes must be clear to both the educator and the learners before any decisions are made concerning the way in which instruction will be organized, what teaching strategies will be used, what content will be covered, how learners will be assessed and what resources are available.

- **Design Down/back**

The Department of Education (1997:18) and Killen (2000:123) describe design down/back as clearly stating the outcomes to be addressed through teaching and learning before developing the teaching and learning activities. Planning for OBE happens by asking what needs to be achieved, before attempting to achieve the final outcome. The outcome must never be lost sight of.

- **High Expectations**

High expectations, according to Killen (2000:126), and the Department of Education (1997: 19), imply that educators must assist learners in reaching their full potential. Educators should have high expectations for all learners, they should not be satisfied if some learners learn a lot and some learn very little. There should be an establishment of high, challenging standards of performance for learners so that they are continuously challenged to improve as they grow and mature on the type of learning defined in the outcome. When learners experience success, it reinforces their learning, builds their confidence and encourages them to accept further learning challenges. Helping learners to achieve high standards is linked very closely to the idea that successful teaching promotes successful learning.

- **Expanded Opportunities**

According to the Department of Education (1997:18), and Killen (2000:127), not all learners can learn the same thing in the same way and at the same time. Educators should vary learning rates and strategies and also use time as a flexible resource to help every learner do her or his best, rather than regarding time as a fixed and inflexible block that should determine whether or not learners get the learning help they need (Spady, 1999:31-33). Teachers must find different ways of exposing learners to those learning opportunities that will help them to demonstrate their full potential in terms of knowledge, skills, values and attitudes.

Mathematics teaching strategies should be derived with the four principles in mind. OBE focuses instructional strategies on clearly defined learning outcomes where high standards and expectations are set for all learners. It also provides expanded opportunities for enrichment and remediation. The principles are assumed to be the guidelines on how an outcome-based instructional system should function. This will assist educators to plan their lessons in line with OBE requirements. The classroom activities will be created in such a way that the climate is conducive to allow learners to be active in their learning.

2.2.3 Application of OBE principles

According to Combrinck (2003:52), educators' lack of knowledge and experience concerning the implementation of the outcomes-based curriculum became a major obstacle since the introduction of OBE in South Africa. Firstly, some educators of mathematics show a lack of or incomplete understanding of the new practices required due to ignorance of sources such as OBE policy documents. Secondly, some teachers lack the capacity to put some requirement of the OBE principles into practice. For example, some educators lack knowledge of the process skills they are meant to be teaching (White, 2003). In order for the teachers to apply OBE principles such as the learner-centred approach, teacher facilitation and integration of knowledge, they have to understand what these principles entail. Their negative attitudes and beliefs concerning OBE also became an obstacle in the successful implementation of the curriculum. Thirdly, some teachers have not yet adapted their teaching to comply with the required OBE practices. For example, Rogan (2003), found little evidence of meaningful group work or adequate achievement of outcomes in his Mpumalanga study involving 240 mathematics and science educators.

Pillay (2006), in a study of grade 9 mathematics studies of all grade 9 mathematics educators in one school, found inadequate lesson planning targeting the required OBE changes. Since educators are not well trained, they experience a lack of confidence with regard to their teaching of geometry. Educators complain that there was a lack of well trained departmental officials to provide them with necessary training for the successful teaching of geometry. According to Pillay (2006), some curriculum supervisors were also not applying OBE principles in their teacher training, instead they trained teachers using the teacher-centred approach. According to Combrinck (2003:54), this is also the case in other countries such as Australia, New Zealand and America. The majority of mathematics educators in these countries believe that they neither received sufficient nor adequate training in how to teach geometry.

In Pennsylvania in the USA, the state legislature only provided a list of learning outcomes, or academic goals that learners should achieve. The educators found it difficult to determine how to structure the teaching and learning environment so that learners would achieve those

outcomes (Parkin, 1994:22). Killen (2000:93) points out that the most frustrating experience for educators who are trying to implement new methods of teaching geometry is a lack of information about what they are required to do and how they should go about doing it.

Research conducted by Schulze (2003:7) shows that learners in South Africa reported a willingness to move towards more meaningful teaching and learning approaches. Yet at the same time they seemed to prefer traditional teaching practices for various reasons. If learners do not experience effective learning, educators will be faced with a major challenge. For educators to be able to change their traditional teaching approaches, they require relevant training.

Training should not only focus on curriculum design, but also on the use of multi-media print and the practical implementation of contemporary teaching and learning theories. In-service training should be based on planned activities and practices both within and outside school to develop the professional knowledge, skills, attitudes and performance of professional staff in schools. Its aim should primarily be to develop and improve educators' daily work. This process can continue indefinitely (Mtetwa & Kwari, 2006:512).

2.2.4 Constructivist view of teaching geometry

The purpose of this section is to place emphasis on learners as active participants in knowledge generation in the teaching learning situation. According to Stoker (2003:15), the current South African national curriculum is based on the constructivist framework. Constructivist theories stipulate that learners need to be actively involved in their learning. Constructivism is a theory of learning that informs on which strategies to use to direct meaningful teaching. Constructivist educators create classroom conditions that invite learners' knowledge by determining their prior knowledge and building on it (Mayer, 1996: 1). If learners' reasoning and reasoning skills are developed, they will be able to justify their responses on the bases of previously learned facts.

Research into learners' understanding of geometry has raised questions about the nature of teaching and the nature of knowledge, in particular, the status of geometrical knowledge compared to informal knowledge held by educators. Researches recognised that learning

should not be seen as some sort of conceptual implanting process, but involves interplay between students' existing ideas and the knowledge or experiences they are exposed to in the classroom (Tytle, 2002:4). According to Smith, Desessa and Roschelle (1993:126), there is a need for energetic classroom discussions in which learners take position, make sense of and explain problematic phenomena and articulate justification of their ideas. Problem areas are identified and confronted only if learners are given the opportunity to communicate their ideas by explaining and justifying their understanding.

From this perspective, learning is viewed as the construction of personal meaning, and this process in the classroom is simply an extension of the same process by which the prior ideas had arisen: from students' active engagement and meaning making with the world from the earliest age.

A personal constructivist view of learning emphasizes, according to Mayer (1996; 2):

- **Posing problems of emerging relevance to learners**

Educators start with what their learners know and help them build increasingly sophisticated understanding by making the material and subject matter relevant to them.

- **Seeking and valuing learners' points of view**

Educators see the viewpoints of their students as "windows into their reasoning." Thus the strategy needed is for educators to talk and listen to their learners and allow learners to come up with their own answers. Erroneous answers are not discarded but are used as opportunities to give constructivist educators a way to reach learners and encourage the growth of new facts and more accurate understanding.

- **Structuring learning around primary concepts**

To better engage their learners, constructivist educators often present the curriculum holistically, organizing materials in conceptual clusters. The aim of the strategy is to make learners realize that the materials they study in different subjects are interrelated and this expands students' understanding of concepts they are dealing with.

- **Adapting curriculum to address learners' suppositions**

If constructivist learning begins with what learners already know and help them build on that knowledge, then educators must realise what their learners know and think at the beginning of the lesson. Thus, the strategy is for educators to determine the degree of their learners' prior knowledge of geometry. This will assist educators to align teaching with the curriculum so that study units open with learners expressing their assumptions.

- **Assessing learners' learning in the context of teaching**

In traditional teaching, teachers assess learners by grading assignments, from worksheets to examinations, and rating learners' work on the number of wrong and right answers. In contrast, constructivist educators assess learners' learning while they teach to gain insight into learners' understanding as well as the level of cognitive development. The reason for doing this is that educators should be in a position to enhance learners' understanding.

2.2.5 Investigative teaching of geometry

According to Sanni (2007: 40), learning is enhanced by learners' engagement with relevant materials, even if they have certain learning difficulties. According to the researcher, the situated theorist's position is that everybody will learn given an enabling environment to participate in a community of practice. Abraham's learning cycle (in Sanni, 2007:40) is an inquiry-based teaching approach, which is found to be relevant in the investigative teaching of concepts in geometry. The approach is derived from the cognitivist and constructivist position on teaching and knowledge-seeking and it divides instruction into four stages namely:

- **Engage**

The educator creates an enabling environment to engage learners in activities that generate curiosity and interest in the planned topic of the day. Usually an enquiry question is presented to the learners at this stage.

- **Explore**

Learners explore the question raised at the engaged stage and generate answers. At this stage, the learners are placed in groups and the educator acts as a facilitator and usually asks further questions to guide learners' explorations, and provides hints about how to proceed, without showing learners exactly how to go about solving the problem (Stein, Smith, Henningsen and Silver, 2000).

Usually this stage is characterized by a series of questions and introductory activities that are similar to the topic presented in their worksheets.

- **Explain**

Opportunities are provided for learner groups to present solutions or answers to the inquiry question, giving justification and explanations for their claims. Learners disagree in order to agree as members of a group before they come up with a common response to be presented to the majority of class members.

- **Extend**

Learners extend their concepts and skills to other situations by applying what they have learned in the explain stage. Further tasks in which these skills can be exhibited are provided for the learners, in groups, pairs or as individuals.

At each of these stages, and at the end, evaluation of the process would go on simultaneously.

However, according to Sanni (2007:39), the sequence of geometry classroom practices which research has documented to be prevalent in our classrooms entails checking homework, followed by teacher lecture and demonstration, followed in turn by learner practice of classroom instructional activities.

2.2.6 van Hiele Levels of Geometric Thought

Geometric thinking must be developed. Educators' strategies of teaching geometry should be building around the fact that all learners can grow in their geometric skills and understanding.

According to Dossey, Giordano, McCrone and Weir (2002:203), the research of two Dutch educators, Pierre van Hiele and Dina van Hiele-Geldof developed a theory of five levels of geometric thought. The theory describes how learners learn geometry. The five levels provide insight into the differences in geometric thinking and how the differences come to be. This suggests that learners' geometric reasoning skills progress through stages in the ways they reason about geometric objects. The levels are as follows:

- **Level 0: Visual**

The focus at this level is on individual shapes, which the learner is learning to classify by judging their holistic appearance. Learners identify shapes according to appearance (what they look like). They recognize and name figures based on global, descriptive visual characteristics of the figure. Students operating at this level are able to make measurements and even talk about properties of shapes, but these properties are not abstracted from the shapes at hand (Van de Walle, 2004:347). Learners at this level will sort and classify shapes based on their appearance. Simple phrases such as “belong to”, “belong on”, and “belong in” are used to sort out objects according to their relations. The learner should thus be able to recognize the similarities and differences between objects (Seopo-Sengwe, 2003: 7).

- **Level 1: Analytic**

Students characterize shapes by their properties. They are able to consider all shapes within a class rather than a single shape. Instead of talking about this rectangle, it is possible to talk about all rectangles. Students are able to think about what makes a rectangle from properties and the irrelevant features (e.g. size or orientation) fade into the background (Van de Walle, 2004:347). Learners operating at level 1 may be able to list all the properties, squares, rectangles and parallelograms but not see that these are subclasses of one another.

- **Level 2: Informal deduction/Abstract/Relational**

According to Siyepu (2005:3), learners at this level are capable of using “if...then” For example: if the opposite sides of a parallelogram are equal, then the opposite angles are equal. The researcher further argues that there are no formal proofs at this stage. Siyepu (2005)

advocates that at this level, figures are seen to have relationships and order. For example: equal sides of any polygon imply that also angles of the polygon are equal.

- **Level 3: Deductions**

Learners at this stage go beyond just identifying characteristics of shapes and become able to construct proofs using axioms (statements) and definitions (IMAGES,2001:2). Siyepu (2005: 33) highlights that learners at this level can prove theorems without memorising a series of steps and procedures to be followed. According to Jordaan (2003:11), learners can see that a proof can be developed in more than one way.

- **Level 4: Rigor**

Learners at this stage are able to compare and contrast among different axiomatic systems of geometry. They can reason formally about mathematics (Dossey et al., 2002:203), and educators should use individual attention in linking learners' pre-knowledge with what is present.

Van Hiele (in Siyepu, 2005:34) suggested that when teaching geometry, educators should at all times locate each learner's level in a given topic.

2.2.6.1 van Hiele Levels and the National Curriculum Statement (NCS)

The assessment standards for geometry as expressed in the South African National Revised Curriculum Statement (NCS) documents require that learners are able to name shapes, describe and/or classify shapes using properties, and construct shapes correctly in order to attain learning outcome 3 that is relevant to van Hiele level 2, that is, the learner is able to describe and represent the characteristics and relationships between 2-D shapes and 3-D objects in a variety of orientations and positions (Department of Education, 2002a: 6).

The first three van Hiele levels can be related to the assessment standards of the senior phase (Department of Education, 2002a:6). Therefore the exit level outcomes for learners in the senior phase of NCS can be related to the expectations of van Hiele level 2.

2.2.6.2 Researchers using van Hiele Levels

Siyepu (2005:33) used the van Hiele Levels to explore problems encountered by learners in circle geometry. The researcher made use of four van Hiele levels which were visualization, analysis, informal deductions and deduction. The research was based on grade eleven (11) learners in the Eastern Cape. The research was based on construction, measurement, deduction, conceptual understanding and language issues. His findings are as follows:

Construction

Out of 21 learners, two (2) learners knew what construction was.

Measurement

Only one group (with four members) out of five groups was able to measure angles using a protractor.

Deduction

Groups were unable to make conjectures as they did not understand the meaning of the word “conjecture.”

Conceptual Understanding

Learners lacked conceptual understanding. They could not explain what a quadrilateral was. Participants responded in *isiXhosa* several times as their first language was *isiXhosa*. They failed to understand instructions well due to language problems.

Siyepu concluded that learners lacked measuring skills from lower classes and that they were not yet in the van Hiele Level 3. Dossey et al. (2002, 204), concur by alluding to the fact that forward progression through the van Hiele Levels is slow. By the time learners graduate from high school they are at level 2.

2.3 PESTALOZZI'S METHOD

The following are the main points of Pestalozzi's method of teaching derived from his conviction that education is the unfolding of the natural powers and faculties latent in every

human being. According to Pestalozzi (2000:2), teaching methods should be informed by the following:

- **Child centredness:** learners should be allowed to be active participants in their own learning while the teacher takes the role of the facilitator for the effective application of the learner-centred approach in the teaching of mathematics generally and geometry specifically. Learners should not be assigned the role of passive recipients of knowledge, where learners passively sit for the whole duration of the period listening to their teacher without asking questions even about things they do not understand, their main role being notes taking.
- **Direct experience:** The teacher must never teach by words when a child can see, hear or touch an object for himself. Nature can teach the child better than man can do;
- **Activity:** The learner is expected to be continually active in seeing for himself; making and correcting mistakes, describing his observations, analysing objects and satisfying his natural curiosity;
- **Induction:** The learner must observe, learn to express his impressions of concrete objects perceived by the senses and must learn to formulate new generalisations for himself.

Pestalozzi is consistent with constructivist ideas about teaching and learning of geometry specifically. From the constructivist perspective, knowledge is not acquired passively. Learners should be allowed to actively create and direct their own knowledge in order to formulate, through activities new knowledge. Pestalozzi concurs to the idea that the classroom situation should be created in such a way that the climate must be conducive to allow the learners to be actively involved in their learning. In line with OBE, the teaching of geometry should be learner-centred, outcomes based and activity driven.

2.4 STRATEGIES FOR TEACHING GEOMETRY

According to Sanni (2007:39), curriculum reform in South Africa recommends classroom activities where teachers create opportunities and listen to learners. This is achieved when teachers use a variety of teaching methods and allow each learner enough time to ensure that

the curriculum is implemented and the outcomes are achieved. The following strategies are common in South African classrooms (Sanni, 2007: 39):

- **Instructive process**

The strategy applied by educators under an instructive process of teaching involves teachers checking and marking learners' written work on given homework (Sanni, 2007: 39). Learners write answers on the chalkboard in group form or one by one while the educator is signing their books and confirming or denying the correctness of what learners have written. This process is followed by the teacher's lecture and demonstration, followed in turn by learner practice of classroom instructional activities. According to IMAGES (2011:1), in a traditional classroom learners first learn about discrete concepts and procedures such as the perimeter and area of a rectangle. They would then learn how to use the formula $A = L \times W$ to find the area of a rectangle, given its length and width. Learners will later learn about the area of a triangle and how to find the area using the formula. Eventually, learners apply this knowledge to determine the area of a figure composed of a rectangle and triangle.

This strategy of teaching is not in agreement with processes required through OBE which advocates that learners should participate in classroom activities, become more involved in the learning process and take responsibility for their own learning rather than the use of educators' "chalk and talk" method.

- **Inquiry-based Learning**

This is a process where learners' thoughts, opinions and curiosities are recognised by the teacher as well as other learners. The teacher, instead of "chalking and talking", arouses discovery and generalisation of concepts by posing a question that will stimulate participation of learners in a classroom. Learners explore the problem while the educator gives guidance towards reaching conclusions. After responding to the question, learners look for efficient procedures and develop conclusions

○ **Problem Solving**

According to IMAGES (2011:1), problem solving is a process that should permeate the study of mathematics and provide a context in which concepts and skills are learned. The strategy encourages learners to develop and apply a variety of problem solving strategies thus increasing their ability to solve problems. According to Lester (1994:154), the focus on teaching geometrical topics through problem solving is characterised by the teacher “helping” learners construct a deeper understanding of geometrical ideas and processes by engaging them in doing geometry.

The following characteristics of a problem-solving approach include, as mentioned by Lester (1994:154):

- Interactions between learners/learners and teacher/learners;
- Mathematical dialogue and consensus between learners;
- Teachers providing just enough information to establish background of the problem, learners clarifying, interpreting and attempting to construct the solution;
- Teachers accepting right/wrong answers in a non-evaluative way; and
- Teachers guiding, coaching, asking insightful questions and sharing in the process of solving problems.

The National Council of Teachers of Mathematics in IMAGE (2001:1) sees problem solving as a vehicle for learners to construct, evaluate and refine their own theories about mathematics and the theories of others. They believe that presenting a problem and developing the skills needed to solve that problem is more motivational than teaching the skills without a context.

○ **Cooperative Learning**

IMAGES (2001:1) describe cooperative learning as an instructional strategy that provides learners with a well-defined framework from which to learn from each other, it is a team approach where the success of the group depends upon every learner pulling his or her weight. Each member of the team becomes responsible not only for learning what is taught but also for helping teammates learn, thus creating an atmosphere of achievement. At the end

of a task after cooperative learning, all members of a group are expected to understand the task better than when the learner would have been working alone.

As the educator introduces a lesson by posing a question or questions to the class, learners benefit more from working together in small groups in an attempt to answer the posed questions by exploring and discussing ideas. They are then given an opportunity to give a report or conclusions to their classmates in the classroom. This also gives rise for further understanding through discussions from different groups. In this way, cooperative teaching does not only give rise to understanding of academic tasks but also that learners also learn the importance of maintaining group health and harmony and respecting the views of others.

2.5 PREVIOUS RESEARCH ON GEOMETRY TEACHING

The momentum for reform in mathematics education began in the early 1980s. Educators were responding to a “back to basics” cry, a reaction to the “new maths” of the 1960s and 1970s. There was a growing interest in making problem solving a focus of the mathematics curriculum. Studies then and since have constantly shown that deeper approaches to learning are related to higher quality learning outcomes (Marton & Saljo, 1997).

In a phenomenographic study, Trigwell, Prosser and Taylor (1999; 58), identified five qualitative approaches to teaching geometry as follows:

- **A teacher- focused strategy with the intention of transmitting information to learners.**

In this approach the transmission is focused on facts and skills, but not on the relationships between them. The lesson would normally start by correction of homework consisting of textbook exercises on the topic for discussion. Answers will be displayed on the chalkboard and learners will mark their work in silence routinely. A few would ask questions about difficulties with their answers and the educator will answer only those who have asked and thereafter continue to lecture geometry content to learners for the sake of giving another homework (Davis,1997:402).

According to Brodie (2007: 3), many educators believe that if they ask questions and learners provide answers, learners are participating in the lesson. However, many question and answer exchanges are not helpful in developing learners' mathematical thinking and this is because many educators often ask very low-level questions and they ask questions to which they already know the answers (Davis, 2005:3). Sfard (1998) defines a problem as a question which engages someone in searching for a solution. The writer contends that the use of "contrived problems" that appears in textbooks is often merely gimmick. They can become useful problems, but only if adopted by the problem solver for some purpose beyond satisfying an educator's requirement. According to Fennema & Franke (1992), recent research suggests that educator's content knowledge influences classroom instruction and the richness of learners' mathematical experiences.

Teaching of a traditional nature is still happening in our schools. The teaching is dominated by the educator talk with attempts at group work by organising learners into groups but continue with the same traditional problem solving tasks and exercises. This might be as a result of the fact that our schools have educators who were trained in an education system that is pre Outcomes - Based Education (OBE). Knowing that the task of teachers' colleges were to make sure that student teachers were adequately prepared in both mathematics content and in teaching methods, their closure did not help in addressing shortages of mathematics teachers and the development of new strategies in teaching methods that conform to the new curriculum. According to Hazelhurst (2007), only one mathematics educator was produced by the University of Witwatersrand in 2005.

- **A teacher-student interaction strategy with the intention that learners acquire the concept of the discipline.**

According to Trigwell et al. (1999:58), the conceptual change/learner-focused approach is one which has the learner as the focus of activities. To the educator adopting this approach, it matters more what the learner is doing or covering. The educator is the one who encourages self directed learning, who makes time for learners to interact and discuss the problems they encounter, who assesses to reveal conceptual change (not only to judge and rank learners), who provokes debate. The educator raises a lot of time to question learners' ideas, and to develop a conversation with learners during lessons.

- **A learner focused strategy aimed at learners developing their conceptions.**

In this approach learners are facilitated by the educator to discover on their own. Learners are required to evaluate their own ideas and those of others and are also encouraged to make mathematical conjectures and test them and develop their reasoning skills.

2.6 EDUCATORS' ATTITUDE TOWARDS THE TEACHING OF GEOMETRY

According to Combrinck (2003:52), educators' lack of knowledge and experience concerning the implementation of the outcomes-based curriculum became a major obstacle since the introduction of OBE in South Africa. Firstly, some educators of mathematics show a lack of or incomplete understanding of the new practices required (Sanders & Kasalu, 2004). Secondly, some teachers lack the capacity to put some requirement of the NCS into practice. For example, some educators lack the process skills they are meant to be teaching (White, 2003). Their negative attitudes and beliefs concerning OBE also became an obstacle in the way of successful implementation of the curriculum. Thirdly, some teachers have not yet adapted their teaching to comply with the required NCS practices. For example, Rogan (2003), found little evidence of meaningful group work or adequate achievement of outcomes in his Mpumalanga study involving 240 mathematics and science educators.

Lewis (1999), in a study of grade 9 mathematics studies of all grade 9 mathematics educators in one school, found inadequate lesson planning targeting the required NCS changes. Since educators are not well-trained, they experience a lack of confidence with regard to their teaching of geometry. Educators complain that there was a lack of well trained departmental officials to provide them with necessary training for the successful teaching of geometry. Combrinck (2003:54) points out that educators in other countries such as Australia, New Zealand and America, also experience similar challenges with regard to NCS training. The majority of mathematics educators in these countries believe that they neither received sufficient nor adequate training in NCS and the training of how to teach geometry.

In Pennsylvania in the USA, the state legislature only provided a list of learning outcomes, or academic goals learners should achieve. The educators found it difficult to determine how to

structure the teaching and learning environment so that learners would achieve these outcomes (Parkin, 1994:22). Killen (2000:93) points out that the most frustrating experience for educators who are trying to implement new methods of teaching geometry is a lack of information about what they are required to do and how they should go about doing it.

Research conducted by Schulze (2003:7) shows that learners in South Africa reported a willingness to move towards more meaningful teaching and learning approaches. Yet at the same time they seemed to prefer traditional teaching practices for various reasons. If learners do not experience effective learning, educators will be faced with a major challenge. For educators to be able to change their traditional teaching approaches, they require relevant training.

Training should not only focus on curriculum design, but also on the use of multi-media print and the practical implementation of contemporary teaching and learning theories. In-service training should be based on planned activities and practices both within and outside school to develop the professional knowledge, skills, attitudes and performance of professional staff in schools. Its aim should primarily be to develop and improve educators' daily work. This process can continue indefinitely (Mtetwa & Kwari, 2006:512).

2.7 CONCLUSION

The strategy adopted by educators has been shown to be related to their conceptions of teaching (Trigwell et al., 1999: 59). Educators who conceive of learning as information accumulation also conceive of teaching as transmitting information to learners, and approach their teaching in terms of teacher focused strategies. This approach is associated with surface approach to learning.

On the other hand, according to Trigwell et al (1999: 60), those educators who conceive learning as developing and changing learners' conceptions, conceive of teaching in terms of helping learners to develop and change their conceptions and approach their teaching in a student focused way. This approach is associated with a deep approach to learning.

The study of geometry at the senior phase level is the study of two and three dimensional shapes, their properties and their relationships. Geometric shapes model our world, so knowledge of geometry is both useful and important. Abstract geometric objects are used to describe and approximate our physical world. Hence if we can reason about these objects and work with them, whether abstractly or otherwise, we can make sense of the physical world.

The study of geometry and measurement prepares learners to interact with the geometric object and relationships that they will encounter throughout their lives. As students learn to make sense of geometric objects, they develop reasoning skills that will serve them well not only in geometry but their everyday life. Research design and methods are discussed in the next chapter.

CHAPTER 3

RESEARCH DESIGN AND METHODS

3.1 INTRODUCTION

The main purpose of this chapter is to explain the rationale behind the methodology used in this study and also the procedures followed in conducting this research. The chapter further outlines the steps taken, among others, to ensure the validity and reliability of the information.

3.2 RESEARCH DESIGN

According to Floyd and Fowler (2002:166), a research design refers to a plan for selecting subjects or respondents, search sites and data collection procedures to answer the research question(s). The design shows which individuals will be studied and when, where and under which circumstances they will be studied. According to McMillan and Schumacher (1997:166), the goal of a sound research design is to provide results that are judged to be credible.

In order to answer the research question and achieve the aim of the research, a research survey was undertaken. According to White (2003:101), a research survey usually involves collecting data by interviewing a sample of people selected to accurately represent the population under study. Each person in the sample is asked the same series of questions, and responses are then organized so that conclusions can be drawn from them. This information is used to solve a particular problem or to add needed information about the problem. In all, 35 mathematics educators in the senior phase in Moses Kotane West Area Office were invited to participate in the survey. The survey involved collecting information using questionnaires. Interviews and classroom observation were used as qualitative data collection instruments.

3.2.1 Research method

The study uses both qualitative and quantitative approaches. According to White (2003:107), in qualitative research, the researcher interacts with participants during the research. The interaction is in the form of communicating and observing informants over a prolonged period of time. In short, the researcher tries to minimize the distance between him or herself and those

being researched. Qualitative researches become part of the situation, present and past and the phenomenon being studied.

Qualitative research is more concerned with understanding social phenomenon from the perspective of the participants. This happens through the researcher's participation in the daily life activities of those involved in the research. Qualitative research, according to Krathwohl (1998: 706), includes fieldwork and observation from which in-depth interpretation can be made. The researchers use the participants or interview them as collaborators from whom they learn rather than as objects to be held at arm's length. According to Leedy and Ormrod (2005:133), all qualitative approaches have two things in common, namely:

- they focus on the phenomena that occur in natural settings that are in the real world; and
- they involve studying those phenomena in all their complexity.

According to White (2003:80), qualitative research methodologies deal with data that is principally verbal while quantitative methodologies are concerned with data that are principally numerical. Qualitative researchers often use an inductive approach in defining the problems to be studied. Quantitative researchers work on clearly identified problems to add to the findings of the qualitative research. Quantitative methods can, in educational research, be carried out through a variety of instruments for an example tally- tables in which the researcher counts the observation and the achievement test for example to measure cognitive skills, language skills or skills to interpret diagrams (Vos, 2005:231). A questionnaire was used in collecting data for the research. For this study, interviews and observations were conducted as fact finding strategies under qualitative research.

3.2.2 Population

According to McMillan and Schumacher (1997:169), a population is a group of individuals that conform to specific criteria and to which the results of the research are generalised. It is also defined by Matshidiso (2008:198) as a group of interest to the researcher, the group to which the researcher would like the results of the study to be generalised. According to Wiesma (1995:54), an entire population of individuals may be included in a research study but in many educational studies, it is simply not feasible to include all members of the population. The target

population of the research consists of mathematics teachers in the senior phase of schools in the Moses Kotane West Area Office (MKWAO). The number of such schools is 27 with the targeted number of mathematics educators being 35.

3.2.3 Sample and Sampling Procedure

Macmillan and Schumacher (1997:170) define sampling as selection of subjects from the population such that all members of the population have the same probability of being chosen. A sample is a group of subjects or situations selected from a large population. Vos (2005:191) mentions that a sample comprises the elements of the population considered for actual inclusion in the study. A sample can be viewed as a subject of measurement drawn from a population in which researchers are interested.

A simple purposive sampling was used in this study to select subjects from the population. MacMillan and Schumacher (1997:175) remark that in purposive sampling the researcher selects particular elements from the population that will be representative or information about the topic of interest. In purposive sampling, the researcher handpicks cases to be included in the sample on the basis of his/her judgment of typicality (Cohen, Manion and Morrison, 2000). Parkin (1994:169) expresses the view that the logic and power of purposive sampling lies in selecting information rich-cases for in-depth study. Information rich cases are those cases from which one can learn a great deal about issues of central importance. In this way researchers build up a sample that is satisfactory for their specific need.

All 35 mathematics educators in the senior phase schools of MKWAO were requested to respond to the questionnaire. Six educators from the 35 schools were selected for interviews and selection was informed by poor learner performance in geometry in the June examinations of 2010 written at MKWAO. Performance of these learners is very similar to the one learners obtained in March 2010. Another six schools were selected for observation lessons. Educators in these schools were selected based on high, moderate and poor learners' average performance. The researcher used Quarterly Analysis of Results for March and June 2010 to determine the performance of learners in mathematics.

3.3 INSTRUMENTATION

For the purpose of this study a questionnaire, interview and classroom observations were used as instruments for data collection.

3.3.1 Questionnaire

MacMillan & Schumacher (1997:164) state that a questionnaire is the most commonly used instrument for collecting data from a prepared data because a questionnaire

- is economical in terms of money;
- helps the researcher to ensure 100% of returns;
- allows anonymity; and
- is easy to score.

3.3.1.1 Structure of the questionnaire

Since questionnaires are valuable methods of collecting a whole range of data from a larger number of respondents, both closed and open-ended kinds of questions were used. The questionnaire was divided into two sections: Section A containing biographic information and profile and Section B consisting of perceptions of a geometry lesson on content, strategies and in general on assessment and media in the teaching of geometry. The questionnaire is attached as Appendix C.

The questionnaire should contain questions aimed at collecting specific data on a variety of topics. Great care has been taken in the construction of the questionnaire because the measuring instrument has the greatest influence on the reliability of the collected data (Borg, 1997:139).

Closed ended questions used in the study consisted of questions that required the respondents to place a mark, alongside several provided possible answers. According to Cohen et al. (2000:184), closed ended questions facilitate answering through the use of a Likert Scale, making it easy for the researcher to code and classify responses. The respondents were required to answer items by selecting a response category from a four point scale which best reflects their perception and opinions regarding the content of that item. This scale is known as the Likert Scale.

The Likert Scale was used by the researcher to record various degrees of intensity or a range of frequency for certain events and the respondents to indicate agreements or disagreements with statements. An example of a Likert Scale is given below:

Indicate your choice by making use of the following scale;

1= Agree, 2 = Strongly Agree, 3 = Disagree, 4 = Strongly Disagree (Leedy, 1997:201).

Open ended questions require more of the respondents' time and thought. Respondents answer in their own words and give their opinion freely and give reasons for their answers. According to White (2003:130), open ended questions can be used when the researcher would like to see what the respondents view as appropriate answers, allowing the respondents to answer adequately with the amount of detail they prefer and to qualify and clarify their answers.

3.3.1.2 Administration of the questionnaire

The researcher distributed the questionnaires personally to sampled educators. Permission was granted by principals or SMT members to distribute them (See Appendix A). Distributing personally is helpful because:

- It is economical in terms of time;
- The researcher is able to introduce and explain the subject and the purpose of the study to the participant (See Appendix B).
- The researcher is able to answer questions that come from the respondents and give additional clarification for respondents to understand the subject matter.

Respondents were given questionnaires and they filled them in on their own. The researcher then collected the completed questionnaire directly from the sampled schools for analysis after consultation with respondents to determine their readiness.

3.3.2 Interviews

According to Cohen et al. (2000:243), an interview provides access to what is inside a person's head, makes it possible to measure what a person knows (knowledge or information), what a person likes or dislikes (values and preferences) and what a person thinks (attitudes and beliefs).

According to Bell (1998:79), an interview is a conversation between the interviewer and the respondent (interviewee) with the purpose of soliciting certain information from the respondents.

For the purpose of this study, a semi structured interview was used to elicit information from respondents. A semi structured interview yields a great deal of information because it involves direct interaction between individuals. It is flexible in the questioning process and brings high response rate. If the interviewee's responses are brief or incomplete, for example, the interviewer can ask follow up questions, pressing for more details and more clarification. According to Hitchcock and Hughes (1995:111), educational research mostly favours semi-structured interviews.

3.3.2.1 Interview Schedule

The semi-structured interview, consisting of ten open-ended questions, revolves around content, strategies and methods, assessment and media. The interview was conducted in face-to-face situations with one interviewer and one interviewee. The interview had freedom and flexibility since the mode of questioning was directed to suite the occasion and the respondents were accorded the opportunity to ask for further information.

Six mathematics educators in the MKWAO were selected to respond to the interview. The six educators were selected based on geometry results of their learners in the 2010 June examinations. Every interview was conducted at the respondent's workplace where respondents were provided with an interview concern form (See Appendix D). An interview schedule is attached as Appendix E.

The interview's data was recorded with a tape recorder on the basis of its convenience. According to Punch (1998:76), a recorder provides not only a complete and accurate record of the interview, but the interviewer can concentrate on listening without being distracted by trying to write down what is being said. Tape recording ensures that the whole interview is captured and provides complete data for analysis. Permission to use the tape recorder was asked from the respondents well in advance. The recorded information was transcribed and responses were put under themes for analysis (See Appendix F). The duration of the interview differed from one educator to another. This situation was caused by the fact that educators' responses depended on

a number of factors, for example, attitude towards the teaching of geometry and knowledge of OBE principles. The longest interview took approximately 35 minutes. The researcher returned to the participant with the recorded information for further discussions and the recorded information was destroyed thereafter in the presence of the respondent.

3.3.3 OBSERVATION

Leedy and Omrod (2005:145) express the view that in qualitative studies, observations are usually recorded in great details with field notes or video tapes that capture a variety of ways in which people act and interact. According to Macmillan and Schumacher (1997:41), direct observation is an interactive technique of “participating” to some degree in naturally occurring situations over an extended time and writing extensive field notes to describe what occurs. For the purpose of this study direct observation was used. Six educators in six schools were observed in class while teaching learners. Although one lesson for each teacher is presented, more than one classroom observation was carried out. The researcher is a subject advisor whose responsibility it is to do classroom support in order to assist improve mathematics teaching in schools and the recorded information was destroyed thereafter in the presence of the respondent.

3.3.3.1 Direct observation

According to Cohen et al. (2000:104), during direct observation, the researcher is able to take notes of what he hears, sees, experiences and perceives in a particular classroom situation. Direct observations are intentionally unconstructive and free flowing: the researcher shifts focus from one thing to another as new and potentially significant objects and events present themselves. Field notes are the researcher’s records of what has been observed, descriptions of the individuals, the conversations and other interactions as completely as possible.

For this study, the researcher constructed an integrated picture of how educators and learners spend their time in the classroom during a geometry lesson. Direct observations took place at the researcher’s site, namely the classroom, in the sampled school. The researcher observed and described the setting, activities and the way educators expressed strategies of geometry teaching in different classrooms on a checklist.

3.3.3.2 Observation Checklist

Six lessons were observed with an observation checklist in six schools. This was meant to establish what was really taking place in the classrooms. Since the researcher is the subject advisor in this Area Office, the teachers were used to his presence and thus were more relaxed making it possible to collect relevant information for this study. The checklist was used to establish the activities and behaviour of teachers during the observed lessons. The checklist was divided into three sections which mirrored the lesson phases, namely, the introduction of the lesson (basis teaching skills), the lesson presentation (teaching skills reflecting mixed abilities and learner-centred orientation) and the conclusion (general impression) of the lesson. A sample of the checklist is attached as Appendix G.

During the observed lessons, the researcher was introduced to the learners by the participating educator and the researcher informed them of his intentions about his presence and also to get their consent. Notes were also taken during the six observed lessons. The researcher returned to the school to show the participating educator the observation checklist with the intention of discussing the instructional strategies applied during the lesson. According to Lincoln and Guba (2000), this process of validity referred to as member checking, has the advantage of putting the respondent on record as having said or done certain things and having agreed to the correctness of the investigator's record. Classroom transcripts are attached as Appendix H.

3.4 ETHICAL CONSIDERATIONS

According to Miles and Huberman (1994:266), the researcher should make known to the respondents the actual reason for the researcher's presence and intentions and also how the data will be collected and for what purpose it will be used. Permission to conduct the research in the sampled schools was sought from the principals and SMT members of the schools involved.

3.5 ENHANCING VALIDITY THROUGH TRIANGULATION

The use of questionnaire, interview and classroom observation ensures that the information provided is valid. According to Leedy and Omrod (2005:98), validity of a research study is the extent to which its design and the data it yields allows the researcher to draw accurate conclusions about the cause and effect and other relationships within the data. It is also the extent to which its results apply to situations beyond the study itself, the extent to which the conclusions that are drawn can be generalised to other contexts.

Cohen et al. (2000:98) define triangulation as a combination of more than one method of data collection and the advantage of each method complementing each other, thus resulting in a stronger research design and more valid and reliable findings. Triangulation strengthens a study by combining methods, which is, using different kinds of methods or data including using both qualitative and quantitative approaches.

3.6 CONCLUSION

The intention of this chapter is to describe the research design and methods. It was also explained that the study employed both qualitative and quantitative methods of data collection. In this study the researcher used the questionnaire, interview and classroom observation as data collection instruments. The data received was verified and marked by the researcher. In chapter four the collected data is interpreted and the analysis is presented.

CHAPTER 4

DATA ANALYSIS AND INTERPRETATION

4.1 INTRODUCTION

According to Punch (1998:166), data analysis is a process that entails categorising, ordering, manipulating and summarising the data and describing it in meaningful terms. This chapter presents the results of educators' responses to the data collected. Most of the data collected were of a qualitative and quantitative nature. The first part focuses on educators' responses to the questionnaires, followed by interview responses and lastly classroom observation field notes. In order to determine how the participants taught geometry in the senior phase of the GET band, participants' responses to the various items were tabulated in the frequency table. The results emanating from the responses were presented.

A computer-aided statistical analysis was employed. The Statistical Package for Social Sciences 17.0 (SPSS 17.0) programme was used. This programme required one to begin by defining a set of variables to create a number of cases, to perform the analysis and to present one with the requested output. One then instructs it to draw graphs and charts. Once the data has been entered into SPSS, the analysis is run by selecting the data one wishes to run from the menu (Department of Education, 2010:7).

4.2 ANALYSIS OF EDUCATORS' QUESTIONNAIRES

The section that follows highlights the results of the questionnaires that were administered to selected participants on instructional strategies in the teaching of geometry. The results were organised and presented as tables of frequencies and percentages.

4.2.1 Educators’ responses on teaching experience in mathematics

Table 2: Teaching experience in mathematics

	Frequency	%
5 years and below	11	31.4
6-10 yrs.	5	14.3
11-15 yrs.	6	17.1
16-20 yrs.	6	17.1
21 yrs. and above	7	20
Total	35	100

The responses in Table 2 indicate the following about mathematics educators in Moses Kotane West Area Office:

Thirty-one point four percent (31.4%) of the respondents had teaching experience of less than 5 years; 14.3% of the respondents taught for between 6-10 years; 17.1% of the respondents had taught for between 11-15 years; 17.1% of the respondents had taught for between 16-20 years; and 20% of respondents have taught for 21 years and above.

4.2.2 Educators’ responses on highest qualification in mathematics

Table 3 Highest qualification in mathematics

	Frequency	%
Matric without professional qualifications	4	11.4
Professional teaching qualification with mathematics as a major subject	14	40
Professional teaching qualification with mathematics as an ancillary subject	4	11.4
Bachelor’s degree (e.g. B.A, B.Sc. etc.) with mathematics as a major subject	3	8.6
Bachelor’s degree (e.g. B.A, B.Sc. etc.) with mathematics as an ancillary subject	3	8.6
Others (specify)	7	20
Total	35	100

Table 3 reveals that 11.2 % of the respondents taught mathematics without a professional qualification while 40% of the educators had a professional qualification with mathematics as a major subject; 11.4% had a professional qualification with mathematics as an ancillary and 8.6% were graduates with mathematics as a major subject.

4.2.3 Educators' responses on attendance of geometry workshops

Table 4: Geometry workshops attendance

How often do you attend geometry workshops?	Frequency	%
Fortnightly	0	0
Monthly	1	2.9
Quarterly	22	62.9
Does not apply	12	34.3
Total	35	100

The responses in Table 4 indicate that there were no workshops held fortnightly and 2.9% of respondents indicate that they attended on monthly basis. The majority of educators, according to the Table, attended geometry workshops quarterly and 34.3% did not attend any geometry workshops.

Table 5: Officials conducting the workshops

Who usually conducts the workshop ?	Frequency	%
Educators	5	14.3%
Master Teachers	1	2.9%
Subject Advisor	28	80
Non-governmental Organisations	1	1.9
Total	35	100

Table 5 indicates that the number and percentage (80%) of officials who conducted the workshops were subject advisors and 14.3% indicates that educators conducted the

workshops. Non- governmental organisations involved in conducting the workshops account for 1.9%.

Table 6: Sections covered during workshops

Workshops where concentrated on	Frequency	%
Generic	3	8.6%
Content	28	80%
Methods of teaching	4	11.4
Total	35	100

Table 6 above presents information on which specific area the workshops were concentrated on. It reveals that 8.6% of workshops concentrated on generic aspects of the mathematics learning area, 80% of the workshops concentrated on content whereas 11.4% addresses methods related topics.

Table 7: Content aspects usually taught at the workshops

Content in	Frequency	%
Algebra	25	71.4
Geometry	10	28.6
Total	35	100

Table 7 reveals that 71.4% of the respondents stated that algebra was usually discussed at the workshops held for educators. Only 28.6 % of respondents indicated that content topics discussed during workshops were geometry topics.

Table 8: Average number of learners in the classroom

Number of Learners	Frequency	%
1-35	15	42.9
36-70	20	57.1
71 and above	0	0
Total	35	100

Table 8 shows that 42.9% of classrooms had 35 or less learners as the average number whereas the majority of classrooms had between 36 and 70 as the average number

Table 9: Duration of mathematics periods per day per class?

Period duration	Frequency	%
30 minutes	11	31.4
45 minutes	17	48.6
1 hour	7	20
Total	35	100

Table 9 shows that 31.4% of schools allocated 30 minutes of their teaching time to a mathematics period per day and 48.6% of schools allocated 40 minutes. Only 20% of schools followed the requirements of the notional time of 1 hour per period per day as prescribed for mathematics.

Table 10: Sitting arrangement of learners in your classroom

Sitting arrangement	Frequency	%
Individually	2	5.7
Two per desk (in pairs)	17	48.6
Groups	11	31.4
Depending on topic that is taught	5	14.3
Total	35	100

Table 10 presents data regarding sitting arrangement of learners in different classrooms. It revealed that 48.6% of classrooms were arranged in such a way that learners sat in pairs and 31.4% of classrooms accommodated learners sitting in groups. Groups varied between

three to six learners in a group and 14.3% of respondents indicated that they sit learners depending on the topic that is being taught.

4.3 SECTION B: PERCEPTIONS OF A GEOMETRY LESSON

This section provides information on participants’ perceptions of geometry lessons. The data presented represent the opinions of the participants. The templates present data regarding number and percentage of respondents. The data in this study attempted to give insight and understanding on how educators teach geometry.

Table 11: General Questions

	Yes		No	
	f	%	f	%
11.1 Were you as a teacher trainee, trained on how to teach geometry to learners?	24	68.6	11	31.4
11.2 Is time allocated per policy for mathematics on the school time table?	7	20	28	80
11.3 Does each learner have mathematical instruments?	5	14.3	30	85.7
11.4 Does each learner have a mathematics textbook?	13	37.1	22	62.9
11.5 Do you, as an educator, use chalkboard instruments to teach geometry?	32	91.4	3	8.6
11.6 Do you inform learners about the outcomes of your geometry lessons	10	28.6	25	71.4
11.7 Your learners perform better in algebra than in geometry	29	82.9	6	17.1

Item 11.1: Training at college

Item 11.1 indicates that the majority of educators (68.6%) had been trained while at teacher training colleges on how to teach geometry to learners pre – OBE. According to Stols (2006:667), an educator's way of teaching is influenced by the way he or she was taught. The majority of these educators attended teacher training institutions before the introduction of Outcomes- Based Education (OBE) and therefore would time and again resort to using traditional methods of teaching. According to Emanuelsson (1999:28), both teachers and learners had limited knowledge of the new curriculum. Teachers were not well equipped and ready for the actual application of the new education principles and teachers also felt that in-service training received in the form of workshops was insufficient to empower them to apply OBE principles. Not enough OBE training workshops were conducted to allow educators the opportunity to fully understand OBE teaching.

Item 11.2 Allocation of teaching time per period

Item 11.2 points out that the majority of the respondents (80%) did not have enough time on the school time table to teach geometry. From Table 10.8, the majority of educators indicated that they were allocated 45 minutes of mathematics teaching time per day. The standard notional time allocated for teaching during a mathematics period is 1 hour per day (DoE, 2008: 7).

Item 11.3 Learners' mathematical instruments

Eighty-five point seven percent (85.7%) of learners did not have mathematical instruments. According to Sanni (2007:40), learning is enhanced by learners' engagement with relevant material, even when they have certain learning difficulties. This does not happen since most learners do not have mathematical instruments.

Item 11.4 Mathematics textbooks

Item 11.4 indicates that less than fifty percent (37.1%) of learners had mathematics textbooks. According to the Mail and Guardian (2011:12), African learners lack adequate

access to textbooks and where textbooks have been produced, they are not always available to learners in sufficient numbers

Item 11.5 The use of geometric instruments

Item 11.5 shows that the majority of respondents (91.4%) used chalkboard instruments to enhance geometry teaching.

Item 11.6 Information on outcomes of the lesson

The majority of respondents (71.4%) revealed that they did not inform learners about the “business of the day”, indicating to learners what their intentions were as far as that day’s lesson was concerned, 28.6% of the respondents revealed that they informed learners on the expected learning outcomes of the lesson. A learning outcome (LO) is a description of what knowledge, skills and values learners should know, demonstrate and be able to do at the end of the lesson (DoE, 2002a:1).

Item 11.7 Learners' performance in algebra and geometry

Item 11.7 indicates that the majority of respondents (82.9%) agreed that learners in the senior phase of the GET band perform better in algebra than in geometry. Sheil and Kelly (2001) made similar conclusions from studies conducted in 2001 and 2003 respectively. Results of the North West Department of Education research as reflected in the literature also show that learners in the senior phase of the GET band perform very poorly in geometry. Educators interviewed indicated that one of the reasons for the poor results is that, though work schedule and programme of assessment prescribe when geometry should be taught, they skip the part and do it somewhere before the beginning of examinations. Not much is then taught in geometry where educators also do selective teaching. In this case, learners lose marks since they are unable to answer geometry questions.

Table 12: Lesson Procedure

Item description	SA		A		D		SD	
	f	%	f	%	f	%	f	%
12.1 The introduction of lessons should be problem based	5	14.3	24	68.6	6	17.1	0	0
12.2 More examples should be given to learners in assisting them to understand a concept better.	25	71.4	8	22.9	1	2.1	1	2.1
12.3 Educators must connect lessons and the physical world to assist learners to understand geometric concepts better	35	100	0	0	0	0	0	0
12.4 Teaching strategies should allow learners to ask questions.	27	77.1	8	22.9	0	0	0	0
12.5 Teaching strategies should be such that educators allow learners to work on their own.	18	51.4	15	42.9	2	5.7	0	0
12.6 Educators should recognise when learners require assistance.	20	57.1	13	37.1	2	5.7	0	0
12.7 Lesson conclusions should involve going over the lesson again in the form of questions and answers.	22	62.9	12	34.3	1	2.9	0	0

Key: SA = Strongly Agree A = Agree D = Disagree SD = Strongly Disagree

Item 12.1 The introduction of a lesson should be problem based

Item 12.1 indicates that 82.9% of the respondents agreed that the introduction of lessons in geometry should be problem based and 7.1% disagreed. Most educators during the interviews also indicated that problem based approach assists learners in concentrating on the focus of the lesson.

Item 12.2 More examples should be given to learners in assisting them to understand a single concept

More than 90% of the respondents agreed as reflected in Item 12.2 that more than one example should be given to learners to assist them to understand a single concept

Item 12.3 You must connect your lessons and the physical world to assist your learners to understand geometry better.

According to Item 12.3, all the respondents (100%) agree and strongly agree that geometry lessons should be connected to the physical world where learners find themselves in, in order to assist learners to understand geometry better.

Item 12.4 Teaching strategies must allow learners to ask questions.

Item 12.4 shows that all the respondents (100%) agree and strongly agree that teaching strategies should allow learners to ask question. The literature has also indicated that educators see viewpoints of their students as ‘windows into their reasoning’.

Item 12.5 Teaching strategies must allow learners to work on their own.

More than 90% of respondents agreed that geometry lessons should allow learners to work on their own. By so doing educators believe that learning geometry is not separated from doing geometry.

Item 12.6 Teaching strategies should recognise when learners request for help.

The responses in the item indicate that 94.2% of respondents agreed that strategies that educators use in teaching geometry should recognise when learners need assistance from the educator.

Item 12.7 Lesson conclusions should involve going over the lesson again in the form of question and answer.

Item 12 7 shows that 97.2% of respondents were of the opinion that the conclusion of a lesson should involve going over the lesson again in the form of questions and answers.

Table 13: Resources used in the teaching of geometry

	Often		Seldom		Not at all	
Resources	F	%	F	%	F	%
	5	14.3	30	85.7	0	0
Worksheet	14	40	16	45.7	5	14.3
Geometry Charts	13	37.1	13	37.1	9	25.7
Mathematical Instruments	8	22.9	26	74.3	1	2.9
2-D shapes and 3-D shapes	14	40	16	45.7	5	14.3

Only 14.3% of respondents use a textbook as a resource. It can also be deduced from Table 13 that most of the respondents (85.7%) seldom used textbooks as a resource material for teaching. Less than 50% of respondents often used resources such as worksheet (40%), geometry charts (37.1), mathematical instruments (22.9%) and 2-D and 3-D shapes (40).

Table 14 : Strategies followed in presenting geometry lesson.

	Yes		No	
Strategy	F	%	F	%
Telling	30	85.7	5	14.3
Question and Answer	18	51.4	17	48.6
Problem solving	20	57.1	15	42.9
Projects	6	17.1	29	82.9
Research	5	14.3	30	85.7
Group Report	5	14.3	30	85.7

The responses in Table 14 indicated that 85.7% of respondents used telling method in teaching geometry and just above 50% of respondents used question and answer (51.4%)

and problem solving (57.1%) methods. Above 80% of respondents did not use Project (17.1%), research (14.3%) and group report strategies to teach geometry.

4.4 ANALYSIS OF EDUCATORS' INTERVIEW

In the previous chapter the researcher stated that six educators from six schools were interviewed. The following questions were asked during the interview with the participants:

- In your opinion, do you think it is necessary for learners in the senior phase to be taught geometry?
- How do you ensure that learners are taught geometry that is appropriate to their level of understanding?
- How do you select or make sure that the strategy that you use to teach a particular topic is the appropriate one for learners' understanding?
- How do you ensure that learners participate during a geometry lesson?
- What challenges do you experience in teaching geometry?
- How can these challenges be overcome?

The interview transcripts are attached as Appendix F

Item 4.4.1 Necessity for learners to be taught geometry

All interviewed educators (06) indicated that it was necessary for learners in the senior phase to be taught geometry because this would assist the learners to interpret their environment correctly. They agreed that geometry is applicable in learners' everyday experiences, for example, house plans, measurements, units and traffic signs boards. Two educators also indicated that the geometry educators should also show a positive attitude toward the teaching of geometry. They indicated that this would motivate learners to explore the section on their own to show appreciation.

Item 4.4.2 Teaching geometry that is appropriate to learners' understanding

Four out of the six educators interviewed indicated that it is important to use and follow appropriate documents that will guide them on what to teach in geometry. They indicated

that they use policy documents such as work schedule and programme of assessment to look for the relevant learning outcomes which will inform them of the correct assessment standards to be taught. They stated that they also look for relevant everyday experiences in other sources to assist learners to understand concepts better. The other two educators stated that they follow the textbooks they use to teach their learners.

Item 4.4.3 Selection of teaching strategies

Educators differed in their views about the selection of strategies to use in presenting the same topic. Three indicated that they follow what has been written in the textbook exactly as it is to teach their learners. They indicated that this will assist learners when they are revising on their own to “understand” what the educators did with them during the lesson without causing confusion. Two educators indicated that they were informed by learners’ prior knowledge during the introduction of their lessons. One educator stated that the selection of a strategy is informed by a number of factors such as cognitive level of his learners, the environment around the school and resources that can be used to make the lesson presentation understandable to learners.

Item 4.4.4 Learners’ participation

The six educators who participated indicated that they involve learners in their lessons by asking them questions at the beginning of the lesson. Four of the six educators alluded to the fact that they sometimes just continue with the lesson without involving learners because of the poor responses the educators receive from the learners. In responding to the question of learner involvement, one teacher responded by saying “asking them questions is a waste of time because I know they won’t answer”. Two of the six teachers stated that they do not give learners time to discuss on their own during the lesson because in most cases when they do so, learners tend to make noise and they feel that time is limited to allow for such discussions.

Item 4.4.5 Challenges in teaching geometry

The following are challenges mentioned by interviewees:

- The lack of previous knowledge from learners on what they were taught in geometry;
- The lack of understanding of basic concepts by the learners;
- Lack of teaching aids/ resources;
- Work-load. The majority of teachers teach more than four learning areas due to the shortage of teachers. Others teach learning areas which they were not trained to teach. In one school one educator taught all learning areas from grade four to six. In some schools the same teachers have management responsibilities to perform; and
- Over-crowded classrooms.

Item 4.4.6 Suggestions to overcome the challenges

- Educators should attend workshops on how to teach geometry to learners;
- The Department of Education should provide schools with resources;
- The curriculum planners must revisit policies of the department in order to look at possibilities of reducing the work-load prescribed by employing more educators; and
- Revisit educator-learner ratio to improve the Post Provisioning Model. Post Provisioning Model is a formula that the Department of Education uses to provide educators in schools. it is informed mostly by the number of learners in a particular school.

4.5 ANALYSIS OF THE OBSERVATION SCHEDULES

The paragraphs that follow give a detailed analysis of observations that were made in the schools.

Item 4.5.1 Classroom dynamics

In five classes out of six, learners were sitting in groups varying from two learners to ten learners. The intention of grouping these learners together, according to the educators, was to instil in the learners a spirit of working together, helping each other where they struggled. The researcher picked up the fact that these learners did not understand the reasons why

they were sitting in groups. Lack of monitoring these groups, the level of the noise and unconstructed disagreements between the learners in a group made it clear that these groups were arranged for group sake and not to enhance teaching and learning. Surface questions were also asked using the question and answer method by three of the six teachers as a form of involving learners in the learning process and the educator gave answers to those questions in most instances. In one group, learners were writing notes while in the other remaining two groups learners were not concentrating on what the educator was doing. The only available resources which were used by all educators were the textbooks and the chalkboard. Only two of the six educators used extra resources like ruler and a t - square. Only two of the six educators contextualised their lessons. Sanni (2007: 40) remarks that learning is enhanced by learners engagement with relevant material while Pestallozi (2000:2) notes that nature can teach children more than human beings. The remaining four educators used the textbook as the only reference during their teaching. Two educators did not have a lesson plan while one educator had an incomplete lesson plan. The remaining three educators were in possession of their lesson plans.

Item 4.5.2 Structure of the lesson

The researcher observed that educators introduced their lessons in different ways. Teaching in four out of the six lessons observed was teacher-centred. This is supported by the fact that in the four classrooms the educators did not do baseline assessment and did not direct learners by writing down the topic. Though educators asked questions, most learners could not answer the questions and the educators resorted to giving learners those answers and continued to teach without checking whether learners understood their answers. Most lessons were caught up by time such that work which was supposed to have been done in class was given to learners as homework. Two of the six lessons involved learners throughout the lesson since the lessons were based on activities where learners had to discover facts.

Item 4.5.3 Procedure of teaching

In three of the six lessons the educators went straight to the concept of the day without correcting the work that was given to learners as homework. Two of the remaining educators asked learners basic questions and when they could not answer some of those

questions the educator continued to teach. One educator worked directly from the textbook. During some lessons, learners were given the opportunity to work in groups and because of lack of supervision, some learners “pretended” to be solving the problems. Some of the educators referred to the textbook instead of helping struggling groups. Four of the educators reproduced content from the textbook when they were teaching. There was no extra material from other sources which could have enhanced teaching. Three educators used code switching in assisting learners to understand concepts better. The researcher’s observation was that learners understood better where educators used code switching. The advantage of those educators who used code switching is that all learners were Setswana speaking. Adler (2004:10) points out that using English only as a Language of Learning and Teaching (LoLT) in mathematics classrooms in South Africa where English is not the main language of the learners has a negative effect on the learners’ meaning making and problem solving. She sees learners’ main language as a resource for learning mathematics while they develop proficiency in the LoLT. Four out of the six lessons ended abruptly because the period was over while teaching was still taking place. This affected learners’ problem solving by denying them the opportunity to try other methods of solving the problems. Two out of the six educators engaged learners with problems that involved real life situations and all learners were actively involved in trying to find the solution to the problem.

Item 4.5.4 Assessment

It was noticed during observations that the majority of educators did surface assessment. The type of questions that teachers asked were basic questions that did not promote growth and development but were questions that needed reproduction of information from learners. Some questions asked did not assist in preparing them for the lesson. Based on the manner in which the teachers asked questions, it was evident that five out of six teachers did not plan for assessment. It was only in one of the six lessons where the teacher’s assessment invoked discovery.

4.6 Summary

This Chapter gave analysis of data collected.. The presented data were analysed to help answer the questions of this study. From the analysis made, the study’s findings indicated that mathematics teachers in Moses Kotane West Area Office did not teach geometry

according to the requirement of NCS, namely learner-centredness. According to Killen (2003), education that is outcome-based is a learner-centred, results-oriented system founded on the belief that all individuals can learn. Although the teachers did their best, it was evident that they lacked the knowledge and skills to do so in a systematic manner. This lack of knowledge and skills could be attributed to the teachers' poor training by subject supervisors as shown and their misunderstanding of policies. The next chapter presents discussion, conclusion and recommendations.

CHAPTER 5

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

The main objective of this study was to explore the application of instructional strategies in the teaching of geometry in the senior phase in order to recommend those that can be used in Moses Kotane West Area Office by teachers. Discussions in this chapter are based on the analysis of data from responses of teachers to the questionnaire, interviews and observations. Answers to the three major research questions as stated in Chapter 1 are given and are based on teachers' perceptions on the teaching of geometry. Lastly, recommendations are made.

5.2 DISCUSSIONS

Discussions are based on findings from Chapter 4 identified in the instruments and from the analysis of data. In the following paragraphs, an analysis of the research questions is presented. The researcher aimed to answer the following research questions as articulated in Chapter 1 and they were not necessarily intended to set limits on what the study aimed to achieve:

- Which strategies do teachers use in teaching geometry?
- Which challenges do teachers face in teaching geometry to their learners?
- What can be done to improve geometry teaching in schools?

The findings are presented using the following headings:

5.2.1 Strategies that teachers use in the teaching of geometry

In this study, it has been established that educators introduce their lessons in the form of surface questions which do not assist learners but instead involve the reproduction of previous straight forward answers. To these educators, learner centred approach means asking learners questions and moving on with the lesson without tracing their (learners) conceptual understanding. Thus, this implies that educators lack the knowledge and skills of assisting learners to be engaged in lessons in such a way that they are offered opportunities to develop as well as apply independence and flexibility in their thinking.

Findings in this study also indicate that geometry teachers in the Moses Kotane Area Office rely on the usage of textbooks in presenting their lessons. This explains the reason why most of them still use the lecture method, which is teacher centred in presenting their lessons. These educators apply strategies which were used during their teacher training days since the majority of them (54.2%) were trained before the introduction and the training of teachers in the OBE approach. Learners' involvement in the construction of knowledge was very minimal since it was the teacher who was talking most of the time and this led to situations where learners did not listen to the teacher. This encouraged learners to start talking to each other resulting in more reprimand from the teacher. Furthermore, it was found that teachers' workshops were dominated by algebra content knowledge and less was done in geometry content and instructional methods.

According to Van der Walle (2004:366), the teacher must create an interactive learning environment which encourages learners to challenge and negotiate meaning and solutions to geometric problems. The teacher must steer learners' thoughts towards the anticipated outcome through questions. The questions should be open-ended to allow learners to seek and elaborate on their solutions.

5.2.2 Challenges that teachers face in teaching geometry

The following are challenges that emerged during the interviews:

- Lack of different instructional methods in the teaching of geometry;
- Lack of teaching aids/ resources;
- Teacher work-load. The majority of teachers teach more than four learning areas or subjects due to the Post Provisioning Model that is used by the Department of Education to allocate teachers to schools according to the number of learners. Others teach learning areas which they were not trained to teach. In one school one educator taught all learning areas/subjects from grade four to six. In some schools the same teachers have management responsibilities to perform; and
- Over-crowding of classrooms as a deterrent factor in allowing them to assist individual learners.

Respondents were further requested to come up with suggestions regarding how to overcome these challenges. The following are suggestions advanced by respondents:

- Educators should attend workshops and be exposed to different methods for teaching geometry;
- The Department of Education should provide schools with resources, like financial resources so that schools can be in a position to supplement what parents can purchase and educators need to improvise resources where possible;
- Curriculum planners must revisit policies of the department in order to look at possibilities of reducing the work-load; and
- Revisit educator-learner ratio to improve the Post Provisioning Model. Educator posts in schools are determined by the number of learners in that school.

5.3 RECOMMENDATIONS

The following strategies are recommended since they are not only instruments for acquiring skills but they also are practices in which learners can learn how to participate.

Interactive Teaching Methods

Interactive teaching methods are methods of teaching that maximise the interest of learners. Such methods promote learning experiences and hence increase information (IMAGES, 2001:2). These methods recognise the fact that learners learn differently. Some learn through touch and others learn by doing and being involved. The following Chinese proverb gives us a feel of interactive methods: "Tell me and I will forget, show me and I may remember and involve me and I will understand". Interactive methods use various tools like games, simulations and role play in the classroom and are advocated by the following instruction strategies:

○ **Problem-Based Learning**

This is sometimes also called ‘problem first’ approach. In traditional teaching, the teaching strategy in Euclidean geometry was such that teachers gave learners information first about a particular geometric topic and thereafter asked questions concerning the same topic. The teaching material was usually presented to students as a readymade end product of mathematical activity. Hence the strategy does not fit well where learners are expected to take an active part in the development of their mathematical knowledge.

In problem based learning, a particular question will always lead to a conversation in a teaching learning situation that automatically promotes learner participation. By so doing, learners search for solutions. Learning becomes purposeful and self-motivating.

Features for this strategy include initiating learning with an ill structured question, using the question to structure the learning process. An ill structured question is defined as that question which lacks all the information necessary to develop a solution and which does not have a single right way to approach the task of problem solving. In problem based learning the information that students gather for the unit of study is learned for the purpose of solving a problem

○ **Visualisation**

According to Kehoe (1996: 13), visualisation is the ability of learners to draw a mental picture of an activity. The mental picture we indulge in and the ones we regularly think about become a blueprint for our goals. The pictures become real forces that will work for us. It is using your imagination to see yourself in a situation that hasn’t yet happened, picturing yourself having or doing the thing you want and successfully achieving the results you desire. You picture yourself in situations that normally give you difficulty and you see yourself in these situations at ease, confident and performing well. Visualising encourages one to see oneself doing the thing one wants and generates the exact pictures and scenes one wants in one’s mind and allows images and thoughts to come and go without choosing them directly, as long as they show a positive outcome of your goal.

○ Co-operative learning

Co-operative learning as a teaching strategy is more than just group work and it demands some special demands on learners. To use co-operative learning successfully as a teaching strategy, teachers have to prepare to the fullest while it is expected of learners to be disciplined and to think critically and creatively. Co-operative learning is an instructional strategy in which learners work together in small groups to maximize their own learning and the learning of their peers. It is based on the belief that learners of any age or ability can help one another to learn if they are given an opportunity to learn. According to Le Roux et al. (2007:100), for group work to be considered co-operative, five basic requirements are necessary, namely:

- **Positive interdependence:** Learners must know and understand the reason behind their being grouped together and be willing to work with one another.
- **Face-to-face promotive interaction:** All group members should be willing to participate and share information and also have an ear to listen to others' contributions and work under an encouraging atmosphere (Le Roux et al., 2007:100) provide a plausible connection between practice and learning in which learning is constituted as participation in practice and the mediating mechanism is the situated negotiation of meaning in the world.
- **Individual accountability:** All learners within a group should be able to contribute towards the attainment of goals. They must all have the interest or the reason to learn.
- **Appropriate interpersonal skills:** Learners must use these to create a conducive learning environment. Values such as respect, trust and good communication skills are required so that information can be retained and applied well beyond the end of the group meetings.
- **Reflexive learners:** Learners must be able to look back at their combined effort to see whether initial goals are achieved and analyse how well the group functions.

According to Stols (2009), the reason for having learners in co-operative groups is so that learners can be more academically successful as individuals than they would be if they worked alone. Group rewards encourage learners to help one another if the rewards are based on the individual learning of all group members.

Vygotsky's theory of proximal development in Stols (2009) suggests that learners can provide one another with stepping stones or scaffolds for thinking, and this is one reason why learners can learn from one another when they work co-operatively. While the learners are engaged in co-operative learning or as individuals, the teacher walks around the rows of desks observing learners at work, assisting whom she/he identifies as having challenges.

The recommended strategies will need enough implementation time and more dedication by both teachers and learners. The National Department of Education can assist that this goal be achieved by reducing topics that need to be taught in the senior phase. According to Kornhaber (2004:52), lengthy standards in subject areas are often not used in the classroom by teachers. This is because, according to the researcher, human minds, especially those juggling with the diverse tasks present in most classrooms seek far fewer, manageable chunks of information. Only topics that are of outmost relevance in Grade 10 of the Further Education and Training (FET) band should be concentrated on.

5.4 CONCLUSION

This study aimed at exploring instructional strategies that teachers might use to assist learners understand geometry better and improve their conceptual understanding and geometry results. Furthermore, it aimed to provide an in-depth description of the geometry classroom instructional practices as observed in Moses Kotane West Area Office that might have contributed to the low levels of geometric conceptualisation of its learners as reflected in their geometry results. The latter aim was conceived in order to assess what learning opportunities instructional methods currently being used offer learners of geometry.

It is therefore important for teachers to be exposed to instructional strategies which will support learners' involvement in their teaching. The strategies should address the concern of the Department of Education including the fact that learners cannot read, write and numerate at the expected level. According to Ashfield and Prestage (2006: 14), geometry stresses the

use of language more than any part of a mathematics curriculum. In the senior phase, learners should be allowed to read mathematics concepts that are exposed to them in order to know how to pronounce them correctly, some learners might be seeing those words for the first time. This exercise should be followed by learners writing down those words in their note books to add to their comprehension and vocabulary. Learners' acquisition of the correct terminology in school geometry is important for their success in the subject. Mathematical meaning should then be attached and learners should be exposed to conceptual procedures.

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Appendix A

P.O. BOX 2490

MOGWASE

0314

05 AUGUST 2009

THE AREA PROJECT OFFICE MANAGER

MOSES KOTANE WEST APO

PRIVATE BAG X 82110

RUSTENBURG

0300

Dear Sir

PERMISSION TO CONDUCT RESEARCH FOR A MASTERS DEGREE

I am registered for a Masters Degree in Mathematic Education at University of North West. I am engaged in a research project on improving the teaching of geometry in the senior phase (grade 7- 9) of our schools in the Moses Kotane West Project Office.

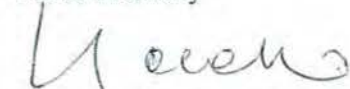
The topic for my research is: An exploration of strategies used in the teaching of geometry in the senior phase of the General Education and Training Band. I have identified schools with senior phase in Moses Kotane West as my population and some from the population will serve as sample for my study.

Please understand that the study involves no invasion of individual rights or privacy, nor will it apply any procedures which may be found ethically objectionable. No personal information regarding those who participate in the research will be made known.

The researcher undertakes to share the outcomes of the study with the office of the APO Manager.

Your attention to this matter is highly appreciated.

Yours faithfully



Kolokoto J.B. - Researcher



Appendix B

CONSENT FROM PARTICIPATION

Dear Participant

I am conducting a research study to comply with the requirements for the M.Ed in Mathematics Education degree with the North West University. I need your participation as the aim of this study is to come up with strategies that will help improve the teaching of geometry in the senior phase. Your input as a mathematics teacher is therefore of the utmost importance.

Your participation might include:

- Filling in of a questionnaire
- Discussing observed lessons conducted by you with the researcher.

Your anonymity is guaranteed as neither your name, nor that of your institution will be mentioned anywhere and all raw material is destroyed after validation and completion of the study.

No remuneration for participating in this study is offered, but I believe that your participation will be of value to you and your school.

I can be contacted at the following telephone numbers:

01455001191(W)

0832602442 (C)

Appendix C

QUESTIONNAIRE ON THE TEACHING OF GEOMETRY- EDUCATORS

Dear Participant

The purpose of this questionnaire is to assess the degree mathematics educators connect with learners in the teaching of geometry so as to identify strategies that can be used to improve its teaching.

INSTRUCTIONS

1. Kindly answer the following questions on the teaching of geometry in the senior phase by making an X where appropriate.
2. Be open, honest and objective in your answers as your answers determine the results of this study and also the recommendations resulting from it.
3. Your anonymity is guaranteed as your name and the name of your school appears nowhere on the questionnaire.
4. Information from this questionnaire will be treated confidentially.

Thank you very much for your valuable input into this study. It is really appreciated

SECTION A: BIOGRAPHIC INFORMATION

1. Teaching experience in mathematics

5 yrs. and below	1
6-10 yrs.	2
11-15 yrs.	3
16-20 yrs.	4
21 yrs and above	5

2. Highest qualification in mathematics

Matric	1
Professional teaching qualification with mathematics as a major	2
Professional teaching qualification with mathematics as an ancillary.	3
Bachelor's degree (e.g. B.A., B.Sc., etc.) with mathematics as a major.	4
Bachelor's degree (e.g. B.A., B.Sc., etc.) with mathematics as an ancillary.	5
Others (specify)	6

3. How often do you attend geometry workshops

Fortnightly	1
Monthly	2
Quarterly	3
Does not apply	4

4. Who usually conducts the workshops?

Educators	1
Master Teachers	2
Subject Advisor	3
Non-Governmental Organisations	4

5. Workshops conducted are mostly concentrated on:

Generic	Content	Method
1	2	3

6. Which content aspects are usually covered at workshops?

Algebra	Geometry
1	2

7. What is the average number of learners in your classroom?

1-35	1
36-40	2
40-50	3
51-60	4
61 and above	5

8. What is the duration of your mathematics period per day?

30 minutes	1
45 minutes	2
1 hour	3
Other (Specify)	4

9. Sitting arrangement of learners in the classroom

Individually	1
Two per desk (pairs)	2
Groups	3
Depending on topic that is taught	4

SECTION B: PERCEPTIONS OF A GEOMETRY LESSON

10. Tick the block which responds to your situation correctly:

Item description	Yes	No
10.1 Were you trained/skilled in how to teach geometry to learners as a teacher trainee?		
10.2 Do you allocate enough time to teach geometry?		
10.3 Does each learner have mathematical instruments?		
10.4 Does each learner have a mathematics textbook?		
10.5 Do you, as an educator, use chalkboard instruments?		
10.6 Do you inform learners of the clear focus of your geometry lessons?		
10.7 Your learners perform better in algebra than in geometry		

11 Answer by making a tick in one of the boxes

1 = Agree; 2 = Strongly Agree; 3 = Disagree, 4 = Strongly Disagree

Item description	1	2	3	4
11.1 The introduction of your lesson should be problem based	1	2	3	4
11.2 More examples should be given to learners in assisting them to understand a single concept.	1	2	3	4
11.3 You must connect your lessons and the physical world to assist your learners to understand geometry better.	1	2	3	4
11.4 Your teaching strategies should allow learners to ask questions	1	2	3	4
11.5 Your teaching strategies allow for learners to work on their own	1	2	3	4
11.6 Your teaching strategies should recognise when learners request for help	1	2	3	4
11.7 Your lesson conclusion should involve going over the lesson again in the form of question and answer	1	2	3	4

12 Tick the following to indicate resources that you often use in the teaching and learning of geometry.

	Often	Seldom	Not at all
Textbook			
Worksheet			
Geometry charts			
Mathematical instruments			
2-D shapes			
3-D shapes			

13. Which strategy do you usually follow in presenting your geometry lesson?

.....

.....

.....

.....

.....

.....

14. What advice will you give to your colleague/s to help him/her/them make the teaching of geometry effective?

Thank you for your support.

Appendix D

Interview Consent Form

In an attempt to improve the teaching of geometry, it is important to listen to educators' thoughts and feelings regarding the use of this instructional methods. Based on the results of the questionnaire completed earlier, you have been identified as an individual who might provide additional relevant information to this study. The researcher is inviting you to participate in a one-on-one interview to be conducted by the researcher. The completion of this interview should take approximately 30 minutes and will be scheduled at a time and venue that is most convenient to you.

Your decision to participate is completely voluntary and comments made during the interviews will in no way affect your grade in this course.

Please note: All records of the content of your interview will be held strictly confidential by the researcher. Even though the researcher asks for permission to tape record the session, individuals will not be identified by name. All raw data will be held by the researcher and will not be distributed to any other unauthorised individuals.

Further information on the research can be obtained from the researcher.

Participant's signature

Researcher's signature

Date

Date

(Adapted from Leedy: 1997, 118).

Appendix E

INTERVIEW SCHEDULE

This interview schedule was used to interview mathematics educators on how they teach geometry.

1. In your opinion, do you think it is necessary for learners in the senior phase to be taught geometry?
2. How do you ensure that learners are taught geometry that is appropriate to their level of understanding?
3. How do you select or make sure that the strategy that you use to teach a particular topic is the appropriate one for learners' understanding?
4. How do you ensure that learners participate during a geometry lesson?
5. What challenges do you experience in teaching geometry?
6. How can these challenges be overcome?

APPENDIX F

INTERVIEW TRANSCRIPTS

Educator 1

TRANSCRIPT
Interviewer: In your opinion, do you think it is necessary for learners in the senior phase to be taught geometry?
Interviewee: Yes they should be taught geometry because it is around them
Interviewer: How do you ensure that learners are taught geometry that is appropriate to their level of understanding?
Interviewee: I use the textbook
Interviewer: How do you select or make sure that the strategy that you use to teach a particular topic is the appropriate one for learners' understanding?
Interviewee: I know my learners. I ask them questions
Interviewer: How do you ensure that learners participate during a geometry lesson?
Interviewee: I ask them questions as and when it is necessary
Interviewer: What challenges do you experience in teaching geometry?
Interviewee: learners seem not to be understanding what they are doing and I don't have geometry teaching aids to make it simple
Interviewer: How can these challenges be overcome?
Interviewee: I give them more exercises

TRANSCRIPT
Interviewer: In your opinion, do you think it is necessary for learners in the senior phase to be taught geometry? Interviewee: Yes because doing geometry is good for carrier choice at university or college.
Interviewer: How do you ensure that learners are taught geometry that is appropriate to their level of understanding? Interviewee: By using the relevant textbook and also doing practical examples.
Interviewer: How do you select or make sure that the strategy that you use to teach a particular topic is the appropriate one for learners' understanding? Interviewee: I usually ask them what they know about the topic we are going to do so that I determine their shortfalls.
Interviewer: How do you ensure that learners participate during a geometry lesson? Interviewee: During the lesson I ask them questions and also give them tasks to do.
Interviewer: What challenges do you experience in teaching geometry? Interviewee: Sometimes some learners do not understand the questions and get confused by the diagrams and I also don't have time to help them because I teach many subjects and the learners are many.
Interviewer: How can these challenges be overcome? Interviewee: by teaching learners about things they are familiar with, doing some tasks with a group so that they can be free to ask their friends and also they must have homework after each lesson

TRANSCRIPT
Interviewer: In your opinion, do you think it is necessary for learners in the senior phase to be taught geometry?
Interviewee: Yes, geometry is a life long process, it teaches learners a variety of reasoning, measurement and constructions which can be used in real life situations.
Interviewer: How do you ensure that learners are taught geometry that is appropriate to their level of understanding?
Interviewee: Through planning, linking with previous knowledge, clarity of assessment
Interviewer: How do you select or make sure that the strategy that you use to teach a particular topic is the appropriate one for learners' understanding?
Interviewee: Curriculum is based on the level of learners that you teach, method of questioning and pre knowledge always give direction
Interviewer: How do you ensure that learners participate during a geometry lesson?
Interviewee: Educators should facilitate learners when they do their work. The educator should also request for feedback from learners and supervision is essential. Avoid laziness from learners.
Interviewer: What challenges do you experience in teaching geometry?
Interviewee: Working conditions not conducive: lack of resources, lack of interest from learners lack of knowledge of geometry, continuous change in curriculum and overloaded educators and there are many learners.
Interviewer: How can these challenges be overcome?
Interviewee: Schools should be well equipped -educators should focus on one learning area -well trained teaches -well organized disciplinary measures -better remuneration and working conditions

TRANSCRIPT
Interviewer: In your opinion, do you think it is necessary for learners in the senior phase to be taught geometry? Interviewee: Yes because this will be taken as the building block of knowledge. Geometry will encourage learners to participate in problem solving. They will have good knowledge of the subject.
Interviewer: How do you ensure that learners are taught geometry that is appropriate to their level of understanding? Interviewee: By confirming the content using the learning programme.
Interviewer: How do you select or make sure that the strategy that you use to teach a particular topic is the appropriate one for learners' understanding? Interviewee: Making sure that you start with simple or easy tasks Questions that suit their knowledge
Interviewer: How do you ensure that learners participate during a geometry lesson? Interviewee: Making sure that they are free and at ease to bring forth their ideas. Motivating them to ask questions
Interviewer: What challenges do you experience in teaching geometry? Interviewee: The learners lack background on the subject . learners not given enough chance to participate in class. I cant help them the are many.
Interviewer: How can these challenges be overcome? Interviewee: After school lessons. Guiding of learners from lower classes on geometry.

TRANSCRIPT
Interviewer: In your opinion, do you think it is necessary for learners in the senior phase to be taught geometry? Interviewee: Yes, it is necessary because they see geometry in their everyday lives
Interviewer: How do you ensure that learners are taught geometry that is appropriate to their level of understanding? Interviewee: By using the work schedule when teaching them so that they do not do something that is above their comprehension. What you teach must progress according to grades.
Interviewer: How do you select or make sure that the strategy that you use to teach a particular topic is the appropriate one for learners' understanding? Interviewee: by using the programme of assessment, work schedule and using the appropriate assessment standards
Interviewer: How do you ensure that learners participate during a geometry lesson? Interviewee: By involving all of them in group work or as individuals.
Interviewer: What challenges do you experience in teaching geometry? Interviewee: Lack of resources and the contexts of the lessons
Interviewer: How can these challenges be overcome? Interviewee: By asking for funds from companies or raising funds in order to buy those resources

TRANSCRIPT	
Interviewer:	In your opinion, do you think it is necessary for learners in the senior phase to be taught geometry?
Interviewee:	It is necessary. In the senior phase, learners get the foundation for geometry in the FET phase. Geometry is also part of their everyday experiences
Interviewer:	How do you ensure that learners are taught geometry that is appropriate to their level of understanding?
Interviewee:	I make use of the policy documents for mathematics, which has Learning outcomes and assessment standards relevant to each grade and therefore relevant to learners in each class I teach.
Interviewer:	How do you select or make sure that the strategy that you use to teach a particular topic is the appropriate one for learners' understanding?
Interviewee:	I consider the context in which they live, their everyday life and try to align my strategy.
Interviewer:	How do you ensure that learners participate during a geometry lesson?
Interviewee:	I use teaching aids and I make sure that they are enough to be seen or used by everyone. I also use learners at times, in making teaching and learning aids.
Interviewer:	What challenges do you experience in teaching geometry?
Interviewee:	In most cases learners do not have the foundation needed for my lessons. I always start with the previous class's content, wasting time for my grade.
Interviewer:	How can these challenges be overcome?
Interviewee:	If teachers in the intermediate phase could teach what is required by the work schedule, this might go a long way to overcome my challenge. according to my observation, most teachers who teach mathematics are not adequately or at times unqualified in mathematics teaching.

Appendix G: Observation Schedule

Item	Observation
4.6.1 Classroom Dynamics	
4.6.1.1 Grouping of learners; strategy used and general classroom dynamics	
4.6.1.2 Learners' involvement in the lesson	
4.6.1.3 Availability of resources	
4.6.1.4 Inclusion of context	
4.6.1.5 Educator planning	
4.6.2. Lesson structure	
4.6.2.1 introduction of lesson	
4.6.2.2 What strategies does the teacher use in introducing the lesson	
4.6.2.3 Content level	
4.6.2.4 Explanation of terms	
4.6.2.5 Problem solving	
4.6.3. Process of teaching	
4.6.3.1 Content delivery; what geometry information does educator provide	
4.6.3.2 Code switching	
4.6.3.3 Is educator succeeding in achieving goals	
4.6.4. Assessment:	
4.6.4.1 Educators' questions to learners	
4.6.4.2 Are learners allowed to ask questions	
4.6.4.3 Educator's response to learners' questions.	
4.6.4.4 Conclusion of the lesson.	

Appendix H

CLASSROOM OBSERVATION

Educator 1

Item	Comments
1. Classroom Dynamics 1.1 Grouping of learners; strategy used and general classroom dynamics	Learners are sitting in groups of six, boys and girls separated. -Most answers to teacher's questions were answered by the same group of learners The teacher concentrated on this group. -The information written on the chalk-board was haphazard.
1.2 Learners' involvement in the lesson	-Through questions and answer method, learners responded to questions. - The learners answer questions in chorus. - The learners answer questions on the chalk board, four at the same time
1.3 Availability of resources	Chalkboard, pencils - T-square used as a ruler, hand-outs - Not all learners have textbooks to refer to. - Not all learners had a set of mathematics instruments
1.4 Inclusion of context	- The corners of the classroom -Learners measure the sides of a classroom to determine its area - Determining the area of other resources in the classroom for an example the area of the chalkboard. - A drawing of a soccer with no scale given field was used as an example

1.5 Educator planning	- Lesson procedure on the lesson plan shows that educator has planned for the lessons.
2. Lesson structure 2.1 Introduction 2.2 What strategies does the teacher use in introducing the lesson	- There was no topic written on the chalkboard and the teaching took place without informing learners about the expected outcomes. - The educator asked all learners to draw a soccer field. Most learners were involved and some learners used pens as rulers. The teacher requested one learner to draw the field on the chalkboard. The learners were requested to measure the sides of the soccer fields they drew and they exchanged their drawings. No scale was given to learners. Some learners did not participate because they had no rulers to measure their drawings with.
2.3 Content level: 2.4 Explanation of terms and processes	- The content was in line with the grade of learners - Some terms were explained by the educator to the whole class and when it was necessary, an explanation was given to individual learners e.g. measuring of angles
2.5 Problem solving	The educator was leading learners in problem solving in the lesson - One group answered almost all the questions asked by the educator. In some questions learners answered in chorus.

3. Process of teaching 3.1 Content delivery; what geometry information does educator provide	- The educator is leading learners towards understanding of procedures - Educator requested learners to talk the correct language of geometry.
3.2 Code switching	- Simple sentences or explanations were done by the educator in both languages(Setswana and English) - Done with learners to understand concepts
3.3 Is educator succeeding in achieving goals	- Procedure and answering of questions by learners indicated achievement and understanding by some few learners though educator was leading to most of the answers.
4. Assessment: 4.1 Educators' questions to learners	- Continuous through lesson - Straight forward questions were directed to learners. - Most questions were verbally answered than written by learners
4.2 Are learners allowed to ask questions	- Yes learners were allowed to ask questions but very few did and they responded to questions from the teacher in chorus
4.3 Educator's response to learners' questions.	- The educator summarised concepts on the chalkboard to cement answers to learners questions
4.4 Conclusion of the lesson	- Problems were given as an exercise on the chalkboard and learners were answering on chalkboard. The learners were given class work /homework and it was dictated to them. - The chalkboard was cleaned before all learners took down notes

Educator 2

Item	Comments
1. Classroom Dynamics	- Learners were sitting individually in rows. The number of learners (15) allowed the educators to involve all of them in the lesson
1.1 Grouping of learners; strategy used and general classroom dynamics	
1.2 Learners' involvement in the lesson	The question and answer method was used by the educator to allow learners to answer questions verbally and were given an opportunity to answer questions on the chalkboard and explained to other learners what it is that they were writing. They were shy to explain.
1.3 Availability of resources	- Chalkboard, - A page was used as a resource to indicate different types of changing positions.
1.4 Inclusion of context	No contextual examples and exercises were given to learners.
1.5 Educator planning	The teacher did not have a lesson plan
2. Lesson structure	Through question and answer method prior knowledge was established from learners.
2.1 Introduction	The majority of learners could not answer the asked questions and the educator had to give them answers.
2.2 What strategies does the teacher use in introducing the lesson	- The topic was written on the chalk board and it was about transformation. The content suited the learners
2.3 Content level	

2.4 Explanation of terms	The following terms were written on the board and the teacher read their meaning from the textbook: transformation, translation, reflection, rotation. Learners were listening to the teacher without participating.
2.5 Problem solving	- Two examples were solved by educator with learners answering questions
3. Process of teaching	
3.1 Content delivery; what geometry information does educator provide	The educator used a rectangular piece of paper in trying to explain the types of transformations taught to learners. The teacher did not allow learners to do as he was doing.
3.2 Code switching	Code switching was not used. The teacher struggled to find relevant words to use.
3.3 Is educator succeeding in achieving goals	After learners had failed to respond to educator questions, educator gave answers to learners using words such as “akere” meaning isn’t it? And the learners answered in chorus with a big “yes sir”.
4. Assessment:	
4.1 Educator’s questions to learners	Most questions were asked by the educator and answered by the educator.
4.2 Are learners allowed to ask questions	- Yes but they did not ask any questions
4.3 Educator’s response to learners’ questions	Since learners did not ask any questions, the teacher did not answer any.
4.4 Conclusion of the lesson	- No summary/ consolidation was done with learners. The period was through before the educator could summarise and give homework to the learners the lesson.

OBSERVATION CHECKLIST

Lesson 3

Item	Comments
1. Classroom Dynamics	
1.2 Grouping of learners; strategy used and general classroom dynamics	Learners were sitting in rows and two shared a desk. Boys were sitting together and the same for girls except in to desks.
1.3 Learners' involvement in the lesson	Not all learners were concentrating on the lesson. This was exposed by the teacher when she was reprimanding some learners.
1.4 Availability of resources	Chalkboard and T-square
1.5 Inclusion of context	Some of the problems that the teacher solve with learners included context
1.6 Educator planning	The lesson plan was available
2. Lesson structure	
2.1 Introduction	- The teacher asked questions on different types of triangles Which lead to the mentioning of a right angled triangle. He assisted learners to derive the Pythagoras theorem using a rope investigating the relationship of the sides.
2.2 What strategies does the teacher use in introducing the lesson	
2.3 Content level:	The teacher explain the properties of the acute ,straight, obtuse, reflection, and right angled triangles
2.4 Explanation of terms	
2.5 Problem solving	The educator uses the equation $x^2 + y^2 = r^2$ in leading learners to solve problems of

	calculating a missing side..
3. Process of teaching	
3.1 Content delivery; what geometry information does educator provide	Educator using the right angled triangle to introduce Pythagoras theorem; early history of Pythagoras, use of rope to tie knots and the introduction of the formula $x^2 + y^2 = r^2$
3.2 Code switching	The teacher used code switching to emphasise concepts during the lesson
3.3 Is educator succeeding in achieving goals	The activeness of the learners indicated that they understood the educator. The learners solved most of the given problems correctly.
4.Assessment:	
4.1 educator's questions to learners	The educator asked questions to learners throughout the lesson which challenged learners to get involved.
4.2 are learners allowed to ask questions	The learners were asking questions were they did not understand
4.3 educator's response to learners' questions	The educator was moving between learners' desks assisting them individually as they were asking questions.
4.4 Conclusion of the lesson	Some learner were writing on the chalkboard without explaining their answers because they wrote at the same time on the chalkboard

Lesson 4

Item	Comments
1. Classroom Dynamics	
1.1 Grouping of learners; strategy used and general classroom dynamics	Learners were sitting in groups of four. Boys and girl were sitting together in all the groups. The educator indicated to the researcher before the lesson that this is an arrangement she prefers when teaching a concept for the first time so that the “group leaders” should assist the learners who are slow in grassping mathematics concepts.
1.2 Learners’ involvement in the lesson	Learners where assisting other learners in their groups after the educator has explained a concept and given an exercise.
1.3 Availability of resources	The educator used the chalkboard to draw a free hand right angled triangle.
1.4 Inclusion of context	No context was included. The teacher gave examples from the textbook using a right angled triangle to calculate for the third side.
1.5 Educator planning	The lesson plan was well constructed.
2. Lesson structure	
2.1 Introduction	The educator drew a right angled triangle on the chalkboard and named the triangle. - The educator did not allow learners to discover information
2.2 What strategies does the teacher use in introducing the lesson	
2.3 Content level:	The educator explained the concept of hypotenuse and introduced the Pythagorus theorem
2.4 Explanation of terms	
2.5 Problem solving	Learners solved problems on calculating a missing side

3. Process of teaching	
3.1 Content delivery; what geometry information does educator provide	After a learner has cleaned the chalkboard the educator drew a right angled triangle on the chalkboard and wrote the equation used to calculate sides on the triangle. The educator introduced and explained the word hypotenuse.
3.2 Code switching	The educator was code switching throughout the lesson.
3.3 Is educator succeeding in achieving goals	Learners were struggling to convert the equation to find the other sides since the examples given were for the calculation of the hypotenuse only.
4.Assessment:	
4.1 educator's questions to learners	The educator's questions were biased since they only involved solving the hypotenuse only.
4.2 are learners allowed to ask questions	Learners were asking questions more especially to their colleagues rather than to the educator.
4.3 educator's response to learners' questions	The educator responded to the few who asked questions and it was the group leaders mostly.
4.4 Conclusion of the lesson	Homework was given to the learners at the end of the lesson from the problems they were expected to solve in the classroom.

Lesson 5

Item	Comments
1. Classroom Dynamics	Learners were grouped together in fours.
1.1 Grouping of learners; strategy used and general classroom dynamics	
1.2 Learners' involvement in the lesson	The involvement of learners was very minimal. The educator did most of the talking
1.3 Availability of resources	The only available teaching resources were the chalkboard and the textbook of the educator. Most learners also had textbooks.
1.4 Inclusion of context	The teacher did not use any context in teaching and in exercises which were given to learners. The impression was that the educator concentrated on problems that he used when he was planning for the lesson.
1.5 Educator planning	The educator relied much on the examples of the textbook as they appeared. The educator time and again referred to the textbook during his teaching. This was an indication that proper planning was not done.
2. Lesson structure	The educator opened his textbook and also requested learners to open on a certain page. Those without books moved away from their desks to share with those who have textbooks. The teacher read the topic
2.1 Introduction	
2.2 What strategies does the teacher use in introducing the lesson	

	from the textbook and moved to write on the chalkboard.
2.3 Content level:	The content of the topic was of the level of the learners because the educator was using the examples of the textbook. The teacher did not explain terms to learners.
2.4 Explanation of terms	
2.5 Problem solving	
2.5 Problem solving	Learners “copied” the examples from their textbooks into their exercise books and were given problems similar to the examples to do as exercises
3. Process of teaching	The textbook and the chalkboard were used as reaching aids. The educator taught area of polygons
3.1 Content delivery; what geometry information does educator provide.	
3.2 Code switching	The educator did not apply code switching.
3.3 Is educator succeeding in achieving goals	Learners copied the examples from the textbook and did exercises referring to them and getting the exercises correct but when asked to explain how they arrived at the answers they could not elaborate. This indicated that there was no conceptual understanding.
4.Assessment:	The educators’ questions were based on surface questioning and the educator was leading the learners to answers, for an example: “the answer is twenty..., twenty... twenty four”.
4.1 Educator’s questions to learners	
4.2 Are learners allowed to ask questions	Yes but very few questions were asked by the learners.
4.3 Educator’s response to learners’ questions	The educator answered learners’ questions without assisting learners to understand how the educator arrived at those answers.
4.4 Conclusion of the lesson	The textbook was used to give learners more problems to solve.

Lesson 6

Item	Comments
1. Classroom Dynamics	
1.1 Grouping of learners; strategy used and general classroom dynamics	Two groups of learners, nine learners in one group and the other group consisting of ten learners. The educator could not explain the reason for arranging learners in this way. Pictures on the walls of the classroom were used as teaching aids.
1.2 Learners' involvement in the lesson	The educator was doing the talking while learners were writing what the teacher was writing on the chalkboard.
1.3 Availability of resources	Pictures with different shapes on the classroom wall, the chalkboard were used as teaching aids.
1.4 Inclusion of context	No context was used to enhance teaching.
1.5 Educator planning	An incomplete lesson plan was available. The lesson plan did not include information on baseline assessment, expected learning outcomes and assessment.
2. Lesson structure	
2.1 introduction	- The topic was written on the chalkboard and it was about triangles. Learners asked to identify triangle in real life
2.2 What strategies does the teacher use in	
2.3 Content level:	The educator asked learners to mention the types of angles they know and explained their meaning as they were mentioned.
2.4 Explanation of terms	

2.5 Problem solving	In solving problems that the educator gave, the group of nine learners was more active than the one consisting of ten learners.
3. Process of teaching	The educator deliberated on concepts that learners could have discover if they were allowed to do so, for an example discovering that the angles of a triangle equals 180° .
3.1 Content delivery; what geometry information does educator provide	
3.2 Code switching	No code switching was practiced, the educator used English. One could read that this is not always the case.
3.3 Is educator succeeding in achieving goals	Partly the educator was succeeding more especially with the group of nine learners.
4.Assessment:	The teacher's questions were based on the lesson.
4.1 educator's questions to learners	
4.2 are learners allowed to ask questions	Learners did not ask questions.
4.3 educator's response to learners' questions	No question was answered by the educator.
4.4 Conclusion of the lesson.	Learners were given work to go and do at home. This might have been caused by the fact that the period came to an end before the educator finished the presented content.