AN EXPLORATION OF TEACHERS' EXPERIENCES IN TEACHING GRADE 10 GEOMETRY WITHIN CURRICULUM AND ASSESSMENT POLICY STATEMENT (CAPS) IN UMBUMBULU CIRCUIT.

BY

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DEDICATION

This work is dedicated

To:

To my son and two daughters: **Nhlakanipho, Sinqobile and Sisanda**

My late father **Moses BhekumndeniNdlovu,**

who was the original sources of my inspiration.

My sister **Phumelele Jane Ndlovu,** who played a parental role in my life.

She looked after us as siblings after the death of our parents, and became the pillar of our strengths.

And

My husband **Khonzokwakhe Welcome Shange**

DECLARATION

I, **Dumazile Sylvia Shange,** declare that this research is my own work. It is being submitted for the Degree of Masters of Curriculum Studies at the University of KwaZulu-Natal, Durban. It has not been submitted before for any degree or examination in any other University.

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(S**ignature of Candidate)**

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Date

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Signature of Supervisor

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Date

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Abbreviation and Acronyms

Abbreviation	Description
AMESA	Association for Mathematics Education of South Africa
C2005	Curriculum 2005
CAPS	Curriculum and Assessment Policy Statements
CNE	Christian National Education
DBE	Department of Basic Education
DoE	Department of Education
FET	Further Education and Training
HOD	Head of Department
ICT	Information and Communication Technology
KPMG	Klynveld, Peat,Marwick and Goedeler
KZNDoE	KwaZulu Natal Department of Education
MRI	Magnetic Resonance Imaging
NCS	National Curriculum Statement
OBE	Outcomes Based Education
OHP	Overhead projector
POA	Programme of Assessment
RNCS	Revised National Curriculum Statement
SAMS	South Africa Mathematical Society
TIE	Technology in Education
TIMMS	Third International Mathematics and Science Study
TOE	Technology of Education
UK	United Kingdom
UNESCO	United Nations Educational Scientific and Cultural Organization
USA	United State of America
WIHIC	What Is Happening In this Class

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ABSTRACT

This is a qualitative case study within an interpretive paradigm of five Grade 10 Mathematics teachers from five different schools in the Umbumbulu circuit who reflected on their experiences of teaching geometry. The teachers are working in Umbumbulu area and are in one cluster where they meet once a term for cluster moderation. As a result of the reflection, reflective activity, semi-structured interviews and focus group interviews were used for data generation to explore these reflections. Purposive and convenience sampling was used in selecting this specific group of teachers because I needed to be involved in Mathematics in order to help in addressing challenges that are facing Mathematics South African teachers in the implementation of CAPS. This study concluded by approving the ten principles that underpin a curriculum with their propositions as curricular spider web. The principles of teaching and learning are presented for discussing the important activities for learning. Therefore, this study mentions the application of ten curricular spider web concepts as the teachers' reflective framework.

CHAPTER ONE

INTRODUCTION AND ORIENTATION TO THE STUDY

1.1 Introduction

Prior to 1994, the South Africa education system was segregated according to the race under Christian National Education (CNE) Chisholm (2003). The boundaries formed by the isolation caused by apartheid created injustices, which led to the need to rebuild and unify the national curriculum. The revision done was trying to restore the unfairness of the past. When democratic government took office in 1994, the education sector saw comprehensive changes because the government wanted to redress the injustices of the past (Carl, 2009). By redressing the injustices of the past, the government wanted to give equal education for all South Africans and restructure the separated nation (Motshekga, 2009). As a result, C2005 was introduced with the hope of changing South African education system to better represent the values of the democratic government. When C2005 was introduced by Minister of Education Sibusiso Bhengu, it was widely criticised by teachers, scholars and teachers' union who argued that the system had failed in other countries, and that it contained concepts such as its critical outcomes, developmental outcomes, learning outcomes that were not clearly explained and learning areas where the integration of subjects was practised. The learning area within Science stream included Mathematics, Technology and Physical Science. Therefore, some aspects were done at the same time and must be linked within each other, it was based on integration (connection of the same topics between these learning area). Those topics were taught using Outcomes Based Education (OBE) approach that focuses on group work, facilitation, and a learner-centeredness to the acquisition of skills. This curriculum was based on the competence curriculum (competence-based education) and on horizontal approach, which means, it uses different theories. According to Bernstein (1999), horizontal approach is the use of multiple approaches and it considers the cultural activities and practices that the school is embedded in. Since there is no specific method to follow, learners were expected to pass (achieve outcomes) because the competence curriculum's main focus is on attainment of the results irrespective of the approach used in order to get those outcomes (Bernstein, 1999).

Eventually, C2005 was reviewed since teachers and scholars had concerned that it included many new terminologies and there was no proper training for the curriculum implementers to implement the curriculum (Motshekga, 2009). The review led to the implementation of National Curriculum Statement (NCS), which was introduced in 2002. It was believed by

curriculum evaluators that NCS had its shortcomings: it had no clear plan of application, and it was developed by the people who established C2005 because teachers had to use the same teaching methods based on outcomes (DoE, 2007). Again, NCS was adapted into the Revised National Curriculum Statement (RNCS), which was introduced in 2007. It was developed but did not produced the satisfactory results. As a result, it was also reviewed and the Revised National Curriculum Statements (RNCS) was developed for Grade R-12 and was introduced in 2002 for 2004. However, scholars criticised the RNCS by claiming that it did not help South Africa to compete on the international level. CAPS was introduced in 2012 by Angie Motshekga to help South Africa to compete with other countries. The introduction was meant to replace RNCS in order to correct the weaknesses of the RNCS and leave those elements that worked well (DoE, 2007). Therefore, CAPS was meant to be based on school knowledge (performance curriculum). Performance curriculum focuses on school knowledge and uses vertical approach to learning. According to Bernstein (1999) vertical approach uses clear logically, ordered plans based on scientifically principles and the structures. The emphasis of those structures is on school knowledge entails by the document that needs to be taught, and what to be acquired by the learners. According to CAPS, the content taught to the learners should promote reasoning skills in order to produce critical thinkers (DoE, 2011).

This chapter intends to briefly introduce the study' rationale, summary of literature review, research questions, research methodology, data generation tools and methods, sampling, data analysis, ethical issues and the layout of the chapters.

1.2 Background in the field of Mathematics

In 1995 and 1999 South African learners took part in the Third International Mathematics and Science Study (TIMMS). The study found that out of the 38 countries who participated in the test, South Africa the performed the most poorly and the language of instruction was found to be the cause of the low performance, most South African pupils are taught in English which is not their mother tongue (Howie, 2003). Therefore, language, socio-economic factors, age and negative attitude were predicted as the factors of poor performance in Mathematics (Howie & Pieterson 2001). Further, to develop mathematical ideals in South Africa Mathematics and Mathematical Literacy were introduced as compulsory subjects. Through this, the government was trying to increase the number of learners who complete secondary education with mathematical reasoning and solving problems capabilities. Learners' performance failing to compete with international countries indicated that learners are unable to use the "school

knowledge and skills learnt in school mathematics in everyday situations" (Howie & Plomp, 2002). Therefore, the focus of the study is on teachers' experiences in teaching geometry.

1.3 Problem statement

My study focuses on the experiences of the Grade 10 Mathematics teachers in black African school, especially those school that do not produce the intended examination results. This problem emanates from the results of the learners in their mid-year and final examination as observed from my experiences as a Mathematics teacher in the FET phase. I am therefore, faced with the challenge of understanding the teachers' experiences of teaching Grade 10 geometry.

1.4 Purpose of the study

The purpose of the study is to explore teachers' experiences in teaching Grade 10 geometry within CAPS. During the implementation of the curriculum, teachers encounter different almost daily, challenges. Exploring their experiences may help to understand those perceptions encountered when implementing the performance curriculum.

1.5 Location of the study

My research project was conducted in a public black African secondary schools that are under-resourced and disadvantaged in the rural area of the Umbumbulu circuit under Umlazi district, in Kwa-Zulu Natal. In these schools, most of the learners use IsiZulu as their home language and come from poor families who lived on social grants as the primary source of income. Furthermore, learners walk long distance to and from schools, which have a negative impact on learners' performance. Changing weather conditions prevented some learners from reaching school due to environmental factors. The use of English as a medium of instruction also contributed to the low level of Mathematics results obtained.

1.6 Rationale

In the past twelve years of my teaching Mathematics in Secondary Schools, I observed the shift of South African curriculum from a competence-based (Curriculum 2005 and Revised National Curriculum Statement (RNCS)) to a performance-based curriculum (Curriculum and Assessment Policy Statement (CAPS)). Competence-based syllabus focuses on everyday knowledge where the learners acquired knowledge from different discipline, whereas the performance syllabus focuses on school knowledge (Hoadley & Jansen, 2012). I observed that

teachers are not producing the intended results in Mathematics paper 2 since CAPS is aimed at producing the learners who can compete with other countries at a macro (national) level and supra (international) level. In the past, examination for Mathematics Paper 3 had been optional but, in CAPS Paper 3 is been included in Paper 2, which means that geometry is taught from Grade 10 as one of the topics within the content. Teachers fear the change, since Paper 3 is no longer optional. The transformation of how the learners are assessed would mean that they should master the content of the competence syllabus in order to have a smooth transition from competence to performance curriculum.

The change of the education system in South Africa has caused confusion to African teachers where they have to use the document without understanding, since they are not given enough training on how to deliver the content of the curriculum (Msibi & Mchunu, 2013). "Once curriculum changes in any educational environment, the way in which teachers see themselves also change" (Fomunyam, 2014, p. 29). The transition of the curriculum would give teachers' perception of their educational experiences. The study conducted by Alex and Mammen (2014) on Grade 10 learners' assessment within CAPS based on the Van Hiele' model of geometrical thinking levels used both qualitative and quantitative research, multiple choice questions followed by structured interview was used as a tool for data generation. While the above study used a mixed approach, I feel there is a need to use a qualitative approach in order to understand better the teachers' experiences while teaching geometry. Therefore, this suggests that there is a need to conduct the study on teachers' experiences using interviews instead of multiple-choice questions.

The study suggested that the curriculum (CAPS) developers and implementers improve the instructional strategies of geometry learning and teaching. In another study conducted by Clausen-May, Jones, McLean, Rowlands, and Carson (2000) geometry curriculum designers experienced difficulty with establishing what is and not to be taught in school-level. Communicating the intended curriculum is challenging, because teachers tend to deliver what is presented to them. Further, CAPS gives the prescribed content to be taught. Another study conducted by Fomunyan (2014) to explore student teachers' experiences of teachers' professional identity used document analyses and semi-structured interview to generate data. The above study use document analysis, which is the secondary source. This study generated data by interviewing teachers in order to explore their experiences in teaching geometry. The use of the mentioned data generation tools may help this study to bridge the gap of using secondary data source by generating data directly from the teachers. Another study by

Mthembu (2007) on the use of instructional approach in Grade 11 Euclidean geometry reveals that it was framed by constructivist's view, this study is framed by curricular spider web as a conceptual framework in order to explore the teachers experiences in teaching Grade 10 geometry. While the above study used Grade 11 Euclidean geometry teachers, the current study used Grade 10 teachers to explore their experiences of teaching geometry.

1.7. Significance of the study

This study may be useful to the curriculum developers, designers, teachers and Department of Education (DoE, 2011) in developing the new abilities, understanding, and may close the gap in the practices faced by mathematics teachers in Grade 10. The teachers' experiences were explored using curricular-spider web as the way of linking the different aspects of the implemented curriculum. The curricular spider-web is the "clarifying way to see the connection between the different aspects of the curriculum" (van den Akker, 2003, p. 11). The current study is framed by curricular spider web, it is used to help the teachers to reveal their daily encounters of teaching geometry and what can be done in order to meet CAPS standard of education to develop critical thinkers who can compete internationally with other countries. In addition, it may be useful to update other mathematics teachers and curriculum developer on the vulnerability of geometry curriculum implementation within CAPS.

1.8 Objectives of the study

- To understand the experiences of Grade 10 teachers in teaching geometry in Umbumbulu circuit.
- To understand the reasons for the teachers' experiences of teaching geometry in Grade 10 in Umbumbulu circuit.

1.9 Research questions

Specifically, the following research questions were addressed.

- What are the Grade 10 teachers' experiences of teaching geometry in Umbumbulu circuit?
- Why do Grade 10 teachers have particular experiences of teaching geometry in Umbumbulu circuit?

1.10 Layout of chapters

Chapter One: Introductory of chapters

This chapter provides the reader with the background of the curriculum in South Africa and the development of the field of Mathematics within a changing education system. The research questions were acknowledged and objectives have been discussed.

Chapter Two: Literature review and conceptual framework

This chapter reviews the literature on teachers' experiences under the three educational levels: technical, practical and critical. The chapter covers the intended curriculum within implemented curriculum and related concepts of the curriculum. The spider web as a conceptual framework was used with propositions to give data for this research.

Chapter Three: Research design and methodology

This chapter provides the reader with research design, methodological approach and strategies used to complete its research objectives. This study used a qualitative case study under an interpretive paradigm to understand teachers' experiences of teaching geometry in Grade 10. Purposive and convenience sampling were used for sampling of the participants. Data were generated using reflective activity, semi-structured and focus group interview. During data generation, trustworthiness, and ethical issues were taken into consideration. Thus, the limitations of the study were taken into considerations.

Chapter Four: Data analysis and discussions

This chapter presents the findings and discussions of the data generated from the case study of five Mathematics Grade 10 teachers in the Umbumbulu circuit. In order to represent the Mathematics teachers' experiences in teaching Grade 10 geometry, data was framed by the curricular spider-web as a conceptual framework. To ensure the accuracy of the empirical data direct quotes from the participants were used during data analysis.

Chapter Five: Summary, conclusions and recommendation

This chapter presents the general aims and objectives of the study to ensure that the findings in the previous chapters address them. Then the research findings were concluded within the

specific research objectives. Thereafter, recommendations were made in reference to the conclusions and research objectives.

1.11 Conclusion

This chapter presents the introductory chapter, background of the study, and research questions the study wants to respond. The study intends to understand teachers' experiences in teaching of geometry and Mathematics as a whole. The study was not intended to judge teachers' experiences in the implementation of the school based knowledge performance curriculum. Also these experiences will bridge the gap of CAPS and RNCS during implementation process. Then, the following chapter discuss the literature review of teachers' experiences in the implementation of geometry curriculum

CHAPTER TWO

LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

2.1 Introduction

This chapter presents the literature review on different studies concerning the teachers' experiences in teaching Grade 10 geometry. Literature review combines different kinds of materials into a meaning of the research and builds arguments and identifies the gaps in the research filed (Cohen, Manion, & Morrison, 2011). Further, Rowley and Slack (2004), state that literature review is the abstract of a particular research questions that underpin the classification of the study. In addition, this chapter defines the aspects on teachers' perception by using three levels of educational experiences. It also reviews literature related to the implementation of intended, implemented, and attained curriculum. Further, this chapter is trying to cover the gaps of the existing studies, reveals areas where research is needed (Webster & Watson, 2002), and review conceptual framework as framed by curriculum concepts: rationale, goals, content, teacher role, learning activities, materials and resources, time, learning environment, assessment and accessibility.

2.2 Description of concepts

Teachers' experiences

Educational experiences are "experimental ground upon which our knowledge is constructed" (Manen, 1977, p. 13). Kardos and Johnson (2010), state that teachers' experiences are the conflict within themselves on the teaching strategies to use, content to teach, resources to use on the design of the lesson that will draw learners' attention, and how to meet the requirements of the standardized tests. This suggests that the differences within the teachers and between the teachers and educational policies can help the teachers to learn from their experiences so that they can reflect on what they have experienced during their teaching processes. Therefore, experiences can enable teachers to change their teaching strategies and select the suitable resources that will best promote learners' interest in the lesson. In addition, Youngs (2007) states that interactions between mentor and mentee, school policies and differences in their opinions are also perception. The way teachers communicate with one another and how they comply with the school policies describes their perception. Further, their perception indicates that teachers have challenges that are related to the insufficient time available to deliver subject content, developing the learners' learning theory, the correct teaching method suitable for the

learners, and how to deliver the content learned in higher education into real-world practice (Spooner, Flowers, Lambert, & Algozzine, 2008).

A survey conducted by Spooner *et al*. (2008) reveal that good communication between the mentor and mentee, school policies and procedures, provide the students with valuable teaching abilities and that their professionalism is further developed. Therefore, teachers' perception is affected by the way the teachers communicate with their colleagues, their management and the curriculum they implement. Experiences can help teachers to learn from their behaviour and use the knowledge learned from their former encounters. In order to explore the previous experiences, teachers' reflection are used by Van Manen (1977) in the form of three levels of experiences: technical, practical and critical experiences.

Technical experiences

In this stage the interest is on the application of knowledge and the approach they use (Van Manen, 1977). In this level, teachers are more concerned with the results of their abilities. Furthermore, Yost, Sentner, and Forlenza-Bailey (2000) argue that technical level is about strategies used in the classroom. Teachers are more concerned with the use of teaching equipment as well as teaching methods when delivering the lesson According to Yost *et al* (2000) teachers are concerned about their daily encounter in terms of teaching methods and the geometrical teaching tools they used in the classroom. This is an indication that relevant teaching method can yield good results even though there are no technical tools available in the school (Yost *et al*., 2000). Therefore, what is happening in the classroom is important for the teachers to reflect on their perception. In addition, the correct use of technical resources will be determined by the teaching method (Yost *et al*., 2000). This suggests that geometry teachers should use teaching methods that will accommodate different learners' abilities. The technical experiences are determined through classroom practical experiences.

Practical experiences

A paper by Van Manen (1977) states that teachers are concerned about the classroom situation. Teachers are concerned about content they teach within the curriculum even though they have little control of it. This is an indication that teachers are more concerned with daily planning and that they fail to think critically to their daily activities because they are more concerned with the theory to use during the teaching process. Their routine is concerned about analysis,

objective, beliefs and measurement of the results (Hatton & Smith, 1995). At this level teachers are concerned about the objective to be obtained (Van Manen, 1977).

In addition, Collier (1999) states that practical experiences define subjective understanding or responsibility that is different from the theory or method used. Practical experiences include the reasoning skills, actions and modification of progress exercises based on how the teaching is conducted (Schön, 1983). This suggests that teachers thinking skills are connected to the way they teach. Therefore, cognitive thinking in geometry is enhanced by the theory chosen by the teachers, and the objectives of the teaching is based on the theory and how teaching is conducted. Therefore, teachers' previous encounters of teaching geometry would help in choosing the theory that will promote the cognitive thinking in geometry of an intended curriculum they are teaching. Practical experiences may help the teachers to develop their critical experiences

Critical experiences

Schön (1983), defines this level as an action where teachers examine their thought by looking back on their achievement and how they got their information. Van Manen (1977), argues that critical experience deals with making conclusion on external factors that might influence classroom exercise, which will include the individual' socio-historical and politico-cultural environment. According to Hatton and Smith (1995), critical experiences includes self – criticism with the aim of improving your practices. The above studies indicate that self-criticism and introspection in educational experience is needed to make sound decisions. Based on the study professional introspection within the socio-political issues is vital to see if the curriculum produces the intended outcomes since the curriculum is affected by political issues (Hoadley & Jansen, 2012). South African education is influenced by the teachers union and ruling political party, since CAPS as an intended curriculum was introduced to rectify the criticism of the C2005, NCS and RNCS. Therefore, teachers' critical experiences on their geometry teaching are needed for classroom practices in order to accommodate learners' social needs and political effects on the curriculum (Van Manen, 1977).

In addition, the paper written by Mezirow (1990, p. 1) on how transformation occurs in adult learning, states that, "to make meaning means to make sense of an experience, and an interpretation of it". The research identifies that meaning comes from the experiences we encounter and the experiences change people. This can mean that experiences of teaching geometry encountered by the teachers can be interpersonal and societal. Fomunyam (2014)

reveals that students explain their curriculum experiences as personal, political and social. This is an indication that teachers should check on how the curriculum relates to their experiences in all spheres of life. According to Fomunyam (2014), personal experiences are the realisation of self-awareness, ideology and subjective experiences that need to be considered when doing introspection. As the school is part of the social context, critical experiences would help in giving a clear picture of what is needed by the society they are embedded in since the intended curriculum relates to societal aspects of teaching

Hence, curriculum is influenced more by politics, because its ideology are political because the curriculum planned and funded by the government, and was introduced after 1994 where the minister of education was trying to address imbalances of the past (Fomunyam, 2014). Therefore, the geometry curriculum that is taught should meet the learners' personal and social needs. Thus, CAPS (2011) was introduced in order to produce the learners that "participate as responsible citizen in the life of local, national and global communities" (DoE, 2011, p. 9). This can be achieved through the use of theory together with their pedagogical experiences when teaching, because existing knowledge can be applied together with theory used in the classroom to give more understanding to different learners (Kirby, 1988). Therefore, teachers' critical experiences of previous syllabus would help to make meaning of the curriculum presented to them for teaching.

2.2.2 Different forms of curriculum

Curriculum is defined as a "plan for learning" (van den Akker, de Boer, Folmer, Kuiper, Letschert, Nieveen & Thijs, 2009, p. 9). This means that it is a combination of intended curriculum as a plan for learning and attained curriculum as their learning (Khoza, 2015). Hoadley and Jansen (2012) define curriculum as the set that prescribe what is to be taught in the classroom. This suggests that what is taught and learned in the classroom must be part in the curriculum. Van den Akker *et al*. (2009) state that curriculum should be differentiated into five levels: Nano (leaner), Micro (teacher), Meso (school), Macro (national) and Supra (international). This can mean that at the Nano level, the curriculum would be the product of the learners focusing on their personal planning and their individual way of learning. The different levels of curriculum indicate that there are role players in any level of the curriculum. The Micro level would mean that the curriculum is the product of the teachers planning for their teaching through the use of materials, modules and textbooks. According to van den Berg (2014) curriculum in this level should be planned, implemented and evaluated in order to make

changes on the planned lessons. Hence, Meso level curriculum would be the product of the school programme and examination programme. Lastly, in the Supra level, the curriculum would be the product of international countries (van den Akker, 2006). This suggests that curriculum should meet the standards of international countries. They further mentioned the three forms of curriculum as the intended (formal), implemented (perceived) and attained (learned). However, Hoadley and Jansen (2012) suggest forms of curriculum as intended (prescribed), enacted (curriculum-in-practise) and implicit (covert and hidden) curriculum. This suggests that curriculum development should be done "with most other actions in education, and must not be done separately, but must be part of continuous processes of planning, implementing and evaluating learning experiences" (van den Berg, 2008, p. 91). This is an indication that curriculum designers should consult all stakeholders when developing the curriculum to be taught in schools.

Hence, curriculum development is the process focusing on the improvement and innovation of education (van den Akker *et al*., 2009). Like many other countries this process started here in South Africa after the 1994 elections. While, this process is ongoing van den Akker *et al*., (2009) emphasise the importance of the core activities which are analysis, design, development, implementation, and evaluation. The article identifies the curriculum development process as important actions, and the process should be reviewed for development to be effective. According to van den Akker (2006) the five activities should happen simultaneously in development of the curriculum. Hence, analysis of the existing curriculum is needed in order to reveals the aims for the anticipated amendments. After the evaluation is done, it will help to check the implementation of the standardized curriculum and indicates the change needed in during the implementation process (van den Akker *et al*., 2009). This suggests that curriculum developers should involve teachers in the process of curriculum development, because they are the ones who communicate the curriculum and what is happening in school is well understood by them (Hoadley & Jansen, 2012).

However, current South African curriculum CAPS (2011) was design following instrumental approach because it emphasises the importance of a systematic design process and it had measurable objectives (van den Akker *et al.*, 2009). Hence, Ayers (1992, p. 259) emphasises that "curriculum is the product of someone else's thought, knowledge, experience, and imagination". Geometry curriculum within CAPS (2011) is an intended curriculum produced nationally to meet international standards.

Intended (formal) curriculum

Intended curriculum assists to directs the teachers with the least information, competency, and principles that the curriculum designers think are significant for the human being and the world (Hoadley & Jansen, 2012). The study indicates that intended curriculum determine the knowledge within the defined school subjects. While, Bantwini (2010, p. 1) reveals that teachers state that an intended curriculum have to "takes place concurrently with other changes in the education system in order for the teacher to have a significant and long-lasting effect". This agrees with Porter, McMaken, Hwang, and Yang (2011) who argue that an intended curriculum should clearly state the common core standards of the curriculum designed. The above studies indicate that curriculum policy should state clearly the ideas and goals that will assist teachers to work according to the ideas and goals of the curriculum. This implies that teachers should be trained before the implementation of the curriculum in order to produce learners that are scientifically literate, and intended to restore the skills needed for science subjects (Bantwini, 2010). Thus, intended curriculum is in line with Tyler's objective approach driven by objectives (Hoadley & Jansen. 2012). The approach is aimed at how those objectives are being obtained, how the school is organised in order to achieve those objectives and to find out if the short goal have been attained (van den Akker *et al*., 2009). This suggests that teachers should teach geometry and promote CAPS by developing spatial skill and solve critical problem (DoE, 2011). Although the intended curriculum clearly states what should be achieved by the learners, it will be impossible for teachers to achieve those objectives if they are not trained to teach the intended curriculum.

Furthermore, Porter *et al*. (2011) state that the content for intended curriculum should clearly indicate what the learners should learn in Mathematics, and how to teach the content. The study indicates that the content of an intended curriculum must be precise in what should be taught, and which teaching strategies is relevant. CAPS (2011) is given to teachers to teach the content and design the lesson according to the documents in a specific time, but it doesn't specify the approach to use. Teachers used the method that work better in the classroom. Therefore, the intended curriculum compels teachers to teach and cover the matter that is going to be set in the common paper, and the intended curriculum focus is on standardised tests (DoE, 2011). In order to meets the standards of the intended curriculum, curriculum development should include "society values, beliefs, norms, religion, customs and other issues that involve cultures"

(Oguzor, 2014, p. 2). Curriculum designers of the intended curriculum should consult and involve all stakeholders during the process to meet the society ethics, and be sensitive to the religion and cultures, since these factors play a vital role in the learners' process of learning (Oguzor, 2014). Then the involvement of all stakeholders in the development of the curriculum will help in developing the school knowledge and improve society, individual and educational needs as well as learners' interest (van den Akker *et al*, 2009). Knowledge and skills of the intended curriculum are being practiced under the implemented curriculum.

Implemented (perceived) curriculum

Implemented curriculum represents "the actual process of teaching and learning" (van den Akker *et al.*, 2009, p. 10). This indicates that the perceived curriculum describes how the intended curriculum is interpreted by teachers, meaning the actual practice during the process of teaching in the classroom. Furthermore, Gvirtz and Beech (2004) state that implemented curriculum is interpreted and communicated by the teachers and also gives equal opportunities to the learners and respects their cultural issues by giving equivalent respect to their social upbringing. For the teachers to be able to interpret the curriculum, professional development needs to be improved. Penuel, Fishman, Yamaguchi, and Gallagher (2007), proclaim that teacher development needs to be detailed than attending one-day workshop where the facilitation, group studies take place. Technical support is important to teachers in order for them to practice the implemented curriculum in their classroom, and teachers' understanding of the curriculum they teach must be in line with skills needed for that curriculum. One of the skills CAPS want to develop from the learners is critical thinking. For the implemented curriculum to be successful, teachers must be trained to explore new ideas and teaching methods in-depth, then the curriculum will be practicable if professional knowledge is given support to accommodate different learners' ability.

As a result, Mathematics teachers must understand the concepts of the intended curriculum together with the implemented curriculum in order to bridge the gap between prescribed and practised curriculum, because they communicate the ideas of the policy through implementation (Gvirt & Beech, 2004). Therefore, Mathematics teachers should teach the geometry that will produce creative and critical thinkers to achieve the principles of the implemented curriculum. Teachers are expected to design the lesson that will be meaningful to the learners and promote the aims and objectives of the curriculum (Chisholm, 2003).

Attained (learned) curriculum

Achieved curriculum is concerned with what is learned between intended and implemented curriculum (Hoadley & Jansen, 2012). This curriculum is divided into implicit and hidden curriculum. Explicit curriculum defines what is official and actually planned. Hence implicit curriculum defines what is learned through the environment exposed and is not officially planned and how an individual perceives the world (Hoadley & Jansen, 2012). Hidden curriculum is questionable, because it teaches outdated and questionable ideas about the world, and teachers are not critical assessed on what they teach. These ideas are often taught as natural and cannot be questioned.

Attained curriculum deals with what the learners had learned that can be used in other educational contexts irrespective of their environment (Howie, Scherman & Venter, 2008). Handal and Herrington (2003), state that the way the learners learn Mathematics in the classroom is influenced by teachers' opinion and their experiences. It is clear that learning outcomes are influenced by what has been taught. The way learners learn is impacted by their teachers' belief, it can be personal or pedagogical experiences. This concurs with Howie *et al.* (2008) arguing that learners who score high marks in English tend to get high score in Mathematics. Teaching Mathematics using English as the medium of instruction helps the leaners to master it easily. That means they have good command of English, since it is used as the medium of communication in many countries. Some African schools use English as medium of instruction, where bilingual learning takes place but learners fail due to socio-economic factors (Benson, 2004). Therefore, economic factors played a vital role in the country's education system. As a developing country, South Africa had changed the curriculum in order to address the imbalances of the past and provide equal education to all South Africans.

2.2.3 Curriculum change in South Africa

Prior to 1994, the South African curriculum was known as the Christian National Education (CNE) under the governing authority (Botha, 2010). When democratic government came to power in 1994, curriculum was revised to address the imbalances of the past caused by apartheid (Chisholm, 2003). Curriculum 2005 was introduced in 1997, then revised in 2000 to the Revised National Curriculum Statement Grade R-9 and then the National Curriculum Statement Grade 10-12 in 2002 (DoE, 2002). Further, the National and Assessment Policy

Statement (2011) was introduced combining the two curriculum into a single policy document known as CAPS (DoE, 2011). The revision of the curriculum caused the shift of the curriculum from competence-based Curriculum 2005 (OBE) and Revised National Curriculum Statement (RNCS) to performance-based curriculum which is Curriculum and Assessment Policy Statement (CAPS).

2.2.4 Looking to the CAPS document for Mathematics in the FET

CAPS was developed as one complete and brief policy for Grade R-12 (Motshekga, 2009). This policy gives a clear guideline on what to teach and how to assess learning for each such grade. As other subjects, the Mathematics document has four sections. Section one contains the background on the development of CAPS and an overview of the NCS and RNCS which led to the development of CAPS. This section describes the purpose and long term goals of the South African curriculum, of equipping the learners to be able to participate as the citizens of the democratic country, as well as principles of changing the community, provide high knowledge and to produce learners who are critical thinkers. It also has instructional time allocated for Grade 10-12. Mathematics is given 4, 5 hours per week. Section two gives the definition of Mathematics as the language of "symbols, notation for explaining numbers, geometric and graphical relationships" (DoE, 2011, p. 8). This suggests that learners should be able to use numbers and interpret data represented graphically. It also clarifies Mathematics long term goals of developing learners' skills of using number system, and mathematical language correctly. This is indication that teachers should design their objectives as based on aims of the national curriculum. It also clarifies the content that needs to be taught and its weighting per grade per term of the year.

Section three gives the specification of the content to "show progression in terms of concepts and skills per grade for each content area, teaching guidelines and time allocated for the topic" (DoE, 2011, p. 11). Lastly, section four has assessment in Mathematics. This section gives the clear definition on assessment and how it should be used. It also gives the different forms of assessment e.g. informal assessment that is used to assess learners' achievement in order to develop learners' learning, and formal assessment that is used as a Programme of Assessment (POA) to promote the learners to the next grade. This section also gives Programme of Assessment to be used by the teachers and cognitive levels as suggested by TIMMS, and the percentage that needs to be achieved by the learners (DoE, 2011). It also states that during examination, learners work obtains 75% of their year mark while remaining 25% comes from

their work during the year. All the assessment given to learners as their POA should be recorded and reported to the parents, school and the department stakeholders. This recording and reporting should be moderated at school, district, provincial and at national level (DoE, 2011).

Furthermore, the above aspects that CAPS has identified as the most important when implementing the curriculum, have been linked with curricular spider web components which are: rationale, goals, content, learning activities, teacher role, resources and materials, time, assessment and accessibility that was used by van den Akker *et al.* (2003, 2006). CAPS see the same aspects as important in the implementation of CAPS, although the document did not mention these aspects as component of the spider web. Linking CAPS with spider web will help the study in understanding the teachers' experiences of teaching geometry, since the document they are using touches all the aspects that were used by van den Akker in curriculum development and implementation. Although the curricular spider web was used for learning by van den Akker (2009), this study will use spider web as the conceptual framework as mentioned in the introduction.

2.2.5 Curricular spider web

Curricular spider web is defined by van den Akker (2003) as the descriptive mode to imagine the connection between the different aspects of the curriculum. Berkvens *et a*l. (2014) and van den Akker *et al*. (2009) describe the spider web as the clarifying approach of looking for the connection amongst various curriculum angles. The teachers' experiences were explored using the spider web concept rationale as the connection concept. Rationale serves as the link between all other curriculum concepts: goals, content, learning activities, teacher role, materials and resources, location, time, assessment and accessibility. This is an indication that teachers' experiences of teaching geometry will help them to understand the educational reasons for teaching geometry within CAPS, and how their lived experiences influence their teaching. The rationale was used to help the teachers to understand their experiences of teaching geometry that will help them to connect with other aspects of the curriculum. Each concept will use proposition to help in understanding teachers' perception in teaching geometry. Hence, this study is framed by curricular spider web concepts with the relevant questions and the quality criteria of the curriculum, and it is shown in Figure 2.1 below.

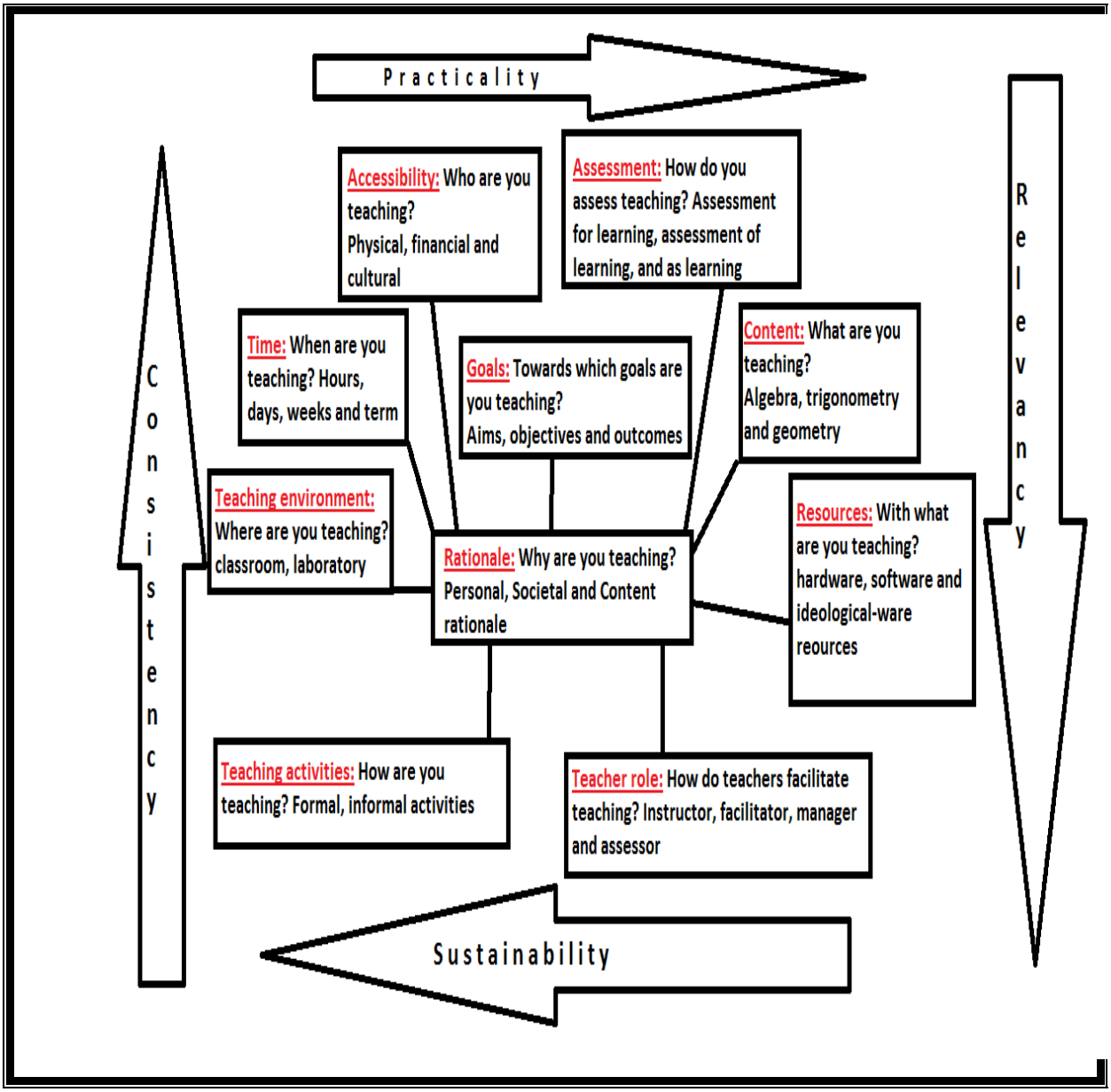


Figure 2.1: Curriculum spider web framework for teachers' experiences (Redrawn from Berkvens, van den Akker and Brugmans, 2014, p. 8)

When Berkvens, van den Akker, and Brugman (2014) look at the susceptibility of the curriculum through spider web concepts (rationale, content, teaching activities, teacher role, learning environment, accessibility and assessment); they added the quality measures of the curriculum which are: relevance, practicality, sustainability and consistency. This was done to evaluation the curriculum through the above measures. The curriculum assessment process is important to see if the curriculum is relevant, consistent, and practical and then evaluation can be done to improve sustainability of the curriculum (van den Akker *et al*., 2009). Therefore, this study will also understand the reasons for teachers' experiences within the quality of CAPS

(2011) using the propositions under the concepts of the spider web. Then the conceptual framework is discussed in the next section.

2.6 Conceptual framework

Within this context**,** concept is defined as "theory that gathers together all isolated pieces of empirical data into a coherent framework of wider applicability" (Cohen et al., 2011, p. 9). On the other hand a study by Rowley and Slack (2004) state that a conceptual framework is the constructive instrument used in promoting an understanding of the meaning of concepts about the phenomena in the research study. The above study identifies that conceptual framework is necessary to generate understanding from the study conducted. According to this, Rowley *et al* (2004) conceptual framework should drive the whole study and give meaning to the finding of current study. Therefore, conceptual framework must communicate theory into practice (Leshem & Trafford, 2007).

To add, on the above studies, Berkvens *et a*l. (2014) at UNESCO reveal that the spider web concepts display the susceptibility of the curriculum, and if there is nothing done until the web breaks, the curriculum will lose its consistency. Hence, the case study by Khoza (2013b) deduce that teachers do not know the theory that underpins subjects in CAPSs. This suggests that spider web concepts are useful in understanding teachers' experiences of teaching geometry within CAPS. The spider web concepts and its propositions are presented in a Table 2.1 below. The table also links the teachers' experiences with the existing studies. Thus, the summary of the existing studies was presented in the table below *(Table 2.1*

Concepts	**Propositions**	**Studies**	**Gaps identified**
Rationale	Personal(pedagogical) Societal(beneficial) Content(studies)	Adler (2005) Ball (2003) Mji and Makgato (2006)	Practiced-based theory of Shulman's notion, the aim of this study is to use spider web. Learners and non-experimental instrument, this

			study will use reflective activity.
Goals	Aims Objectives Outcomes	Anderson (2002) Khoza (2013a) Hargreaves and Moore (2000)	University facilitator Document analysis Priori analysis theory, I will use Grade 10 teachers, curricular spider web as conceptual framework.
Content	Algebra Trigonometry Geometry	Sandt and Niewouldt (2003) Katz (2007) Catoni, Cannata and Zampeti (2005) Mistretta (2002)	Grade 7 teachers Van Hiele as a theory, this study will use Grade 10 teachers.
Learning activities	Face-to-face On-line	Atebe and Schafer (2011) Mthembu (2007) Khoza (2012) Julie and Mbekwa (2005)	Instructional method Video tape and recording to collect data, this study will use reflective activity and interview.
Teacher role	Facilitator Instructor Manager/assessor	Mthembu (2007) Van der Walt and Maree (2007) Mapolela (2003) Weldeana (2008)	Piaget and Vygotsky constructivist view as a theory, in-service teacher,

			observation, this study will use interview and reflective activity with qualified teachers.
Materials/Resources	Hard-ware Soft-ware Ideological-ware	Khoza (2012) Choi-Koh (2010) Mudaly (2004) De Villiers (2010)	Document analysis, observation, secondary school students, Van Hiele theory Experiment with grade 10 learner, this study will use grade 10 teachers and reflective activity as an instrument.
Time	Hours Weeks	Berkvens (2014)	
Learning environment	Inside the classroom On-line learning	Birjlall, Maharajh and Jojo (2006) Aldridge, Fraser and Ntuli (2009) Sipos and Kosztolanyi (2009)	Primary school learners, questionnaire, using of DGS, visualization, this study will use, reflective activity and interviews as a tools.
Assessment	Assessment for learning Assessment of learning	Krathwohl (2002) Smeets (2005)	Blooms Taxonomy, Van Hielle theory,

	Assessment as learning	Vandeyar and Killen (2007) Unal, Jakubowski and Corey (2009) Alex and Mammen (2014)	mixed method using multiple-choice questions, this study will use qualitative method using reflective activity.
Accessibility	Physical Financial Cultural	Atebe and Schafer (2010) Hockman (2005) Setati and Barwell	High learners, stratified and fishbowl sampling, questionnaire and multiple choice question, this will use purposive sampling with reflective activity and interview.

Table 2.1 Summary of existing study framed by curriculum spider web concepts and proposition

Table 2.1 represent the gap between the current study and the existing studies using the spider web components and its proposition. This study is aimed at bridging the identified gaps by exploring teachers' experiences in teaching geometry. The concepts and proposition of the spider web will used to give the clarity on which of the component is given more attention than the others (van den Akker *et al.*, 2009). This suggests that not all of the components are given equal opportunity in the implementation process. According to the spider web, some components are given more attention than the others. Hence, the questions will help to determine from the findings and literature reviewed, on what is experienced by the teachers in teaching Grade 10 geometry. Therefore, the curricular spider web components will be discussed below as mentioned above.

2.7 Rationale of teaching geometry

Van den Akker (2009, p. 12) describe rationale as "the link of connecting the entire curriculum component". In addition, Berkvens *et al*. (2014) state that rationale helps the teachers to understands the reasons of teaching geometry. The following propositions: personal (pedagogical), content (studies) and societal (beneficial) reasons were used as mentioned in the table above. According to the studies, rationale will give good reasons for the teaching of Grade 10 geometry.

2.7.1 Personal (pedagogical) reasons

Berkvens *et al.* (2014) on UNESCO post-2015 education agenda state that content, pedagogy and society are the areas that should be given priority in order to provide a consistent education. Adler (2005), states that teachers teach Mathematics because of interest, irrespective of the skills that enables them to teach Mathematics. This study indicates that learners' performance is influenced by their teachers' attitude and interest towards the teaching of geometry. According to the study, teachers who shows positive attitude towards geometry may gain learners' interest in learning Mathematics especially geometry which seems to be more challenging to the teachers and learners (Ball, 2003). This indicates that teachers with low self-esteem may hinder the learners from producing the intended results. Besides personal reasons to teach Mathematics, some teachers are influenced by society in their teaching of Mathematics.

2.7.2 Societal (beneficial) reasons

Mathematics is taught by teachers who understand Mathematics as a subject, but have little knowledge of geometry, because they are a product of an unfair Apartheid curriculum, and some teachers were taught by the teachers who lack knowledge due to their teachers (Ball, 2003). In addition, some teachers teach geometry because of the qualifications they have, irrespective of the knowledge they have for the content subject (Ball, 2003; Ensor, 2001; Hill *et al*, 2005). The above studies indicate that some teachers experienced challenges when teaching geometry because they were not trained to teach Mathematics, they teach because they understand Mathematics as a subject, or they passed Mathematics at their Senior Certificate level. The above study suggests that qualifications are of concern in teaching geometry, even though the teachers are not able to promote the goals of the intended curriculum. Teachers should learn more about geometry so that they will impart knowledge to

the learners and be able to unpack mathematical knowledge to accommodate learners with different learning abilities (Ball, 2003). According to the studies, teachers teach geometry because they experience the shortage of Mathematics teachers. "Teaching geometry depends on teacher's knowledge of the subject matter" (Ball, 2003, p. 1). This is an indication that teachers should develop their geometrical knowledge in order to teach geometrical content.

2.7.3 Content (studies) reasons

A paper written by Ball (2003) on what mathematical knowledge is needed to teach geometry in the USA, proclaims that teachers need to understand the content and be able to implement curriculum effectively. On the other hand, Mji and Makgato (2006), state that teachers' pedagogical content knowledge may have an influence towards the poor performance in Mathematics. According to Mji and Makgato (2006) teaching geometry depends on the teachers' content knowledge they have. This suggests that teachers' content knowledge helps in developing learners spatial reasoning, make valid reasons about subject management, and class arrangement. (Ball, 2003). When teachers have good understanding of the content, they will be able to use theories that will suit learners' needs, and choosing the relevant theories this would mean that teachers have done critical introspection in their teaching (Ball, 2003)

Jones and Mooney (2003), state that geometrical concepts need to be developed in primary school in order to develop geometrical reasoning at an early stage. According to the study, geometry content should be taught in primary schools to prepare the learners for secondary school levels (Jones & Mooney, 2003). In addition to the above, Brown, Jones, Taylor and Hirst (2004) wrote a paper on how geometrical reasoning is developed in the Secondary school level state that, teaching geometry in secondary levels is about acquiring knowledge, understanding, competent in using geometrical figures' properties and theorems and to develop the use of conjecture, deductive reasoning and proof. The above studies indicate that teaching geometry should develop learners' geometrical needs and solve problems using geometrical ideas. According Brown *et al*. (2004), teachers' experiences in teaching geometry may help the learners to develop geometrical ideas in different contexts that needs mathematical knowledge (Jones & Mooney, 2003).

It is noticeable that teachers and learners are experiencing difficulties with developing geometrical ideas. As a result, teachers are experiencing the problem of learners who chose not to write paper 3 in Mathematics during matriculation examination, because they learners have a fear of geometry (Naidoo, 2011). Paper 3 has been optional for the past years. From 2015

geometry is written as a compulsory paper for all matriculates. This is an indication that under-performance of learners in secondary schools is a concern to the whole country. The pass percentage of previous years by DoE shows that there is huge concern about Mathematics and Science (DoE analysis document, 2008 - 2013). This is the results of fewer student entering the courses that need Mathematics. South African learners performed poorly in both Mathematics and Science. According to Reddy (2005, p. 126) "South Africa is experiencing poor performance in Mathematics"

However, this suggests that teaching as a profession requires qualification and skills to be enable people to teach Mathematics. Those qualifications needed should be in line with the curriculum content that that is to be taught. This implies that teachers should be given courses based on the curriculum they are teaching in order to meet the required outcomes of the given curriculum. The qualification possessed by teachers enables them to be professionals of the subject (Hill *et al.,* 2005). Some educators are Mathematics specialist but they experience the inefficiency of geometry teaching skills, because they were not trained to teach geometry within CAPS. This indicates that teachers can become specialist of the subject content, but lack skills to implement the curriculum in the classroom situation.

Although teachers become specialist through their profession, policy designers must provide support to teachers to improve their mathematical ideas so that learners' mathematical knowledge will improve. Teachers show subject content proficiency through subject content specialisation, qualification, or their equivalent qualification (Hill *et al*., 2005). However, other teachers teach geometry because of curiosity and understanding of subject content, but they encounter challenges on how to deliver the content with understanding to the learners' (Hill *et al*., 2005). Consideration of teachers' qualifications e.g. certificate, diploma, degree they possessed is not important, because the teacher might not have the required skills to teach geometry. Teachers can attain high qualification but lack the required skills for the curriculum or fail to develop learners' geometrical ideas. Teachers' subject content understanding helps the learners to learn with understanding (Ensor, 2001; Hill *et al*., 2005).

Ball *et al*. (2008), state that geometry is relevant if pedagogical content knowledge bridges content knowledge and the practices of teaching. When learned knowledge is put into practice, learners will be able to use school knowledge in solving problems. Teachers have to enquire their proficiency positioned by subject content information, by analysing mathematics instruction and information that will help in evaluating difficulties that begin when teaching

(Ball *et al*., 2008). Once the teachers understand the reasons for teaching geometry in the school curriculum, they may understand the aims/objectives/outcomes for the intended curriculum they are teaching.

2.8 Goals (Towards which goals are they teaching?)

Aims/objectives and outcomes state what is expected from the teacher and the learner at the end of the lesson. Aims are a broad general statement of teaching intention, and objective is usually a specific statement of teaching intention, and outcomes are statements of what a learner is expected to know, understand and/or be able to show after learning (Kennedy, Hyland, & Ryan, 2009). Goals can determine what learners are to learn and can "reflect what society, academic, community or subject group find important" (Berkvens et al., 2014, p. 13). The study indicates that educational goals are important for the teacher and learners during the teaching and learning process. Further, Khoza (2013b) argues that teachers' teaching should be parallel with aims, objectives and outcomes to do fairness to the learners.

2.8.1 Aims

Aims outline learning during teaching, and are long term goals of the subject (Anderson, 2002). Geometry content specific aims to "use spatial skills and properties of shapes and objects to identify, pose and solve problems creatively and critically" (DoE, 2011). From the broad statements of the intended curriculum, teachers should teach geometry to develop reasoning skills in learners. Geometry aims are important because learners would not be able to learn geometry if their spatial skills are not well developed (DoE, 2011). This is an indication that teachers are experiencing the problem of learners who lack spatial skills. The case study by Khoza (2013a) on intended, implemented and attained learning outcomes explained by University facilitators concludes that aims are produced according to teachers' purpose of teaching. The study identifies that teachers separate aims from the learning outcomes of the intended curriculum. According to Khoza (2013a) teachers see the aims as a separate entity from the learning outcomes.

In addition to the above, geometry aims suggest that the learners should be able to classify geometrical figures according to properties and be able to make geometrical proofs with understanding. This concurs with Berkvens *et al.* (2014) when they argue that aims should develop learners' self-esteem, aptitude, unbeatable and be able to pursuit their careers and become life-long learner. Thus, Anderson (2002) state that we must understand what we are

testing and what is covered in the contents in order to understand what is to be achieved, what form of assessment to be used and what content is being tested?

2.8.2 Objectives

"Learning objective is an objective which is formulated in such a way that is clearly spells out the expected learning profits on the part of the learners, in other words that which the learners should be able to do or know at the end of the lesson" (Carl, 2009, p. 91). Objectives are educational standards that establish curriculum, "standards are similar traditional goals, objectives and outcomes" (Solomon, 2009, p. 3). This indicates that objectives are what teachers want to achieve at the end of the lesson. Some teachers design their teaching and put their focus on objectives to be achieved (Krathwohl, 2002). Objectives-driven lesson comes from teacher-centred approach (Khoza, 2013a). While Hoadley and Jansen (2012) state that objectives-driven teaching is in line with Tyler' s approach. The paper by Hytti and O'Gorman (2004) proclaim that policy makers and teachers need to comprehend different and optional aims of education interventions for the curriculum to be effectively implemented. The study identifies aims and objectives as primary goals that need to be understood by policy makers and teachers for the curriculum to be implemented. According to Hytti and O'Gorman (2004) teachers should align the objectives between content, materials and learning activities. The objectives of the teaching rely on the teachers' intention. This suggests that teachers put more attention on objectives as the curriculum is driven by aims, and the focus is on standardised tests set by the department (Engelbrecht & Harding, 2008). Therefore, teachers must teach geometry by understanding the aims of the intended curriculum, because objectives will be set by aims of the intended curriculum (Hytti & O'Gorman, 2004).

When the objectives are properly designed, the learning will be effective. Therefore, teachers experience the use of objectives to test and measure the curriculum's objectives and learners' performance using standardized test. Hence, aims and objectives must demonstrate the outcomes from the learners (Berkvens *et al*., 2014). A paper written by (Giacardi, 2010, p. 5) state that "the main objective for teaching is the development for the power of reasoning but equally to those of intuition, permit the student to discover mathematical truths on his own". The study states that the objective of teaching geometry is to develop learners' insight and allow them to solve geometrical problem on their own. Development of short goal depends on what is being tested from what has been taught and the instruction used. Therefore, objectives should be set in connection with the instructional activities and assessment. (Berkvens *et al*.,

2014). Hence, Brown, Jones, Taylor and Hirst (2004, p. 127) argue that, "objectives develop knowledge and understanding of, and ability to use geometrical properties and theorems and encouraging the development and use of conjecture, deductive reasoning and proofs". Therefore, geometry teachers should design objectives of the lesson that will develop knowledge of geometrical ideas. Aims and objectives are connected to the outcomes.

2.8.3 Outcomes

Outcomes are what the learners can demonstrate in the world as the result of learning process (Hargreaves & Moore, 2000; Kennedy *et al*., 2009). Outcomes-based education in South Africa was introduced to redress the injustices of the apartheid education (Botha, 2010). The study by Khoza (2013a) concludes that facilitators should operate in parallel to aims, objectives and outcomes in order for them to do justice to their students. This suggests that learning outcomes and subject content should be measured according to the topic taught and what it is intended to be learned. According to this study, each module has its own learning outcome to be achieved. This suggests that teachers set learning outcomes according to the module they are teaching, and geometry topic has its own learning outcomes. Those learning outcomes set for assessment should be in line with Blooms' levels of taxonomy namely: knowing, comprehension, application, analysis, synthesis and evaluation (Kennedy *et al*., 2009). The studies suggest that learning outcomes should promote the learners' reasoning skills as a process and be able to apply all the levels of cognitive domain. Geometry should be taught using instructions with action verbs (list, describe and analyse) as the means of getting the learning outcomes (Kennedy *et al.*, 2009), since the learning outcomes are concerned with what the learners can demonstrate as the end product of learning. Teachers should assess knowledge when the learners are able to define and identify, classify and construct, analyse and calculate, summarise and organise, justify and conclude any theorems of geometry.

In addition to the above, the study by Fauzan, Plomp, and Gravemeijer (2013) state that an outcomes is what the learner can demonstrate as the result of what is learnt. This suggests that geometry curriculum developers should consider developing the topic that will produce learners who have geometrical reasoning skills. Thus, curriculum implementers (teachers) must choose geometry ideology that will produce learners who are critical thinkers and be able to solve mathematical problems (Berkvens *et al*., 2014). Teachers should understand the curriculum aim, because the curriculum is taught by the teachers, and outcomes do not work separately with teachers' interpretation of the curriculum (Ball, 2003). However, curriculum

understanding depends on good instructions that come from the materials supplied for the curriculum. The outcomes of geometry are measured as practical when the learners use the Dynamic Geometry Software (DGS) (Gawlick, 2002). Based on CAPS specific skills (DoE, 2011, p. 9) "use of spatial skills and properties of shapes and objects to identify, pose and solve problems creatively and critically", can be achieved successfully if schools are supplied with geometry soft-ware. There is nothing said about how to achieve the outcomes during teaching processes.

Furthermore, Church and Skelton (2010, pp. 1-2) conclude that for education to be sustainable we need to consider "taking a global perspective, including a recognition that issues, people and places are interconnected, how the system operates and think critically and make informed decision". The study suggests that for the curriculum to be sustainable, curriculum designers need to consider world-wide competition, and what is needed for each country's for their education system to be successful. Based on CAPS general aims, where learners are expected to apply knowledge and skills meaningfully in daily lives, teachers are expected to develop active and critical thinking learners. This suggests that CAPS aims/objectives/outcomes are sustainable since there are school that produced 100% Mathematics pass rate.

In addition, Mayer (2002) states that learning outcomes are consistent if the learners are able to use the previous knowledge to solve problems and use that knowledge to apply in a new learning process. Gellert, Jablonka, and Morgan (2010, p. 259) state that "there is a lack of communication between the demands of the university curriculum and students' experiences of school mathematics". The study indicates that teachers experience communication break-down in schools and higher institutions. The study suggests that the aims of the school curriculum should link with the aims of the university curriculum. According to CAPS specific aims to "adapt the learners to advance education and training as well as the world of work" (DoE, 2011, p. 8), suggest that learning should be meaningful to the learners to further their education. For the learners to continue to pursue their studies, teachers should help the learners to develop all the cognitive processes of remembering, retention and transfer (Mayer, 2002). Hence, learning outcomes are measurable and observable; teachers who drive their teaching towards outcomes, promote learner -centred and learners become active (Khoza, 2013a). Teachers should group learners according to their abilities, and learning outcomes should be aligned with the learning activities and assessment methods used (Khoza, 2001). In addition, Khoza (2013a) reveals the three basics of learning outcomes of the curriculum: intended, implemented and attained. The study concludes that aims, objectives and outcomes are

important in any form of curriculum. Although outcomes are measured in different ways: for intended curriculum, outcomes are produced from content to tackle all the levels of Bloom's taxonomy (Kennedy *et al*, 2009), whereas implemented curriculum focus is on aims and objectives since the teaching is based on the teachers' purpose to teach. However, attained curriculum outcomes rely on alignment of the intended curriculum (Khoza, 2013a). This suggests the geometry learning outcomes of the intended is based on the content and should be designed to address Bloom's levels of taxonomy. From the different perspectives of the above studies, the current study would focus on how teachers promote the learning outcomes of geometry CAPS and how promote educational aims are promoted. Aims, objectives and outcomes should be aligned with the content.

2.9 Content (What are they teaching?)

Content should be fair, well arranged and well structured (Carl, 2009). Content is the subject topics that need to be covered and should be at a suitable comprehension level for the peoples it is designed for (Berkvens *et al.,* 2014). Geometry is a vital portion of Mathematics as it will improve learners' thinking (Naidoo, 2011). The study identifies the specified topics as the formation of the content per subject. This suggests that content is made up of different topics specified for that particular subject content.

According to Achor, Imoko, and Ajai (2010, p. 1) "geometry is branch of Mathematics that deals with the measure and properties of points, lines, curves and surface, and forms the building blocks of engineering and technical graphics". Hence, CAPS (2011) geometry content is divided into two discipline: Euclidean geometry and analytical geometry. The prescribed textbooks are used to give the content to be taught in schools which is in line with the CAPS. According to Naidoo (2011) geometry content for Grade 10 involves space, shape and measurement and properties of different geometrical figures. This study emphasise the sub-topic that need to be taught in Grade 10 geometry. According to the study, learners may arrive at the geometric ideas and order of possessing the anticipated outcomes through teachers help (Van der Sandt & Nieuwoudt, 2003). This suggests that teachers should be able to teach learners how to measure, classify geometrical shapes according to its properties and be able to justify geometrical proofs using geometrical ideas. This implies that teachers should be informative on the subject they teach, as geometry is the most vital part of Mathematics teachers should have adequate information to impart to the learners in order to develop their spatial reasoning skills. Furthermore, CAPS Mathematics contents for Grade 10 are as follows:

algebraic expressions, equations and inequalities, exponents, number patterns, functions, finance and growth, trigonometry, analytical geometry, statistics, probability, Euclidean geometry and measurements (DoE, 2011).

2.9.1Algebra

Algebraic reasoning is the use of algebra as the main source of numbers and operation mathematically into classroom practice through arithmetic, functions and modelling (Blanton & Kaput, 2005). The paper written by Katz and Barton (2007) on teaching algebra in secondary school and higher education, reveal that geometry use algebra when calculating the unknown angle or side of a given geometric shape and when solving equations. The study identifies algebra as the mathematical tool that fits in all mathematical topics. According to the above studies, algebra should be taught thoroughly in secondary and higher education institutions in order for the learners to be able to grasp any geometrical topic (Katz & Barton, 2007). The study indicates that the experience of using algebra is found in all geometrical topics taught in schools. This suggests that algebra includes many topics within Secondary Schools' Mathematics, especially: arithmetic and symbols, linear equations, quadratic equations, lateral equations, linear inequalities, number patterns, exponents, factorisation and algebraic expressions (DoE, 2011).

Further, this suggests that algebra is the pillar of all mathematical concepts in the school curriculum. Having difficulties in algebra and geometrical concepts, would mean difficulties in solving geometrical problems using mathematical ideas, (Blanton & Kaput, 2005). Edward and Jones (2006) argued that GeoGebra link geometry and algebra, therefore better understanding is enhanced in learners through the use of this software. The use of GeoGebra gives a greater understanding to geometrical figures and algebra (Edward & Jones, 2006). This indicates that curriculum implementers (teachers) should first understand all algebraic concepts for the intended curriculum in order to achieve the positively attained curriculum aims (Hoadley & Jansen, 2012). Thus algebra can be used in all geometry topics e.g. in understanding trigonometric concepts and its calculations.

2.9.2 Trigonometry

Trigonometry helps in understanding space, shape measurement of angles and length between two points (Engelbrecht & Harding, 2008). A paper written by Catoni, Cannata, and Zampetti (2005) state that Euclidean and trigonometric theorem comes from examining geometry, and

algebra is used when geometrical ideas are lacking in teaching Euclidean trigonometry. The study extended that "Euclidean trigonometry is obtained through elementary geometry observation" (Catoni *et al*., 2005, p. 2). This study indicates that algebra, trigonometry and geometry are related in developing mathematical ideas. This is an indication that algebra, trigonometry and geometry are related in developing spatial ideas. Trigonometry used more of geometrical ideas when solving its problems, numbers are used to represent the Cosine and Sine rules in a Euclidean trigonometry Pythagoras theorem (Birman & Nomizu, 1984). This suggests that teacher use algebra in teaching geometry and geometry in order to develop learners' understanding. Presenting the trigonometric ratios ($\text{Sin } \theta = y/r$) and trigonometric functions ($\text{Cos } \theta = x$) on a Cartesian plane are explained using algebraic equation (Catoni *et al*., 2005). This suggests that algebra forms the basis of mathematics understanding. Therefore, algebra forms the basis of mathematics understanding.

2.9.3 Geometry

Mistretta (2000), argues that geometry is a vital portion in mathematics as it improves learners reasoning skills. Geometry content helped learners in develop visual and spatial reasoning skills. A paper written by Jones (2000) on how to design a suitable geometry curriculum for schools in United Kingdom (UK) states that geometry curriculum designers have a problem on what to add and what to left, and that geometry depends on shape, space, movement and spatial ability. In addition, Jones (2000) wrote a paper on the important concerns in designing geometry curriculum, states that the concerns should be on the character of geometry aims, how geometry is acquired, teaching strategies and which proofs and theorems that needs to be taught. The above studies indicate that geometry should be taught in schools in ways that develops the reasoning skills, visual and spatial ability. This suggests that curriculum designers should designers should design geometry that will be relevant to the learners and all the ideology of the curriculum should be clearly stated in the intended curriculum for implementation (Hoadley & Jansen, 2012). This would help the curriculum implementers to design the learning that will be fruitful to the learners, by selecting the correct theorems and geometrical proofs to be proven by the learners (Jones, 2000). Therefore, geometry should also develop a lower level of recognizing shapes, and classification of shapes according to their properties and to build geometrical models (Panagiotis, 2009). This implies that curriculum implementers should focus on practical rather than theoretical geometric ideas. Furthermore, visual skills are important in teaching geometry as they enable learners to identify the geometrical figures and classifying them according to their properties (Hill *et al*., 2005). This

is an indication that learners who are able to classify geometrical shapes according to their properties will help the teachers in overcoming the difficulties of teaching proof and conjectures in geometry theorems, and when educators are enable to develop geometrical ideas to the learners, mathematical performance in geometry will improve.

According to CAPS, geometry content includes Euclidean geometry where theorems and proofs on triangle, lines different quadrilaterals are done and analytical geometry where distance between the points, and coordinates of the points are calculated of any geometrical figure presented on the Cartesian plane (DoE, 2011). Thus, Giaquinto (2007) states that geometry needs two aspects which are basic geometry ideas and more complicated extraordinary attitudes. This suggests that teachers should see if the learners are able to identify geometrical figures and evaluate if the learners are able to define the lines, triangles and quadrilaterals according to their properties, and if they are able to represent the geometrical figures on a Cartesian plane. Learners should be able to calculate the distance between the two points, solve problems and make conclusion by proofs on theorems of triangles, quadrilaterals and parallel lines.

However, the vision of the Department of Education is of a South Africa where all people have access to lifelong learning and access to education. Geometry should be relevant to the society or to the individual learner to be productive, otherwise there will be no mathematical discipline in higher education phase (Rowlands & Carson, 2002). Geometry content is practicable to all South Africans, since the document is available in schools and teachers are teaching the same content. However, Mji and Makgato (2006) state that there are factors that contribute to teachers' experiences which are teaching strategies, content knowledge and understanding, motivation and interest, laboratory and syllabus non-completion, parental role and language. This is an indication that teachers are experiencing difficulties in teaching geometry due to different factors that are related to their teaching. External factors can hinder curriculum implementers to implement the intended curriculum in a way that will yield the intended outcomes (Hoadley & Jansen, 2012).

However, for geometry content to be sustainable the department needs to address historical imbalances in South African education, by improving the quality and accessibility of Mathematics education, giving educators vocational workshops, and in-service training for educators, and by providing learning materials (James, Naidoo, & Benson, 2008). Once the

teachers have deeper understanding of the content, they will be able to design the learning activities and plan the lesson in an interesting way.

2.10 Learning activities (How are they teaching?)

Learning activities are class activity, projects, group discussions, assignments and presentations designed for the learners. Therefore, teaching should be part of active learning activities (Berkvens *et al*., 2014). The case study by Khoza (2013a) states that teaching activities represent the way the teaching is facilitated, and that learning activities are unstructured and structured. This means that designing teaching by using different teaching activities is needed in order to accommodate to learners' needs. Hence, teachers who experience the use of unstructured teaching activities promote learners' reasoning skills and abilities. Therefore, learners become active participants, and teachers avoid using structured learning activities because it needs more time to prepare. This suggests that it is important for the teachers to use different teaching activities.

Teaching activities are used during the teaching and learning process where the lesson should be designed in different ways which are: group activity, teacher led activity and whole class activity (Mercer & Sams, 2006). This implies that teachers should experience the use of different teaching design that will be of interest during teaching. Using different forms of teaching activities will help to draw learners' attention and participation during the teaching process. Further, a qualitative study by Atebe and Schäfer (2011) on the use of instructional activities proclaims that the experiences of using instructional methods in geometry classrooms gives the learners inadequate opportunity to learn geometry. The above study indicates that structured teaching activities limit the learners' cognitive development. Therefore, structured and unstructured teaching can be used on-line and face-to-face.

2.10.1 Face-to-face teaching activity

The use of instructional method in teaching geometry in the classrooms gives learners inadequate opportunity to learn geometry (Atebe & Schäfer, 2011). The case study by Mthembu (2007) on the use of instructional methods in teaching Grade 11 geometry proclaims that teachers are responsible for designing activities that will encourage learners to participate in their learning. This suggests that teachers should design structured (formal) activity using instructions that will promote learners as active participants during their teaching. However, geometry class with the use of Van Hiele's model helps teachers to develop learners'

understand of geometry (Atebe & Schäfer, 2011). However, face-to-face teaching may use instructional or cooperative methods (Mercer & Sams, 2006). Thus, Zakaria and Iksan (2007) state that cooperative learning is effective in different subjects because learners become interested in helping each other by sharing their ideas, while working together in finishing their tasks. The study indicates that face-to-face uses both collaborative and traditional approaches and the teaching activity would be teacher-centred and learner-centred. Learner-centred activities usually use group work, and it help learners to become involved by interacting with others in solving problems, practical investigations and to relate their mathematical ideas (Mercer & Sams, 2006). Therefore, the teacher's role in a group work become the facilitator of the learning rather than leading the learning as expected in the traditional approach. Although some teaching takes place in computer laboratories, but teachers instructs and facilitates teaching on-line.

2.10.2 On-line learning activities

On-line learning is the use of internet and other social media network (Khoza, 2012). The study suggests that learners who use on-line learning become active participants, learn from their peers, and get to discover themselves. This implies that computers and cell phones are important digitals in the learners and teachers' lives, but are rare in most of black African schools due to lack of resources and learners' poor economic home background. This is an indication that teachers who experience the use of on-line learning may be useful to learners who are exposed to technology and can make geometry more easy and simple to the learners (Stols, 2007). Although on-line learning is suitable for learners to learn at a distance, some teachers do not prefer it because they are not exposed to technology. They need better training in the use of geometrical software (James *et al*., 2008). This suggests that on-line learning is suitable if the teachers are exposed more to technology. Hence, on-line learning is best preferred by the learners because some who are shy to ask questions in the classroom can use on-line to get the answers quickly and fast.

In addition to the above, structured (formal) and unstructured (informal) learning activities should be used when designing learning activities to accommodate learners with diverse views (Khoza, 2013a). The study states that teachers should use the activity that will encourage learners to become active participants. A study by Julie and Mbekwa (2005) found that learners want to do Mathematics that would be useful in problem solving issues. The study suggests that what is learned from school must be usable in real life situations. However, Gladys,

Nicholas, Graciuos, and Mirirai (2013, p. 19) state that "lack of understanding geometry in learning geometry often causes discouragement among the student, which invariably will lead to poor performance in geometry". The study suggests that geometry taught in schools should bridge the gap between school mathematics and cultural mathematics. Therefore, for geometry learning activity to be sustainable, learners need to understand geometrical concepts (Gladys *et al.*, 2013). This suggests that teachers should design the activities that promote learners' geometrical ideas, and should help the learners in developing those geometrical ideas as intended in the curriculum. The design of the learning activity will determine the role the teacher will play during the teaching and learning process.

2.11 Teacher role (How do teachers facilitate their teaching?)

Teacher role is the part played by the teacher in the classroom situation. According to DoE (2003) Norms and Standards a teacher should full fill the 7 roles for teachers which are: facilitator, interpreter, mediator, leader, pastoral care, assessor, and life-long learner. A case study by Mthembu (2007) on how teachers use instructional approach to teaching geometry, identify that teachers should fulfil their roles by shifting from a traditional to a facilitator approach. The study indicates that the role played by teachers is most vital in geometry teaching. According to these studies, the experience of using different approach in teaching geometry would improve the learners' performance. Teachers should use the different roles in their teaching to accommodate diversity of learners' needs. Mercer and Sams (2006), state that the teacher's role is when the teacher interacts with pupils in leading the lesson. This part needs the knowledgeable person to help the development of learners' knowledge and mathematical languages through the classroom discussion led by the teacher (Mercer & Sams, 2006). This suggests that the teacher's role determines the learner's mathematical development. Learners learn geometric language through the way the teacher is teaching. The study by Klopfenstein (2005) found that the role played by the teachers as learner's role model has an influence on the students' career choices. This indicates that teachers' role goes a long way in influencing the learners when choosing their path in the higher education levels. Hoadley and Jansen (2012), state that teachers can drive the curriculum by being a facilitator (learner-centred), teacher-centred (instructor) and content-centred. This suggests that teachers can experience the fulfilment of their role in teaching geometry by using different forms: instructor, facilitator, manager, assessor and evaluator and resource developer (Crosby, 2000).

2.11.1 Teacher as an instructor

Mthembu (2007), states that teachers should refrain from using instructional and adopt the approach that would encourage learners to participate in the learning. The study concludes that the testing system compels the teachers to use instructional approach, because they focus on the results that will judge their teaching. Hence, teachers who experience the use of instructional approach are driven by teacher-centred approach, which promote aims and objectives (Khoza, 2013a). According to the study, instructional approach does not yield the envisaged intended curriculum because learners tend to be passive and teaching and learning is driven by the teacher. Teachers should change from using instructional approach and adopt the role that will promote learner-centred and facilitating.

2.11.2 Teacher as a facilitator

A case study by van der Walt and Maree (2007) reveal that teachers do not apply adequate meta-cognitive skills and abilities in their class. This is an indication that learners' development of cognitive skills is influenced by how the teachers facilitate the teaching. Teachers need to use facilitation approach that will develop reasoning skills of the learners (van der Walt & Maree, 2007). This indication that teachers' experiences of using learner-centred approach helps learners to develop their geometrical cognitive skills, and the focus is on the outcomes of the intended curriculum. Further, teachers who use learner-centred approach are driven by content-based approach.

In addition, Mukucha (2012) in Malawi states that teachers facilitate second language mathematics students using a combination of practices to define mathematical terms. Thus, in black African schools Mathematics is taught in English which is the second language, this indicates that language is a barrier of teaching Mathematics in black schools which compels the teachers to use bilingual practices in their teaching (Mukucha, 2012). Due to the language barrier, teachers prefer to lead the lesson because learners do not want to participate in the learning if they don't understand geometrical concepts (Hannafin, Burruss, & Little, 2001). This is an indication that teachers prefer teacher-led role to control the class instead of letting the learners to learn on their own and from peers. Besides being an instructor or facilitator, teacher can manage in the classroom situation.

2.11.3 Teacher as a manager

A case study conducted by Mapolela (2003) reveals that teachers as managers uses learner-centred approach, learners knowledge and learners mistakes as the way of starting the lessons. Teachers give the learners the opportunity to attempt geometrical activities using their previous knowledge. Further, teachers use learners' mistakes to teach. This suggests that previous knowledge is important before introducing the new knowledge, and this promotes learner-centred approach. Furthermore, Herbst and Miyakawa (2008) state that teachers manage the proofs and theorems in the classroom, learners tend to do the theorems approved by their teachers. The above study suggests that teachers who experience the teaching as managers tend to use learners to lead the lesson. This is an indication that teachers manage their teaching by selecting the theorems and proofs that will be done by the learners. This suggest that teachers should give the learners the freedom to choose the theorems to be taught, and must give the learners proofs and theorems that will promote the learners' spatial reasoning skills (Herbst & Miyakawa, 2008). Conducting a study on teachers' experience using reflective activity may give an in-depth understanding on how teachers full fill their role of as the manager in teaching geometry. Teachers can also fulfil their role by being an assessor of teaching and learning.

2.11.4Teacher as an assessor

Assessment is influenced by teachers' opinions of mathematics education, present opinions of assessment, assessment elements and school systems (Wilson Thompson, 2006). Hence, a Weldeana (2008) states that problem-solving assessment is valuable in assessing the learners rather than using teacher-centred approach, because it promote reasoning skills. This is an indication that the use of accurate assessment forms in teaching geometry is necessary to meet learners needs (Darling-Hammond & Snyder, 2000). However, Krishnannair and Christiansen (2013) state that little is known by South African teachers on how to choose assessment tasks to link with their teaching. This suggests that, teachers as an assessor should use of peer assessment, because it helps the learners to reduce their fear, promotes the love of working with other learners as well as a teacher (Lavy & Shriki, 2014).

However, for the teachers' role to be practicable in teaching geometry, they rely on skilful materials that the educators can utilise to make it practicable for the learners to use (Herbst, Nachlieli, & Chazan, 2011). Geometry needs to be practical to the learners rather than theoretically applied (Jones, 2000). Therefore, consistent with the role of a teacher depends on how the teachers conducts his/her duties (Da Ponte & Chapman, 2006). According to the study

methods used during teaching should promote the development of geometrical ideas and be more of learner-centred to obtain the intended outcomes of the curriculum (Herbst & Miyakawa, 2008). Further, Baumert *et al*. (2010), states that for geometry to be relevant in high school levels it must promote reasoning skills in learners. This suggests that teachers must be trained or given in-service training, in order to meet the needs of the changing world (Berkvens *et al.*, 2014).

However, the role played by culture, place and individual practices is vital in public education for geometry to be sustainable (Chinn, 2007). This suggests that curriculum developers should design the curriculum to be sensitive to the cultural and individual needs in in a particular society (Van den Akker *et al*., 2009). This suggests that for the teachers to able to fulfil his/her role in class, resources and materials are needed (Jones & Mooney, 2003). Teacher may not be able to fulfil their role without the use of the correct resources.

2.12 Materials and resources (With what are they teaching?)

Resources are the tools used by the teachers and learners for their teaching/learning activities. The most common tools used during teaching and learning are textbook, workbook, calculator, chalkboard, and the teacher themselves. According to Khoza (2012) what is used to communicate learning becomes a teaching and learning resource. Resources are divided into hardware (machines), software (display on the calculator) and ideological-ware (theories) (Khoza, 2012). Further, Solomon (2009, p. 50) asserts that "books and its supplements, kits of hands-on materials, and software for computer-assisted instruction are called published curriculum materials".

2.12.1 Hardware resources

"Hardware resource is any machine or tools used in teaching and learning and is both off-line and on-line situation (Khoza, 2013a). The use of Technology in Education (TIE) and Technology of Education (TOE) help the learners promote their understanding (Khoza, 2013a). Thus, Technology in Education (TIE) is "any teaching/learning resources one can see and touch" (Khoza, 2012, p. 1). Thus, the study by Choi-Koh (1999) reveals that learners gain a deep understanding of geometry when using computers in schools. However, using computers without teacher's help cannot aid the learners to understand geometry because when if learners cannot draw geometrical figures on a paper he/she won't be able to draw on a computer (Choi-Koh, 1999). The above studies indicate that the experiences of using relevant geometry

resources like computer, overhead projector and other visual resources are very important when teaching geometry. This suggests that learners can develop visual skills and geometrical thinking when using a computer. TIE does not work alone software resources (TOE) is needed with the help of TIE (Khoza, 2012). The qualitative case study conducted by Stols (2007) states that teacher cannot utilise Geometer's Sketchpad in school because they lack computer skills and some do not have computers in their schools. This is an indication that computer literacy is very important in schools. Therefore, hardware resources need software to be usable.

2.12.2 Software resources

Software (TIE) is "any teaching/learning resources produced for hardware to display data or communicate teaching" (Khoza, 2012, p. 1). The study suggests that software works together with the hardware tools, since TIE is divided into hardware and software; TIE is needed for TOE to be accessible (Khoza, 2012). Further, technological software had become the important teaching instrument that will help learner to master the geometry content (Solomon, 2009). Ndlovu, Wessels and de Villiers (2010) found that learners can use Geometer's Sketchpad® as a positive working tool for learning. This is an indication that the experiences of using Sketchpad create a positive attitude in the classroom (Ndlovu, Wessels and de Villers, 2010).

Further, Edwards and Jones (2006) argue that GeoGebra link geometry and algebra, therefore better understanding is enhanced in the learners using this software. The above studies indicate the geometrical software can be one of the most important tools used in teaching geometry. This is an indication that teachers need to be computer literate and be trained to use sketchpad in teaching geometry to provide a better understanding in geometrical ideas. The studies by Mudaly (2004) on the use of sketchpad in High school reveal that it helped the learners to develop a better understanding of geometrical concepts, and that computers are important in geometry modelling. This suggests that mathematical software is more important in teaching geometry to instil geometrical concepts in the learners rather than drawing on the board. Therefore, the use of ICT tools by teachers provide learners with support by providing teachers with pedagogical resources that help them to develop new activities for their pupils (Trgalova, Jahn, & Soury-Lavergne, 2009)**.** Hence, Jarvis, Hohenwarter and Lavicza (2011), state that the use of GeoGebra helps in teaching geometry in schools. In addition, ideological-ware is needed as tools for teaching geometry.

2.12.3 Ideological-ware resources

"Ideological-ware (TOE) are the resources that one cannot see or touch like teaching strategies and theories" used during teaching process (Khoza, 2012, p. 21). Hence, the case study by Khoza (2015), states that teachers are not aware of the ideology resources they use during the implementation of the intended curriculum. The study indicates that ideological-ware is important in teaching geometry in order to promote critical thinkers. Further, the study by Stuart and Thurlow (2000) state that teachers' belief plays a vital role in the classroom practice where the teacher is exposed to many unforeseen circumstances e.g. teaching learners who speak English as the second language, learners with disabilities, learners who come from disadvantaged families. De Villiers (2010), states that the learners are failing to understand the teachers because geometry is at higher levels than those of the learners. This is an indication that if the first four levels of Van Hiele' theory are not well developed in the teaching environment, then learners will not understand geometrical concepts as intended by the curriculum. This suggests that teacher who experience the use of relevant ideological-ware in teaching geometry would help learners to be able to recognise, analyse, order and deduce any geometrical concepts presented in the classroom (Naidoo, 2007; Ndlovu, 2012; Ndlovu, Wessels & de Villiers, 2010)

Hence, an article by Ndlovu, Wessels and de Villiers (2010) state that Van Hiele' levels of cognitive development are needed in the classroom for geometric ideas through the use of Sketchpad. According to the study Sketchpad alone cannot help learners to learn geometrical concept, as such theory is needed for the learners to understand geometry. This implies that curriculum implementers should experience the understanding of ideological-ware that is suitable for intended curriculum they are implementing. Through understanding the curriculum ideology, teachers will be able to choose between the teacher-centred, learner-centred and content-centred in order to gain the positively achieved curriculum (Hoadley & Jansen, 2012).

In addition, practicality of geometry is based on theory used by educators when teaching geometry. An investigation study by (Ikle & Goertzel, 2011) reveal that theoretical and mathematical materials are vital in guiding the different learning drawings. This suggests that theory that underpins the curriculum is important to gain the intended outcomes. However, Grade 10 geometry emphasises that learners should develop knowledge, routine procedures, complex procedures and problem solving, but there is no theory to use that underpins the

development of the above mentioned skills. As a result, teachers have to use the Tyler together with Stenhouse' approach during curriculum implementation (Hoadley & Jansen, 2012).

Thus, practicality of geometry is based on theory used by educators when teaching geometry. Supplying materials only in schools would be unfruitful if ideological-ware used does not underpin the intended geometry curriculum (Ikle and Goertzel 2009). Further to that, Ndlovu (2012) reveals that practicality of geometry is when the learners are able to prove geometrical theorems on their own. Due to shortage of information they are exposed to, they fail to do geometrical proofs. This is an indication that ideological-ware used during teaching must develop learners' cognitive skills. As a result, CAPS implementation is not relevant and sustainable in most rural schools, since there is no electricity and computers are not available. Therefore, resources used in teaching geometry must be in line with the time geometry is taught, to accommodate the demands of the changing world.

2.13. Time and learning environment (When and where are they teaching?)

Formal time for teaching is often spent in school (Berkvens *et al*., 2014, p. 18). Hence, the time for learning in schools is guided by hours per week. According to CAPS Grade 10 geometry is taught in term two (Euclidean geometry) and in term three (Analytical geometry). According to the document, "Time allocated for Mathematics: 4 hours and 30 minutes, e.g. six forty-five minutes' periods, per week" (DoE, 2011, p. 17). Euclidean geometry is given 3 weeks in a term which are week 6, 7, and 8. Analytical geometry is given 2 weeks in term three which is week 1 and 2 of the third term. Teachers teach geometry in the classroom using cultural tools.

2.13.1 Inside the classroom

Learning environments define simply different places to teach (Lombardi, 2007). This agrees with Berkvens *et al.* (2009) they state that the environment is where school-based learning activities take place. Aldridge, Fraser, and Ntuli (2009) reveal that learners choose the learning environment that suits them over the one that is available. Further, Naidoo (2011) reveals that scaffolding approaches and methods can be used in any classroom environment. Mathematics classroom environment full of geometrical shapes gives the learners the chance to solve problem, make connection, promote thinking skills, express and connect concepts correctly (Wilhelm, Sherrod, & Walters, 2008). The above studies emphasise is creation of mathematics class conducive for the learners to learn to learn geometry. This implies that geometry should be practical (learners must be able to write geometrical proofs on the board working with their

peers), the pictures of geometrical shapes would help them in developing their deductive reasoning (Wohlhuter, 1998). Teachers working in a conducive place tend to be productive (Wilhelm *et al*., 2008). Therefore,, practicality of geometry has been marked as the most competent strategy of educating in the 21st century (Lombardi, 2007). Thus, geometry can be taught outside the classroom environment, a laboratory can be used in teaching geometry.

2.13.2 Computer laboratory

Sipos and Kosztolányi (2009), state that learners become motivated when working in the computer laboratory. This implies that curriculum designers should consider schools that are under resourced when designing the curriculum. Further, Okigbo and Osuafor (2008) reveal that the use of mathematical laboratory enhanced achievement in Mathematics and that no difference exists between the achievement of male and female taught in mathematics laboratory. The above studies identify computer laboratory as most conducive place to teach geometry. This suggests that the experience of teaching geometry using relevant soft-ware in the laboratory enhanced learners' understanding of geometrical concepts (Edwards & Jones, 2006; Okigbo & Osuafor, 2008). The use of visual devices in classroom draws learners' attention and excitement, and promote understanding (Naidoo, 2012).

As a result, curriculum developers should consider providing digital electronic devices in schools to make teaching geometry sustainable. However, Roberts, and Vänskä (2011) reveal that the use of one mobile-kit makes it difficult to work in that learning environment especially in rural schools, where there is a lack of technological resources. This is an indication that most rural school are faced with the problem of providing the movable technological resources into classroom, and maintenance of the available resources (Milrad *et al*., 2013). Based on CAPS, there is nothing said about the relevant learning environment for teaching geometry, although they want learners to be critical thinkers and be able to compete national and internationally. The above studies indicated that the mobile-kit can be used in classroom environment although learning environment is not sustainable for teaching geometry (Roberts & Vänskä, 2011). This implies that the use of technology in teaching geometry can sustain our curriculum for the changing world.

In addition, Yegambaram (2012) found that the use of technology in teaching geometry can improve learners ability to learn geometry, master geometrical concepts, and promote reasoning skills and learners interest in learning Mathematics. When teaching geometry in a suitable environment, learners choose the environment that is learner-centred (Aldridge,

Fraser, & Sebela, 2004). As a result, schools should provide time and money for curriculum implementers to create a positive learning environment that will allow the use of different resources (Berkvens *et a*l., 2014). Therefore, formal learning and informal learning must be considered by the teachers when teaching geometry (Berkvens *et al*., 2014). Further, Brijlall (2014) found that practical work in a rural area will be sustainable in an efficient mathematics education environment. This suggests that practicality in teaching geometry would demonstrate the quality of geometry.

2.14 Assessment (How is their teaching assessed?)

Assessment is the tool used by the teacher to test learner's progress on what they have learned. Kennedy *et al*. (2009), describe assessment as formative and summative. Formative is used for learning and summative summarise learners learning usually at the end of the learning. Further, Carl (2009, p. 103) states that "assessment is used to enable learners to improve their learning". CAPS (2011) assessment for geometry is in line with the Bloom's Taxonomy levels of cognitive levels, as listed in the document and percentages allocated per cognitive levels to be assessed. Hence, Krathwohl (2002) states the revised Bloom's Taxonomy that needs to be achieved are; knowledge, comprehension, application, analysis, synthesis, and evaluation. Most of the learners achieved level 1 (knowing), 2(describe) and 3(demonstrate) but fail to think at level 4 (deductive reasoning). However, CAPS assessment for Grade 10 is at level 3, 4 and 5. According to CAPS Grade 10 assessment should write common tests on quarterly basis and they are moderated internally and externally. There are different forms of assessment which are: assessment for learning, assessment of learning and assessment as learning.

2.14.1 Assessment for learning

Assessment for learning is described as formative assessment that include the activities chosen by the teacher to assess learners' progress and assist teacher together with the learners to change their teaching and learning activities (Kennedy *et al*., 2009). However, Smeets (2005) states that most teachers choose to use traditional assessment and those methods of assessment are used by teachers to cater for learners' different abilities. Changing the nature of assessment would help the teachers to be specific on why they assess the learners, who are they assessing (e.g. group work, peers or individual) and when to assess the learners (Brown, 2004). Further, Sriprakash (2010) argues that teachers who use learner-centred assessment make the learners to take charge of the classroom. This an indication that assessment for learning is used to judge learners' performance as based on their standardized tests. Therefore, assessment should

clearly states what needs to be learned by the learners and be in line with curriculum by using different forms of assessment (Brown, 2004). According to CAPS assessment for learning has to use: test, assignment, project and investigation to accommodate different learners' abilities. As a result, the experiences of using different forms of assessment should be used to accommodate learners' difficulties in geometry. Therefore, assessment of learning should be used during teaching process to assess learners' geometrical skills development.

2.14.2 Assessment of learning

Assessment of learning is described as summary of learners' performance that use traditional form of assessment e.g. tests and exam (Kennedy *et al.*, 2009). An ethnographic study conducted by Vandeyar and Killen (2007) reveal that teachers do not want to accommodate their assessment methods in a diverse challenging South African educational system. Teachers make conclusion on learners' performance through assessment to inform their teaching (Vandeyar & Killen, 2007). Further, Akyeampong, Pryor and Ampiah (2006) reveal that teachers use informal assessment to find the best approach for effective classroom learning. Assessment of learning should be in line with the curriculum goals and daily activities of educators and learners by marking programmes on future outcomes (Marx *et al*., 2004). From the views of the above studies, assessment of learning is based on what is learned in that specific time and should not be used to make judgement on learners' performance. According to CAPS, assessment of learning is in line with the general aims of inclusive education to address injustice of learning.

Further, Berkvens *et al*. (2014) states that assessment of teaching and learning and its outcomes are needed when measuring the quality of the curriculum. This is an indication that any forms of assessment done in schools depends on the implemented curriculum to gain the intended outcomes of the curriculum. Kauffman, Moore, Johnson, Kardos, Liu, and Peske (2002) proclaim that teachers are not given support on what to teach and how teach. Some teachers are experiencing difficulties and leave the teaching profession because of failing to deliver the curriculum to the learners; the learners learn less of what they are expected to learn in the classroom because the teachers lack support for the curriculum to be delivered (Kauffman *e*t *al.,* 2002). Teachers have to choose the educational psychology that will meet learners' needs in practice and they tend to work using uninteresting teaching approaches because of pressure from the department to cover the whole content that will be set for standardized tests (Spooner *et al*., 2008).

Further, Lavy and Shriki (2014) reveal that peer assessment widen mathematical knowledge of teachers' work. The use of different forms of assessment are accepted in the area of teaching geometry (Lavy & Shriki, 2014). This suggests that CAPS is consistent because it incorporates different forms of assessment, and teachers had to use different forms of assessment as stipulated by CAPS. Teachers who used peer assessment form to assess themselves may support their professional development. Peer assessment provides report that can eliminate mistakes and give positively influence in the assessment processes, therefore learners become involved in the teaching process and develop deeper understanding of the geometrical proofs (Lavy & Shriki, 2014).

Assessment would be successful if it is easy to be used both by the teacher and the learner (Berkvens *et al.*, 2014). The paper written by Alex and Mammen (2014) on the development of cognitive skills using Grade 10 learners in South Africa, proclaims that most of the learners obtained level O on Van Hielle' levels of geometrically reasoning. Level 0 is where the answers are based on visualisation. Geometry assessments are practicable since there are schools that give 100% pass rate in Mathematics. Although some good results are performed, a room of improvement is needed to make it more practical.

Furthermore, assessment as process of weighting and evaluating achievements, it should be used for improvement not to judge the feedback obtained (Maclellan, 2001). Therefore, for assessment to be sustainable the assessor must have the assessment skills, understands the content, gives feedback of the assessment, use the correct assessment instruments, and design the assessment in a well-planned time (Maclellan, 2001). A case study by Lu and Law (2012) on students engaged in peer assessment via on-line systems, find that if the students are given the feedback and a plan to review their achievement it will produce a positive change in the classroom and online. CAPS assessment is sustainable since FET phase wrote common papers for their assessment that are standardised tests (DoE, 2011), hence some of the rural schools are not catered for electronic devices to work on line. From the above studies' views, this study would focus on how teachers assess the learners and the content they are teaching using reflective activity on teachers' experiences. Thus, before assessment is designed accessibility needs to be considered to accommodate learners' abilities.

2.15 Accessibility (Who are you teaching?)

DoE (2011) state that education should be accessible to all the children apart from his/her affordability, ethnic group, gender, socio-economic status, physical abilities and socio-cultural

factors. Hence, Berkvens *et al*. (2014) state that the Department of Education must make sure that these factors does not hinder the learners from learning geometry. Unal, *et al*. (2009) reveal that learners' access to geometry is not the same due to their teachers' abilities to develop the learners' thinking skills. Hence, learners with poor spatial competence find difficulties in geometry, but the average spatial competence display little improvement after guidance from the teachers, and learners with poor spatial reasoning skills displayed less improvement based on Van Hielle' levels of development (Unal, Jakubowski, & Corey, 2009). The way teachers deliver the content they teach, differentiate accessibility to learners, because they are in different levels of learning (Lim & Moore, 2002). Hence, Berkvens *et al*. (2014) suggests that learners should have access to education irrespective of ethnic group, socio-economic status and gender. He further outlines the aspects of accessibility as: physical, financial and cultural.

2.15.1 Physical accessibility

A case study on learner's from Nigeria and South Africa by Atebe and Schäfer (2011) reveal that learners had only partial knowledge of the necessary geometric vocabulary. The study suggests that learners who lack geometry ideas will not be able to understand the teacher's instruction and to follow class discussions. This implies that geometrical language is important for classroom interaction in order for the learners to be part and parcel of the teaching and learning process. Further, Webb (2011) reveals that learners with dyslexia have difficulty in writing and learners with mental and physical tiredness lack concentration in the classroom. The experiences of teaching learners with physical disabilities may hinder the learners from learning geometry since geometry is practical.

The above studies suggest that teachers find themselves teaching learners with disabilities that they are not trained for. Therefore, teachers should be trained for inclusive education in order to accommodate accessibility for all. Learners who are visually disabled find difficulties in reading and in using electronic devices (Webb, 2011). According to CAPS there is no nothing that is said about inclusive education in order to meet the principles of White paper 6 (Inclusive education). The document states that education is accessible to all the learners but no provisions have been made to provide education for all where there are challenges of going to school. This suggests that teachers teaching in a public school are teaching disabled learners whose parents lack finances to take them to relevant schools.

2.15.2 Financial accessibility

Access and success will be possible if funding for students at tertiary should continue to give funding to the institutions in order to produce mathematics teachers needed in the changing world (Hockman, 2005). A study by Sarma (2008, p. 1) on financial access in India, states that financial accessibility is just a "policy in many countries". This is an indication that including all stakeholders in an organisation finances will help in maintaining learners accessibility to school (Sarma, 2008). The study suggests that consultation of all the stakeholders is important and needed for public school, so that all stakeholders might have input in needs of the school. Hence, the public schools belongs to the community they are built in. Schools, principals should involve the parents, teachers and learners to list and prioritise the needs of the schools that needs to be bought using norms and standards, to cater for every individual involved (Lotfi & Koohsari, 2009). To ensure accessibility, government should ensure that public institutions are accessible to all citizen, public schools should be accessible to all individuals regardless of physical abilities and their needs, especially in the developing countries (Lotfi & Koohsari, 2009). Although public schools are accessible, the provision of resources for disabled learners in public schools are still in demand, especially in rural areas where learners could not reach tertiary institutions due to lack of information needed to further their studies. This suggests that there is a need for programmes to empower the learners so that they may further their studies, so that they will get jobs (Berkvens *et al.*, 2014). Therefore, bursaries for mathematics teachers are needed to increase the number of teachers who are trained and qualified to teach Mathematics in Secondary school.

2.15.3 Cultural accessibility

A teacher who teaches in a multi-cultural environments must understands different cultures, because culture entails different vital norms: how the community live, collaborative problem solving and how these can disturb schooling background, aim, and work routine, how the different racial group pupils interact with the seniors, and maintain sexual role fairness in the society and how to use fairness in the classroom teaching (Gay, 2004). Teaching in a multilingual classroom will make it virtually impossible to produce mathematicians, scientists, technologist and engineers, most of the learners learn Mathematics in English which is not their mother tongue (Setati & Barwell, 2008). Multilingual learners find difficulties in learning geometrical concepts presented in English while their thinking is in their mother tongue. Language is the large problem when teaching geometry because of limited proficiency (Duval,

2006). The DoE (2011, p. 8) specific aims of "promoting accessibility of Mathematics content to all learners", curriculum developers ignored the context in which the implemented curriculum takes place, because there are schools that teach under the tree and others in a vandalised classrooms. Therefore, government stakeholders and curriculum developers need to revisit the above aim of the curriculum and revisits these local, national and international background of each school (Berkvens *et al*., 2014). Berkvens *et al*. (2014), reveal that accessibility for the girl child needs to be taken into consideration when they argue that secure surrounding is needed e.g. hygiene places, to get and keep their sanitary to help the learners from being absent when they are in need of the towel. Some schools in rural areas do not have secure environment for girl child to be at school that leads to a dropout of girl before secondary education is reached, therefore education accessibility is limited (Berkvens *et al*., 2014). Further, the quality of CAPS (2011) would be successful if its goal of education for all is achieved in all levels and meets the global standard (Berkvens *et al*., 2014). Therefore, CAPS might fail because the provision of materials is not the same in rural schools compared to urban schools. CAPS (2011) is not relevant to some learners in rural areas with physical disabilities since they drop out from school because of the long distance they walk to school.

2.16 Conclusion

The current study may help the teachers to develop their content knowledge which may help learners to benefit more from their teachers and be able to reflect their knowledge in teaching geometry. Since CAPS (2011) focuses on school knowledge, teachers must be able to use e-learning and teach geometry using technology to meet the standards of the changing world. Most of curriculum components are not relevant, since they fail to accommodate accessibility for all learners. In some rural areas there are no schools for physically disabled learners. Others go to schools which do not cater for their disabilities. Therefore, this study used ten curricular spider web concepts trying to understand teachers' educational experiences in teaching geometry. Thus, the following chapter deals with the data generation methods used to gather geometry teachers' experiences.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

This study started with the dissatisfaction in Mathematics, especially in Paper 2 (geometry) pass rate over the past years in South Africa. This raised the interest to explore and understand the teachers' experiences in teaching geometry. This chapter will discuss the methodology together with the research style and the paradigm and location of the study. The chapter would show how the research data for the study was generated. The population together with sampling will be defined, the research instruments, how access is obtained, arrangement and operation of the pilot study.

3.2 The significant research questions

The main objectives of this study were to explore the Grade 10 teachers' experiences in teaching geometry. The study wanted to answer the following significant questions:

1. What are the grade 10 teachers' experiences of teaching geometry in Umbumbulu circuit?
2. Why do grade 10 teachers have particular experiences of teaching geometry in Umbumbulu circuit?

3.3 Methodological approach

This is a qualitative case study within an interpretive paradigm, in five Secondary schools in KwaZulu-Natal in Umlazi district under Umbumbulu circuit. The study focuses on Grade 10 teachers' experiences in teaching geometry. According to (McMillan & Schumacher, 2014, p. 315), qualitative research is "inquiry in which researchers collect data in face-to-face situations by interacting with selected persons in their settings". Qualitative study illustrates and interprets the participants' characteristics and public action, ideas, opinions, and insight. Qualitative data analysis includes interviews, and reflective activity to answer the significant questions for the study (What and Why) to in-depth understanding of Grade 10 teachers' experiences in teaching geometry within Umbumbulu circuit. This study used interviews and reflective activity to generate data. According to Lauer (2006), qualitative research method use questionnaire, survey, tests, interviews and observation. Using interview as inquiry method,

the researcher would generate data face-to-face by interacting with the selected participants in their location.

This study is positioned within an interpretive paradigm. Paradigm is the way of seeing the world and doing research. According to Taber (2012) paradigm is often to describe approaches to educational enquiry. Paradigm has the epistemological beliefs, perception and assumptions a researcher has about a phenomenon. Interpretive paradigm is the idea that researching human, "subjective experience might need some special approaches has not always been commonly accepted" (Wilson, 2009, p. 260). This study used an interpretive paradigm because I want to understand the experiences of teachers and interpret the meaning of social action. I want to develop an in-depth understanding of how people make sense of contexts in which they live and work. Teaching of geometry in school, teachers use learners' previous understanding to connect with the new information learnt and learners' previous experiences are used to make meaning of geometry concepts. According to Neuman (1997) qualitative interpretive approach is based on the reality created as humans make their meanings and make sense of the world and on the assumptions that teaching experiences are different as per individual teacher. This will result in different realities and different interpretations. Therefore, this would help to understand the meaning which informs human behaviour share their feelings, interpret and how they perceive teaching geometry. This study will give an in-depth understanding on the experiences of teaching geometry in grade 10. That is why I chose to use interpretive paradigm. "Interpretive paradigm is characterized by a concern for the individual, aims to understand from within the subjective world of human experience, focuses on actions to ascertain the intentions of actors to share their experience (Cohen *et al.*, 2011, p. 21).

I am looking at arriving at an absolute truth by using qualitative methodology which is suitable to answer many significant questions, with a great input theory and practice (McMillan & Schumacher, 2014). Qualitative study discovers many realities through interviews. This style helped the researcher in understanding the social situation from the participants. I was immersed in the situation and the phenomenon that is studied. Qualitative research is subjective in generation of data. The advantages of using the qualitative approach are; this style helped the researcher to study the behaviour naturally. That is the reason I chose to use teachers who teach Mathematics to generate an in-depth data directly from them in order to get their experiences in teaching geometry CAPS geometry. This may help them to improve their teaching of geometry after reflecting on their teaching experiences. It focused on what and why teachers have these experiences. I generated data directly from "the source and focus on the

participants' understanding, descriptions, labels and meaning" (McMillan & Schumacher, 2014, p. 321). The design would be able to change as the study takes place if it is possible. Although qualitative interpretive study is suitable in generating data from human behaviour, it has limitation of generating many truths about the phenomena studied. To eliminate generating different truths I chose the participants who are Mathematics teachers and have taught Mathematics in secondary schools for more than 5 years. All the participants are reflecting on their experiences using the same questions framed by curricular spider web concepts.

3.4 Research design

The data was generated using three instruments: reflective activity, semi-structured individual interview, and focus group interview. Reflective activity was used to generate data from what teachers wrote down about their experiences of teaching geometry. After reflective activity had been employed, the semi-structured interview followed to generate data from what the teachers had been written in their reflective activities. After the semi-structured interviews, a focus group discussion followed in order to see if the teachers gave the same data as in the reflective activity and semi-structured interviews. Group discussion also helped the researcher to generate more data from the participants, while sharing what they had gone through and encouraged them from others to continue with their work. The semi-structured and focus group interviews were recorded using a voice recorder and tablet to ensure validity of the data generated. After focus group interviews were conducted, data was transcribed and analysed.

The research design was structured as shown in the diagram *Figure 3.1.* The diagram below shows the stages of research that ensure accurate and fruitful data, therefore it is essential to follow the steps of research as indicated. Though the study followed all the phases mentioned, the limitations for the study are indicated that will permits the conducting of the new study to bridge the gap that might be revealed based on the instruments used about the phenomena studied.

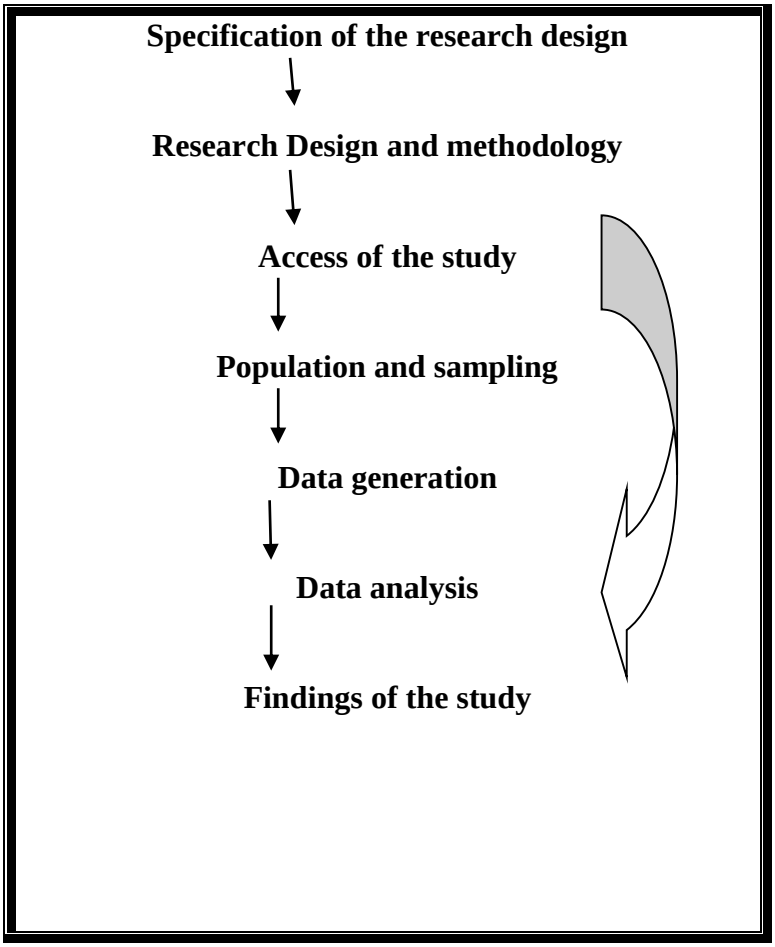


Figure3.1 Research design and methodology table

When the research approach has been defined, the chapter will continue defining the access to conduct the research study.

3.5 Access

Whenever a researcher is conducting a research study, ethical issues arises that need to be considered. Ethical consideration for this study included the University research office (*Appendix 2),* Department of Education *(Appendix 1),* Principals of the schools *(Appendix 3)* as well as Grade 10 teachers that would participate in the study. To follow all the ethical issues, I made an application to the University research office for the clearance certificate as well as application to the DoE. After permission was granted by DoE, University and Principals, a consent form stating that they were willing to take part in the study was given to participants to read and sign *(Appendix 4).* The consent form explained to the participants that their anonymity and confidentiality would be maintained. The researcher also explained the rules, regulations and purpose of the study. The researcher also explained that there were no incentives given to the participants for participating in the study and that the data would be

used for educational use only. The consent form also advised the participants that they were free to withdraw from the study, at any time, and that they would not be forced to participate at any stage and that the study is for educational use only. The ethical approval number for this study is HSS/0285/015M (*Appendix 2)*

3.6 Population and sampling

The population targeted for this study were mathematics teachers in the Umbumbulu circuit Durban, South Africa. The data was collected from Grade 10 Mathematics teachers. The reason for selecting Grade 10 teachers was that Grade 10 geometry lays the foundation of Grade 11 and Grade 12 geometry theorems. The participants were selected from a sample 13 secondary schools. Sampling is defined as a selection of a subset of subjects taken from overall population. According to Patton (2005), qualitative sampling is the selection of the participants who have deeper- understanding about the study, not to generalise but rather to explore particular group under the study. Thus, the schools that were selected to participate in the study all exhibited common features of the 13 secondary schools serving the population. These schools offer Mathematics as a subject and geometry is taught as part of content within the subject. Since the study's focus is to explore teachers' experience in teaching geometry in Grade 10, I selected five teachers who have taught and are still teaching Mathematics in Grade 10. Thus, "Sampling is described as a process of choosing a smaller, more manageable number of people to take part in the research" (Dawson, 2007, p. 49).

Thus, as my population was too large I used sampling to select the participants from the population. Sampling should contain subjects with features similar to the population as a whole (Cohen *et a*l., 2011). I selected teachers working within the Umbumbulu area from the 13 secondary schools in the area. Instead of accessing the entire population, the sample represented the population. If the population is too large, purposive sample is an important alternative and as such a case study was employed. Purposive sampling was used to identify the teachers who are teaching Mathematics in Grade 10. I used a case study of five Grade 10 Mathematics teachers to avoid using the whole population. "A case study is an in-depth exploration of a bounded system e.g. (activity, event process, or individuals) based on extensive data generation" (Creswell, 2013, p. 476). According to Cohen *et al*. (2011) a case study will provide different examples of people in real world situation who will help the reader to understand the situation more clearly than presented with abstract theories or principles. Including five Grade 10 Mathematics teachers enabled the researcher to understand the

experiences of teaching geometry as experienced by male and female teachers in the region. While the use of a case study is time consuming in generating, organising, and describing data. I prefer it as a tool for study because it is easy to manage, rather than managing the whole population. The strength of a case study is that, it uses a manageable number of participants to generate an in-depth understanding that deals with reality of the contexts and to do fairness to the case studied (Cohen *et al*, 2011). The study employed a purposive or network sampling, together with convenience sampling, as a tool used in qualitative research. Therefore, purposive sampling was specific to the Mathematics teachers, and I selected the teachers that have in-depth data for the phenomenon. Specifically, I selected teachers who have more than 5 years' experience of teaching Grade 10 geometry in secondary school and who had experienced the changing curriculum in their teaching experience.

3.6.1 Purposive sampling

According to Cohen *et al.* (2011); McMillan and Schumacher (2014) purposive sampling is used to communicate with participants that have deep understanding about the phenomena. The five teachers selected used for data generation had more than five years' experience in teaching geometry. Purposive sampling is used to "access knowledgeable people for a specific purpose" (Cohen *et al*., 2011, p. 157). The purpose of using five Grade 10 Mathematics teachers working within Umbumbulu circuit was to gain in-depth data on teachers' experiences in teaching geometry in the region. Another purpose was to generate data from different schools. For this reason, I only interviewed one Grade 10 Mathematics teacher per school. By using five different schools I ensured that if some participants dropped out, the research would still generate enough data to continue. Purposive sampling helped to find in-depth information from those who are in a position to give it (Cohen *et al*., 2011). Although using purposive sampling is manageable, the participants could attempt hide the data because they think the information might victimise them as it may reflection on their performance. It can sometimes be difficult to find rich, detailed, information from participants because of their position. For example, if Grade 10 is taught by the HOD or the Principal, it might not be easy to find data needed because their position limits their willingness to reveal weaknesses and challenges. Fortunately, one of my participants is an HOD, to my surprise he participated fully in data generation as well.

However, purposive sampling has been criticised because of the lack of systematic thoroughness and reliability, and because it does not deal with the issues of generalizability (Noor, 2008). Purposive sampling ensured the data did not result in generalised findings of the

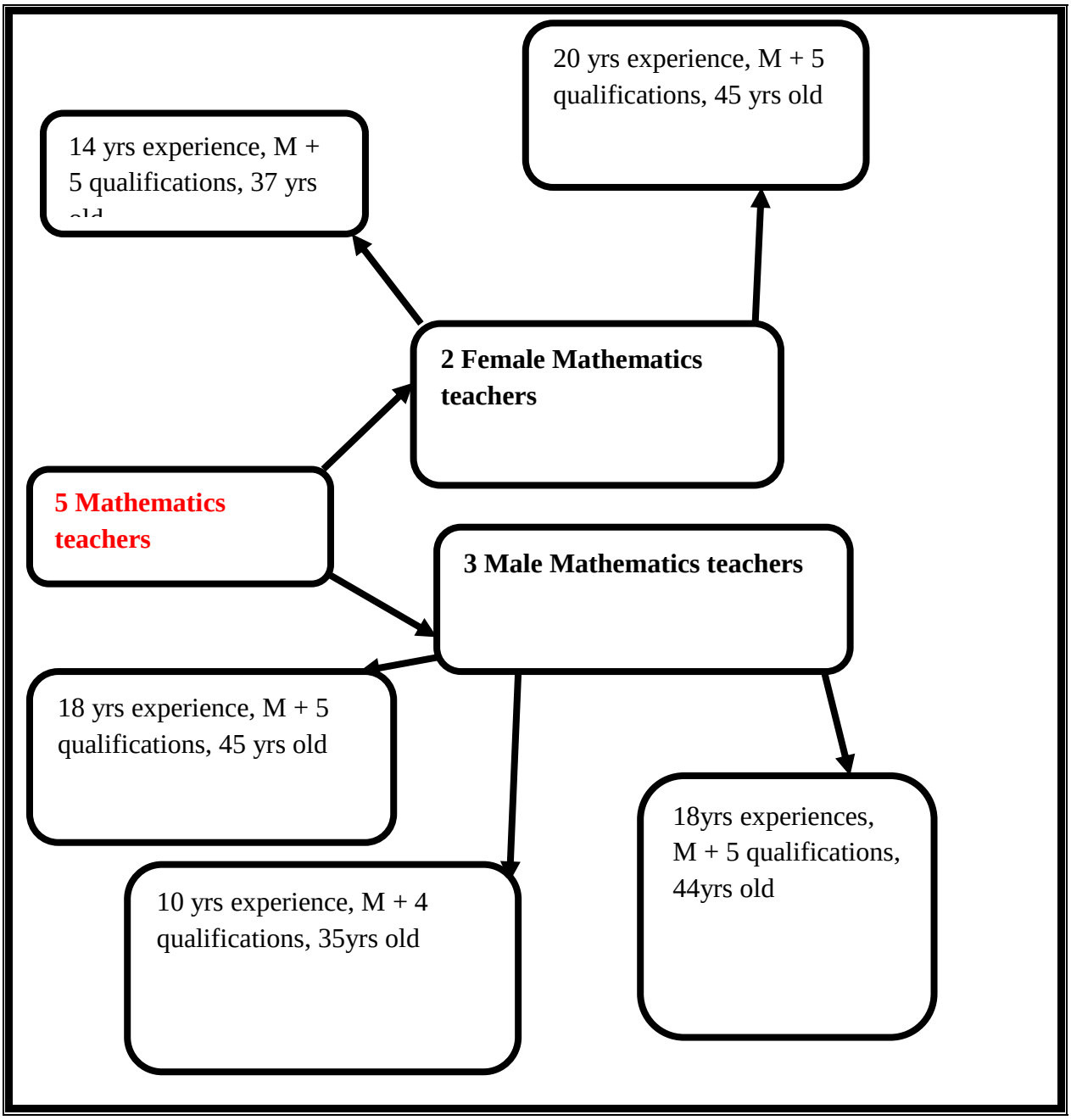
study (Cohen *et al*., 2011; McMillan & Schumacher, 2014). To avoid generalizability when using purposive sampling, I selected five teachers from different schools to explore the cause of their experiences in teaching geometry in Grade 10, and the participants have different qualifications in the field of education. Although, I was satisfied with the findings from the five different secondary schools that offer Mathematics as a subject, I minimise the possibility of generalizability of the findings by not applying to the whole population. To strengthen the sampling of the study, convenience sampling was employed.

3.6.2 Convenience sampling

According to McMillan and Schumacher (2014) convenience sampling is a group of the population chosen on the base of being availability. I have selected teachers with different years of experiences in teaching geometry but have all worked in Umbumbulu for more than five years. This helped the researcher to understand the different experiences teachers had when teaching geometry. The teachers that I have chosen worked in Secondary Schools where geometry is taught, since other schools they offer Mathematical Literacy instead of pure Mathematics and these teachers are in one cluster. All of the participants were black African teachers. The five schools that were sampled were renamed using alphabets A-E, and the participants were renamed using number 1-5. Participant 1came from school A, Participant 2 came from school B, Participant 3 came from school C, Participant 4 came from school D and Participant 5 came from school E. Then the new school and participant names were combined as A1, B2, C3, D4 and E5. The figure below represents the allocation of the participants who participated in the study.

However, Cohen *et al*. (2011) state one of the limitation of convenience sampling as that, it does not deal with the issues of representative of the population by the participants, As a result, the study seeks to understand the common and different perceptions among the participants within the Umbumbulu circuit. To address the above limitation, I selected five Secondary school that are within the Umbumbulu circuit where the study is located, but they do not represent the entire Umbumbulu circuit where the study is located, but they do not represent the entire Umbumbulu circuit. The selected schools were conveniently located and included all the features of the population. Thus, the sampling included two female and three male mathematics teachers. The figure below represents information on the participants' who took part in the study.

Figure 3.2 allocation of participants



3.7 Data generation and research instruments

This study employed reflective activity (on the first stage), semi-structured interviews (the second stage) and focus group interview (the third stage) to generate data.

3.7.1 Reflective activity

The study adopted a reflective activity in the first stage of data generation. A reflective activity is defined as activity where the participants or group of participants take on the work as an object of reflection (Mollo & Falzon, 2004). In the first stage of data generation, teachers used a reflective activity to indicate their experiences, beliefs and attitude while teaching Grade 10 geometry. The participants were given the opportunity to pay more attention to their experiences and give meaning to what had happened to them. Hatton and Smith (1995), reveal that experiences occur in four stages: real procedures about the action, specified time of that experience, the problem of the experience and knowing that the experience take explanations from wider historic, cultural and political values and beliefs. Therefore, in this study teachers' experiences were reflected framed by the ten components of curricular spider web concepts, to give meaning of history in the field of teaching geometry, the causes of the experiences, and how their beliefs and values contributed to their experiences. The reflective activity was designed in order for teachers to look back their journey of teaching as geometry teachers. In this study, teachers were given enough time to reflect on their perception of teaching by completing the questionnaire designed, thereby reflecting on their teaching experiences as based on the ten concepts of curricular spider web. The reflective activity has ten questions.

Question One: Why are you teaching in geometry? This questions focus on the reasons for teaching geometry. Teachers were expected to indicate their experiences of teaching geometry using personal, societal and content reasons. Under these propositions personal reasons occur when teachers indicated their interest in teaching geometry, societal reasons indicate societal benefit in their teaching of geometry and content reasons indicate their experiences of the implemented content and content understanding in their practices.

Question number two: Towards which goals are you teaching geometry? This question required teachers to reflect on their experiences of promoting geometrical goals as based on the propositions: aims, objectives and outcomes. Aims are long term-goals, objectives are short-term goals that the teacher wants to achieve after the lesson, and outcomes are what the learners achieve at the end of the lesson (Carl, 2009;Khoza, 2013b). Teachers were expected to reflect on their understanding of the aims of the curriculum, objectives of teaching and learning geometry and measureable learning outcomes achieved by learners in spatial reasoning.

Question Three: What are you teaching? Teachers were expected to indicate their experiences of Grade 10 geometry content they teach by looking at the use of algebra, trigonometry and geometry as the propositions of the content.

Question Four: **With what are you teaching?** Teachers were expected to indicate their experiences on the materials and resources they use during teaching process. This concept aimed at using the following propositions as resources used by teachers' experiences of teaching geometry: hard-ware, soft-ware and ideological-ware. Teachers were expected to indicate the most useful tool in the teaching of geometry.

Question Five: **How do you design your teaching?** The aim of this question was to gain teachers' experiences on how they design teaching and learning activities. In this question teachers were reflecting on their teaching using informal (learner-centred) and formal (teacher-centred) activities and on-line learning (where possible) as the propositions.

Question six: **How do teachers facilitate their teaching?** Teachers were expected to indicate their experiences on the way they facilitate their teaching using various role as instructor, facilitator, manager and assessor. They were expected to indicate on the role they play when teaching. This concept uses the following propositions for the role played by the teachers: instructor (teacher-centred), facilitator (learner-centred), and assessor (assess to inform teaching). Teachers were expected to indicate which role is most experienced when teaching geometry and why they chose to use that role.

Question Seven: When do you teach? This question was aimed at teachers' experiences of the time stipulated in the DoE document; hours, days and weeks specified for teaching geometry. Therefore, teachers were expected to indicate their ability to teach geometry in the allocated time.

Question Eight: Where do you teach? Teachers were expected indicate their experiences while teaching geometry in different learning environment. This question includes the environmental propositions: classroom and mathematical laboratory (Okigbo & Osuafor, 2008).

Question Nine: How do you assess your teaching? Teachers reflected on their experiences of assessment strategies they used during the teaching process. The assessment concept focused on the propositions: assessment for teaching, assessment of teaching and assessment as teaching. Teachers were expected to indicate their experiences on assessment for teaching (the

use of classwork and homework), assessment of teaching (project, assignment, tests) especially for standardized tests, assessment to promote learners to the next grade and assessment used to promote the learning outcomes for the intended curriculum (Carl, 2009; Krathwohl, 2002). They were also expected to reflect on assessment as learning.

Question Ten: With whom are you teaching? Teachers were expected to indicate their experiences as based on propositions: physical accessibility, financial accessibility and cultural accessibility of the school they're working in. Physical access (how they physically access the school), is the school accessible or in a remote place, financial (money spent going to school) and cultural which involve social beliefs, culture, politics and the religion of the community the school is embedded in. Thus, teachers were expected to indicate their experience on teaching learners who travelled long distance to get to school, and how that affects the participation of the learners during the teaching process.

The reflective activity was used once in the first stage of data generation, I designed the questionnaire with open-ended questions "to enable the participants to write a free account on their responses and be honest" (Cohen *et al*., 2011, p. 382). This is an indication that honesty can be one of the limitation of the reflective activity. To gain true and honest data from the participants, I gave them one week to provide written responses to the question in the reflective activity. I also explained all the questions to the participants in order to make sure that the participants understood them. Before completing the activity, I clarified each question and explained what was expected of them in order to record their educational journey and to relate to their teaching experiences. This guided the teachers towards indicating their technical, practical and critical experiences (Van Manen, 1977). The activity was collected a week before face-to-face interviews. When I went to collect the reflective activity, I found that some participants had not completed the activity, and some had misplaced it. Therefore, I had to provide more copies of the activity to replace those missing and return another day for the responses.

I found reflective activity suitable for the study, because it gave teachers an opportunity to reflect on their perception in my absence and without the pressure from the researcher. The advantage of using reflective activity was that the teachers were given an opportunity to freely write down their experiences and look back on their teaching journey of teaching in order to recall their good or bad memories. However, Xie, Ke, and Sharma (2008) state one of the limitations of a reflective activity is it restricts the contribution of emotions. To avoid the above

mentioned drawbacks, I ensured that during one-on-one interviews I noticed the participants' gestures that may indicate how the participants feel about their experiences, and I probe questions that will not require personal feelings and show insensitivity to the participants. As I have mentioned that, the activity was given to the participants to complete in their own time during the period of a week, which gave the opportunity to motivate their practices (Khoza, 2014). Through reflection teachers get the opportunity to do introspection of their practices (Khoza, 2015a). I collected the reflective activity a week before the semi-structured interview was to take place. This gave me the time to read the reflective activity. The second phase of data gathering occurred during the semi-structured interview

3.7.2 One-on-one (semi-structured) interviews

The study used semi-structured interviews as the second technique to generate data and these were conducted after the completion of the reflective activity. Semi-structured interviews are designed as "around open- ended questions, with other questions arise from the conversation between the participants and the researcher" (DiCicco-Bloom & Crabtree, 2006, p. 315). I found, semi-structured interviews suitable for this study because it allowed the participants to be flexible, relaxed and be able to provide data about their Grade 10 geometry experiences. I started by giving teachers the opportunity to first narrate their geometry teaching experiences. After narration, they were asked questions that were based on the spider web concepts. A semi-structured interviews is a flexible way of generating data because it permits the researcher to ask questions that are based on what the participants have said during interview (McMillan & Schumacher, 2014). Hence, the interviews were conducted in a safe, welcoming, place and used the language that the participants are familiar with, the use of English and IsiZulu were encouraged in asking and answering the questions. Semi-structured interviews occurred in person, face-to-face, between me and the participants (McMillan & Schumacher, 2014). The interviews were conducted with the five teachers who completed the reflective activity. All the participants were given equal treatment and the interviews was done in different places according to the participants' needs. The interviews enhanced the data generated from the reflective activity. In order to do that, I used the same questions as in the activity to cross-examine the uniformity of what was written by the participants.

However, Cohen *et al.* (2011) state that interviews generate large amounts of textual data that can require a large amount of time to transcribe. To overcome the time limitation, the interview, for data generation, was scheduled for 30 minutes per participants. To understand teachers'

experiences, the interview questions were organised according to the curriculum spider web concepts. DiCicco-Bloom and Crabtree (2006) state that semi-structured interviews must be organised in such a way to get participants involved. The participants were allowed to use the language they are most comfortable with (IsiZulu and English). By doing this, I was trying to get and in-depth data of teachers' experiences in teaching of geometry in Grade 10 in the Umbulumbulu area. The advantages of using semi-structured interviews were that teachers were able to give their experiences, opinions, feelings, knowledge and background about the phenomenon studied, and it gave an in-depth understanding of data generated from different participants of the phenomena (Noor, 2008). However, Noor (2008) state that the limitations of the case study and semi- structured interview are that if data is not recorded to secure consistency and precise discussion it may be lost, and it is not easy to record gestures and emotions. To overcome this drawbacks, the discussion was recorded and notes taken during the discussion period, all the recordings were named after the participants used in the study (e.g. A1) to avoid mixing up the data generated and thereby creating difficulties.

The data generated from the semi-structured interview enhanced the generated during the reflective activity. Cohen *et al*., (2011, p. 425) argue that "the researcher should keep the participants on track as well keep the interview moving". As a result, I made follow up questions in order to further explore the participants' experiences of teaching geometry. This was done in the interviews conducted, the interview was directed by the participants' response and not by the order of questions presented in the reflective activity. I always stayed neutral and avoided being biased to the data generated so as not to influence the participants' responses. As a result, semi-structured interviews were used to generate data and help teachers give insight on their teaching.

In addition, (Cohen *et al*., 2011; McMillan & Schumacher, 2014) state that semi-structured interviews involve social action between the researcher and the participants. As a result, the researcher should not judge or criticise the participants. This suggests that the researcher may themselves have an impact on the data generated. To avoid this drawbacks, I did not ask the questions that will need the participants' opinion and refrain from asking questions that will need the participants to support their statements. I did not interrupt the participants while talking, but listened and showed an interest in their thought. Again, I did not ask about sensitive issue (personal or emotional matters). Due to cultural issues, I respected teachers' language usage during the interview session. I listened to the participants' responses with respect on what they said, and ensured all question are answered in a language familiar to the participants.

During the interview processes a voice-recorder, cell phone, and tablet and handwritten notes were taken to help during transcription costs and ensure that the data was recorded.

While interviews are time consuming, they were suitable for this study because I only chose five teachers which is manageable. During interview I explained to the participants the "purpose of the interview and tried to put the participants at ease" (Cohen, *et al*., 2011, p. 421). I explained that the interview would be recorded in order to prevent the lost data during the process. Cohen *et al*. (2011) state that the as one of the shortcoming. That is the reason of recording to refrain from losing the data. For a more in-depth data, generation of a focus group interview was organised after a week after the semi-structured interview was conducted.

3.7.3 Focus group interview

Focus group discussion was also conducted as the third phase for data generation in this study. A focus group interview was employed after the reflective activity and semi-structured interviewed were completed. The aim of using focus group discussion was to get a better understanding of teachers' experiences in teaching geometry. The focus group gathered the participants together to discuss with their different opinions using the same set of questions used in the reflective activity and semi-structured interview. According to Cohen *at al*. (2011) a focus group interview is used to generate a variety choice of answers. As a result, group discussion was employed following semi-structured interviews. During group discussion session, I directed the questions in the group; hence, the participants were able to interact with each other, instead of focusing to the researchers' questions only (Cohen *et al*., 2011). This discussion included the researcher and five Mathematics teachers who have participated in the reflective activity and semi-structured interview. Therefore, focus group interview was used to triangulate between reflective activity and semi-structured interview. Hence, the focus group interview helped to gather the opinions, at one time, opinion from the five participants and encourage the participants to speak about the challenges of the implementation of Grade 10 geometry.

Focus group interview was used once after reflective activity and semi-structured interview was used, to triangulate the teachers' experiences in teaching Grade 10 geometry. The focus group interview was the final stage of data generation and teachers were able to critically discuss their experiences, since they have completed the reflective activity and semi-structured interview. During the discussion period I included myself in the discussion to ensure that the teachers feel free to discuss their experiences. The discussion was designed to last 30 minutes

but it took an hour due to the need to fully explore the data that arose from the participants. Ndlovu (2012), states that the focus group interview should create a sociable place where participants are motivated by responses of others. As a result, the place set for a focus group interview was conducive to the exchange of the participants' ideas and experiences (Cohen *et al*., 2011). This is an indication that the group discussion should be conducted in a place where participants are able to share their ideas concerning the teaching of geometry. During a group discussion, participants were encouraged to speak out in their own words (Cohen *et al*., 2011). Thus, I directed the discussion among the five teachers in such a way that I also participated in a discussion and left room for a discussion of the hurdles they met during the implementation of geometry within CAPS in Umbumbulu area.

However, focus groups are not "without their drawbacks" (Cohen *et al*., 2011). Cohen *et al.* (2011, p. 437) state that, "it is not easy to decide on the number of participants in a group, and sometimes it is not easy to ensure that the participants have something to say and feel comfortable enough". To avoid this differentiation, I limited the study to five teachers in order avoid using large, unmanageable groups. To make sure that all the participants have something to say, I directed the discussion. Questions were derived from the reflective activity as the participants are familiar with these. During the discussion process, recording was used to allow for the transcription of all the data generated in the interview. The discussion was conducted once, a week after the final semi-structured interviews were complete

According to my data generation plan, I mention that I would conduct group discussion at my school. Unfortunately, on the day of the discussion, the security guard was not available to unlock the venue. Only four of the participants was able to attend. The recording of the discussion was done with the participants' permission as per the consent form they signed. During, interview session, I used a voice recorder, cell phone, and tablet so that if one device failed the others would still work. During the semi-structured interviews, I only used the voice recorder. Unfortunately, the recorder failed to record the first interview (which I was forced to repeat so I could record it) and as such I sued multiple devices for my next interview. The data generation plan is shown in the table below according to the objectives of the study. *See Table 3.1.*

Table 3.3 Data generation plan

Questions	**Objectives 1**	**Objective 2**

Why were the data generated?	To understand experiences of Grade 10 teachers in teaching geometry.	To understand the reasons for the teacher's experiences in teaching Grade 10 geometry.
How were the data generated?	Reflective activity, one-on-one semi-structured interview and focus group interview discussion.	Reflective activity, one-on-one semi-structured interview, and focus group interview discussion.
Who were the sources of data generation?	5 Mathematics Grade 10 Teachers from different Schools in Umbumbulu circuit.	5 Mathematics Grade 10 Teachers from different schools In Umbumbulu circuit.
How often were the data generated?	Reflective activity was done in first stage, it was given to teachers and collected after a week. One-on-one interview was done in the second stage and it took for thirty minutes. Group discussion was conducted in third stage, and it took for an hour.	Reflective activity was done in first stage, it was given to teachers and collected after a week One-on-one interview was done in the second stage and it took for thirty minutes. Group discussion was conducted in third stage, and it took for an hour
Where was the data generated?	One-on-one interviews was conducted in different places to meet the participants' needs. Focus group interviews was conducted in my school computer laboratory.	One-on-one interview was conducted in different places to meet the participants' needs. Focus group interview was conducted in my school computer laboratory.
Justification of this plan For data generation:	Reflective activity allowed the teachers to reflect on their experiences by writing down their responses guided by curricular spider web as a	Reflective activity allowed the teachers to reflect on their experiences by writing down their responses guided by curricular spider web

	conceptual framework for this study. Semi-structured (one-on-one) interview with discussion of a focus group interview helped the researcher to obtain in-depth analysis is of the participants' experiences in teaching Grade 10geometry. The interview schedule and questions for the interview was designed that have an inductive and deductive questions. As the researcher I had an opportunity to get first hand data.	as a conceptual framework for this study. Semi-structured (one-on-one) interview with discussion of a focus group interview helped the researcher to obtain in-depth analysis of the participants' experiences in teaching Grade 10 geometry. The interview schedule and questions for the interview was designed that have an inductive and deductive questions. As the researcher I had an opportunity to get first hand data.

Table 3.3 data generation plan

The plan helped the researcher to generate in-depth data using the three instruments mentioned above. During data generation process trustworthiness of the study was considered.

3.8 Trustworthiness

Cohen *et al*. (2011), state that, trustworthiness, credibility, dependability, conformability and transferability as the tools used in a qualitative research design. These tools were considered in this study, since this is a qualitative research that deals with meaning and peoples' experiences as individuals. Thus, this study was aimed at understanding teachers' experiences, and to reflect on the meaning of the findings. As a result, trustworthiness was considered during data generation, data analysis and data interpretation phase. To improve trustworthiness in the study, triangulation was used during data generation phase, and the participants validated the data

after analysis to confirm what they had said. As a result, during data generation I gave the participants reflective activity to complete and recordings were done during interview session to make sure that I accurately noted the exact words used by the participants. Botes and Otto (2003), describe trustworthiness as the standard of truth, value and neutrality of the research. To maintain trustworthiness in the study, I used reflective activity, semi-structured interview and group discussion for data generation. Direct quotes from reflective activity and recordings were used to maintain the trustworthiness of the data generated. I generated genuine data by using Grade 10 Mathematics teachers from different schools in order to generate trusted and objective data in my study. Therefore, direct quotes from the participants were used during data analysis to ensure trustworthiness.

3.8.1 Credibility

Credibility of the study deals with believable, confirmable and a reliability of the data generated (Spencer, Ritchie, Lewis, & Dillon, 2003). To maintain the credibility of the study, I chose participants in different schools, different sex and with different number of year in the teaching to get different experiences of their teaching. Hence, credibility of the study was improved by using reflective activity, semi-structured interviews and focus-group interviews voice recording with the participants together with the notes taken during interview sessions. The use of triangulation in the study was to ensure authenticity of the data generated (Cohen *et al.*, 2011).

3.8.2 Transferability external validity

Transferability is when the research findings can be transferred to another context by the reader (Graneheim & Lundman, 2004). Further,Cohen *et al*. (2011) state that transferability as the level when the research findings can be generalized to the population at large. I gave and explain clear the focus of the study, data collected, analysis and the findings of the study for the reader to conclude if the data can be transferred. Therefore, I enhanced transferability of the study through the clear and detailed research findings of teachers' experiences in teaching Grade 10 geometry in rural areas (Cohen *et al*., 2011). Hence, the teachers' experiences from 5 Mathematics teachers teaching Grade 10 geometry around Umbumbulu can be compared and transferable to other teachers teaching Mathematics in rural areas outside Umbumbulu circuit. This ensures that the research findings can be transferred to other teachers since CAPS (2011) is used in KZNDoE secondary schools.

3.8.3 Dependability

Dependability is the consistency of the study (Graneheim & Lundman, 2004). To accommodate consistency in the study, I generated data in an appropriate setting and at times as suggested in the data generation plan. I ask the questions from the participants based on the phenomena of the study and probe questions where applicable. All the questions were framed by curricular spider web. Hence, data analysis was given enough time for transcription to minimise biasness and subjectivity of the data interpretation by the researcher. Therefore, the participants were given the opportunity to read the findings before submission to see that the data was not interpreted wrong and the direct quote from the recordings were used to give participants the true meaning of data the generated.

3.8.4 Conformability

Conformability is the state of being neutral and reasonable (Graneheim & Lundman, 2004). To ensure conformability of the study, I used data generated from reflective activity, semi-structured interview and group discussion where data generated were kept. As a result, to strengthened conformability of the study I explained my role to the participants before the process of data generation started. To maintain honesty of the study, I used the same questions in the questionnaire, semi-structured interview and group discussion for all the participants to understand their experiences in teaching Grade 10 geometry. Therefore, I avoided influencing the participants during data generation and data analysis. Then data analysis process followed after generation stage was completed.

3.9 Data analysis

According to Cohen *et al*. (2011, p. 537) data analysis that makes meaning of the data "in particular of the participants' definition of the condition, noting designs, ideas, classifications and regularities". Data analysis tries to illustrate the conclusion from the data generated. In addition, McMillan and Schumacher (2014) state that qualitative data analysis is a well ordered process of giving definitions of a particular phenomenon studied. As a result, the study interpreted and analysed the primary data on teachers' experiences of teaching Grade 10 geometry. According to McMillan and Schumacher (2014) primary data is valuable as it derived from original sources. Secondary data is the interpretation of primary data and is not as accurate because data is interpreted by people who did not originally experience the phenomenon. This study used qualitative data analysis in examining the data according to the

participants meaning of the situation, themes and categories (Cohen *et al.*, 2011). I interpreted and presented the data to the participants in order to read the meaning of the data collected in reference to the participants teaching experiences. The data was analysed by reading the questionnaire and listening to the recordings to find the common and different experiences of teaching geometry (McMillan & Schumacher, 2014).

Qualitative data analysis comes from transcribed interviews data, and is influenced by the smaller number of participants (Cohen *et al*., 2011). Thus, from the stories told by the participants, I analysed the data generated by using guided and thematic data analysis. At first I state that I would use guided data analysis, then I used both guided and thematic analysis because I analyse the stories of the participants' experiences. Therefore, as the conceptual framework for the study, guided data analysis was used in accordance with spider web concepts. Guided data analysis describes the behaviour and the context in which the behaviour occurred using open coding (Cohen *et al.*, 2011). However, thematic analysis was used by writing, coding, theorising and reading data of the stories told by the participants about their journey in teaching geometry.

Furthermore, McMillan and Schumacher (2014, p. 364) state that "qualitative data analysis is primarily an inductive process of organising data into categories and identifying patterns among categories". Thus, I organised the raw data generated from the three stages of data collection according to the concepts of spider web. I also organised the data according to the teachers' experiences revealed during the data generation process from the participants. The data generated was reduced, displayed and concluded as based on what the participants had stated about teacher' experiences in teaching Grade 10 geometry. I also read the data generated from reflective activity, and listened to the recorded data from semi-structured and focus group interviews. Whilst reading and listening to the recorded data I wrote down what is in the generated data and classified it according to the concept of the curricular spider web. Thus, the data was analysed for similarities and differences between the five Mathematics teachers' experiences of teaching Grade 10 geometry and conclusions drawn in regard to the curricular spider web.

However, data analysis through transcription is time consuming, and transcribers are expensive (Cohen *et al*., 2011). As a result, I decided to transcribe the data myself to avoid losing meaning within the data and distorting the participants meaning of their experiences. I was able to select the relevant data I needed from the data generated. Furthermore, Cohen *et al*. (2011) state one

of the limitations of data analysis is it can be influenced by the number of participants from whom the data were generated and the way the analysis is written. To avoid the above drawbacks, I selected five participants that are manageable, and it was easy to transcribe the recording of the five participants. While analysing data, ethical issues were taken into consideration, confidentiality was maintained by using the number for the participant and letter for their school for example A1.

3.10 Ethical issues

"Research ethics help us uphold the things we value" (Johnson & Christensen, 2008, p. 99). As this study involves humans, it is important to follow ethical principles and guidelines for research ethics. To follow ethical principles, I maintained confidentiality, anonymity, privacy, caring and fairness to the participants in order to prevent them from any harm that might be caused by the research study. Thus, I submitted the application letter to ask for permission from the DoE to conduct the research within KZNDoE schools and included which schools the research will be conducted in (*Appendix 1*). Permission was granted by the HOD in KZNDoE Mr Sishi. On behalf of Department of Basic Education Nationally (DBE) Mrs Zokwane allowed access to five Secondary schools in Umbumbulu area. I was granted permission by the five principal to access their school for data generation, thereby allowing me to approach each participants and invite them to participate in my study. Fortunately, they all agreed and I explained the purpose of the study to each participant. Hence, all participants were given consent form to read and sign, in which they agreed to take part in the study (*Appendix 4*). Four of the participants who participated in the study are in my cluster. However, one of the participants is not in my cluster, but is working in Umbumbulu area. He was interested in the topic of the study and was willing to participate. It was easy to access him as I had known him for a long time. Thereafter, I explained to the participants that their names and school names would not be used in order to protect them, explained that there were no incentives, and that they were free, at any time to withdraw from participants in the study (Cohen *et al*., 2011). It also requested permission from my principal to use the computer lab as the venue for the focus group discussion.

For the sake of honesty and transparency, I explained to the participants the procedures of the research by explaining to the participants that the data generated is for educational only. Therefore, the letter from Humanities Research and Social Sciences Ethics Committee of the University was shown to the participants to assure them that I had been granted permission by

the University to conduct the study (*Appendix 2*). Then, the participants will get the opportunity to read the data generated before the data was read by others (McMillan & Schumacher, 2014). I respected the culture of each participant, and allowed the participants to use the language they are most comfortable with in order to make them feel welcomed. Voice recording was done with the permission of the participants, and the consent form signed.

However, ethical has its drawbacks, for example, failing to take care of the participants, being unfair by probing questions that will require personal response (McMillan & Schumacher, 2014). To avoid the mentioned drawbacks, I did not asked the questions that may lead to the humiliation and lose trust of the participants. Ethical principles delayed the data generation process because I could not start generating data without full approval from the University. Further, deception is another disadvantage of ethical issues. Deception violates participants privacy when the researcher do not tell the participants the truth about the research (Cohen *et al*., 2011; McMillan & Schumacher, 2014). To avoid deceiving the participants, I explained at the beginning that they are subject of a research study and provided them with the purpose of the study. I also assured the participants that there is no right or wrong answers to assure them that they could freely express themselves during the interview. I also guaranteed the participants that the data generated were not meant to judge them, and publicised data, to avoid betrayal of the participants. (Cohen *et al*., 2011). I told the participants that the data will be kept in the University archives for five years and destroyed thereafter. The access of the archives is limited to the research and supervisor.

3.11 Limitations

As has been noted the qualitative study, as a naturalistic inquiry, is time consuming when it comes to data generation, transcription and data analysis (Cohen *et al.*, 2011). Thus, the interview of 30 minutes took 3 to 4 hours to transcribe, and the gestures used by the participants were omitted during the recording of data generation. Due to and the transcription costs I decide to transcribe the data on myself to minimise the expense. Further, it was not easy to reach all the participants due to distance, and some participants arrived late for the interview. For those participants who do not drive, I offered to drive them to the place of interview. During the data generation, biasness and personal interests might influence the process and the type of data generated. As a result, feeling/opinion during interview can influence the research study. To avoid this, I explained the purpose of the research to the participants before the interview started. I also explained to them that the aim of the study is for educational purpose only. I

explained that the study relied on the data generated from participants. The study is conducted within five Grade 10 Mathematics teachers who does not represent the whole Umbumbulu circuit schools. Therefore, the findings for the study may not be generalised as teachers behave differently in different contexts (Archer & Goreth, 2004). Archer and Goreth (2004), also highlight the fact that teaching contexts are different and challenging too. This suggests that teachers' experiences will be different depending on the participants' previous and present experiences of teaching Grade 10 geometry. Another limitation is that if the participants are not given a clear description of the purpose of the study, they misunderstand the process and think it will enable them to access other employment. Therefore, before signing the consent letter, I explained to the participants that there are no incentives to the participants and no employment opportunities were going to be offered.

Furthermore, during the ethical process of gaining permission from the schools, I found that some principals were reluctant to use their schools for sampling. They wanted to know why I have chosen their schools, and who is going to ask the teacher to partake in my study. I had to clarify to the principal that the data generation process would take place outside of the school and would not occur during school hours. Therefore, I ensured that there was no school interruption for data generation, and everything remained confidential between the researcher and the participants without involving the school. Another limitation was on the participants who had a fear of being interviewed, they postponed the interview schedule. I explained to them that the interview will use the questions as in the reflective activity. In addition to the above, qualitative studies are more concerned with the data gained from the process, not in transforming the people who participated in the study.

3.12 Conclusion

This chapter explores how this research study set about answering the research questions and objectives of the study. It also described research paradigm, methods, population and sampling, data generation methods, trustworthiness, data analysis, ethical issues and limitations of the study. These allowed a fair illustration of how the research study was conducted in order to answer the main questions. Therefore, the above approaches were used together to explore Grade 10 teachers' experiences in teaching geometry. As a result, this study explained the methods and instruments used together with the advantages and disadvantages of using the selected methods. The following chapter will analyse the data generated. The aim of the next

chapter is to give meaning to the research findings gained from following the data analysis process as discussed in Chapter Three.

CHAPTER FOUR

RESEARCH FINDINGS AND DISCUSSION

4.1 Introduction

Chapter Three framed the research design and methodology that has been used in this study. This chapter will display the research findings generated from the case study of five Mathematics teachers as explained in the previous chapter. Therefore, data generated will be presented according to the concepts and proposition of curricula spider web as conceptual framework for the study. Concepts and proposition will help in displaying, synthesis and analysis of data generated from teachers' experiences of teaching Grade 10 geometry. Hence, qualitative data analysis tries to make meaning of data in terms of participants' circumstances, arrangements, ideas, classifications and regularities (Cohen *et al*., 2011). The data was generated through interviews and transcribed for data analysis to give vital aspect of the records (Cohen *et al*., 2011). The transcription of the data will be presented using numbers and letters to represent the participants and their schools e.g. A1, B2, C3, D4 and E5.

4.2 Findings and discussion

The findings and discussion are displayed following the curricular spider web concepts and their propositions using guided and thematic analysis as explained in Chapter Three. According to Cohen *et al*. (2011), qualitative analysis is influenced by the number of participants. Hence, teachers' experiences of five participants was analysed individually and coded with the same issues arose across the participants. Therefore, data analysis for this study is influenced by experiences of the five Mathematics teachers who had participated in the study. The following Table shows the concepts and levels of experiences that arose from data generation process in relation with the propositions.

Themes	**Questions**	**Categories**
1. Rationale	Why are you teaching geometry?	➢ Personal reasons ➢ Societal reasons ➢ Content reasons
2. Goals	Towards which goals are you teaching?	➢ Aims ➢ Objectives

		➢ Outcomes
3. Content	What are you teaching?	➢ Algebra ➢ Trigonometry ➢ Geometry
4. Learning activities	How are you teaching?	➢ Formal activities ➢ Informal activities
5. Teacher role	How do you facilitate your teaching?	➢ Instructor ➢ Facilitator ➢ Manager ➢ Assessor
6. Materials and resources	With what are you teaching?	➢ Hardware resources ➢ Soft-ware resources ➢ Ideological-ware resources
7. Time	When are you teaching?	➢ Hours ➢ Weeks ➢ Terms
8. Learning environment	Where are you teaching?	➢ In the classroom ➢ Computer laboratory
• 9. Assessment	How do you assess your teaching?	➢ Assessment for teaching ➢ Assessment of teaching ➢ Assessment as teaching
10. Accessibility	Who are you teaching?	➢ Physical accessibility ➢ Financial accessibility ➢ Cultural accessibility

Table 4.1 Teachers' experiences categories, questions and themes framed by curricular spider web.

4.2.1 Theme 1: Rationale

Why are you teaching geometry?

The reasons for teaching geometry is presented in three categories which are: personal (pedagogical), societal (beneficial) and content (professional) reasons. Below are the experiences emerged during data generation of teaching geometry.

Participant B2: *I teach geometry because I have a passion to work with shapes, solids, polygons, lines etc, and I want to equip the learners become better citizens in future, so that they can embark to different jobs opportunity*

Participant E5: *I teach geometry because it is within the curriculum, and is part of Mathematics that develops learners' reasoning skills*

Participant C3: *Firstly, I want to develop geometrical awareness to learners, and learners need to know about shapes as part of our everyday vocabulary for example square, circle, cubes etc. Shapes are mostly used by carpenter as part of their daily work.*

Participant D4: *I teach geometry because it is within the curriculum, Geometry helps the learners develop problem solving skills using mathematical rules (theorems). Geometry is around the living space.*

Participant A1: *Geometry is an important topic in Mathematics, because it helps the learners to develop reasoning skills, self -discovery, and be able to analyse the diagram, solve problems and make conclusions of the theorem.*

The reasons for teaching geometry are presented in three propositions which are: personal (pedagogical), societal (beneficial) and content (professional) reasons.

Most of the participant's experiences are based on societal reason, because all of the participants indicated that they are teaching geometry in trying to give back to the community, since they indicated that geometry is everyday life, and learners can embark on various jobs through learning of geometry. However, Participant B2 experience is based on personal reason he stated that *'I have a passion of working with shapes, lines and polygon'*. This is an indication that some of the teachers teach geometry because of the interest they have, and skills that

qualifies them to teach (Adler, 2005). With the love of geometry learners can develop a better understanding of geometrical concepts. Teachers' interest in teaching geometry tends to create positive attitudes towards the learners' interest in learning geometry (Ball 2003). Thus, love of the subject and skills are needed to teach geometry in order to produce good results, because learners' performance is influenced by their teachers' attitude and interest towards the teaching of geometry. Further, Ball (2003) argues that teachers who show a positive attitude towards Mathematics may gain learners' interest in learning Mathematics especially geometry, which seem to be more challenging to both teachers and learners. This is an indication that positive attitudes towards teaching and learning geometry can yield good results of the performance curriculum taught in schools (DoE, 2011)

However, the participants who reflected on their geometry teaching experiences indicated that societal reasons are also important which was significant during the time of competence curriculum (C2005–NCS). From 2012 the correct reasons for teaching are aligned to performance curriculum (content reasons). Participant E5 and D4 reveal that they teach geometry because *'it is within the curriculum'.* This suggests that teachers are teaching geometry to please the curriculum developers and to follow orders of the department of education. This is an indication that some Mathematics teachers teach geometry without identifying their own strengths and weaknesses, they teach what is given to them within the curriculum. Thus, findings indicate that geometry is part of Mathematics that needs to be taught in schools in order to develop learners' reasoning skills. Hence, Ensor (2001) indicates that geometry promotes learners' reasoning skills. This is indication that geometry is needed in most of the careers. Hence, geometry was included in the curriculum because it is needed by the society. Therefore, learners who learn geometry developed their reasoning skills in schools and they may have better jobs opportunities in future. Thus, Participant B2 states that *'I want to equip the learners become better citizens in future so that they can embark to different jobs opportunity'.* The findings reveal that geometry is needed on our daily lives and is something that we see every day. Hence, Participant D4 states that, '*geometry is around the living space'*. This suggests that geometrical shapes are visible and around us in our living space. According to Hill *et al*. (2005), teachers who experience the use of mathematical procedures and concepts help the learners in using the learned knowledge for job satisfaction (in terms of their strengths and weaknesses).

Furthermore, the above teachers' experiences on different reasons for teaching geometry indicate the practical level by Van Manen (1977) where the teachers are more concerned with

the objectives and beliefs. Hence, Hatton and Smith (2005) argue that the outcomes of the practice is not accessible for change and evaluation. This is an indication that societal reason does not bring change to teachers' experiences of teaching geometry. They are teaching geometry because it is within the curriculum, which indicates that teachers do not read studies on the reasons for teaching geometry. Furthermore, Participant B2 experiences were on technical level and critical level, since he started with his personal reasons of working with solids. The love of working with solids would help the teacher to choose the correct teaching methods, and tools to use during the teaching process (Van Manen, 1977). This is indication that teachers who shows positive attitude towards Mathematics may gain learners' interest in learning Mathematics especially geometry (Ball, 2003).

However, Participants A1, C3 and D4 experiences were on critical level when mentioning the reasons of developing geometrical awareness to the learners. At this level teachers' experiences on their teaching was to develop geometrical ideas when teaching geometry. Looking back to their experiences by self-criticism based on the results of study shows where their attentive thoughts examination for the reasons of teaching geometry in their educational experiences (Schön, 1983). Thus, participants who reflected on personal reasons apply their teaching experiences and existing knowledge together with theory to develop learners understanding (Kirby, 1988).

In addition, Mathematics teachers believe that geometry is a practical topic and must be useful in the community. This is an indication that teachers experience the teaching geometry to impart geometrical ideas to the learners and enable learners with different learning abilities (Ball, 2003). However, this can be done through teachers' content knowledge of geometry. Participants A1, C3 and D4 responses show that geometrical reasoning is important in teaching the content. Participant A1 states that *"Geometry is an important topic in Mathematics, because it helps the learners to develop reasoning skills, be able to analyse the diagram, solve-problem, and make conclusions of the theorems".* This suggests that geometry helps the learners to develop reasoning skills. Therefore, learners with high ordered of reasoning skills develop their self -discovery since they give reasons for their proofs. Learners' reasoning power is influenced by their teachers' content knowledge (Mji & Makgato, 2006).

Furthermore, Participant C3 states that *'I want to develop geometrical awareness to the learners, and learners to know about shapes as part of our everyday vocabulary'.* The participant indicates that geometrical awareness helps the learners to recognise different shapes

and classify them according to their properties. This suggests that teachers should develop geometrical awareness among learners. Therefore, geometrical awareness cannot be developed, if the teachers lack professional knowledge of the subject. Ball *et al*. (2008) indicate that pedagogical content knowledge is important in bridging the content reasons and classroom practices. This concludes that society can benefit more from content reason together with personal reasons. However, not all the participants indicated on content for teaching geometry. This is an indication that teachers experience the use of content reasons as important in their teaching of geometry within the performance curriculum. However, if teachers experience content reasons, it would mean that teachers are aware of the intended curriculum they teach, because it provides least information of the content and concept (Hoadley & Jansen, 2013). This would mean that teachers are in line with the promotion of school knowledge (Hoadley & Jansen, 2013)

Mathematics teachers' experiences generated from the three forms of data generation show that geometry is taken as an important part of Mathematics that needs to be taught in order to develop learners reasoning skills. They further, agree during group discussion that learners have negative attitude towards geometry, since they have negative attitudes towards Mathematics as a whole, let alone geometry. However, Participant D4 emphasises the use of geometrical ideas in problem solving. This suggests that learners should "develop geometrical knowledge and understanding in the use of geometrical figures and theorems and be encouraged to develop their use of conjectures, deductive reasoning and proofs (Brown, Jones, Taylor & Hirst, 2004, p. 127). Hence, the above findings show that teachers are not readings the studies based on geometry teaching as suggested by Brown, Jones, Taylor and Hirst (2004).

I conclude that the Mathematics teachers' responses indicate that they did not read further studies on the teaching of geometry within the performance curriculum. This is an indication that they are not driven by content reasons for teaching geometry, which is the vision for the performance curriculum, therefore they are working against CAPS. Furthermore, responses from group discussion indicate that teachers have experiences of working with learners who have a negative attitude towards Mathematics. They indicate that it is because learners' geometrical concepts are not well developed. According to Jones and Mooney (2003) geometrical concept needs to be developed at an early stage. The findings also show that Mathematics is taken as an important subject in the Science field but learners' performance is poor, and some they learn Mathematics because it is within the subjects in the school curriculum. This is an indication that learners are more influenced by their teachers'

experiences of teaching and learning geometry: the influence of society rather than content reasoning. Thus, rationale can helps the teachers to promote the aims, objectives and outcomes of CAPS.

4.2.2 Theme 2: Goals (aims, objectives and outcomes)

Towards which goals are you teaching geometry?

Participant A1: *My goals for teaching geometry are: to develop the independent matured citizens who can do things on his her own and who can do things independently. The second reason for teaching geometry is to produce learners with better understanding of the world more especially in things that surround him or herself. Thirdly, we want the learners to be able to make good decisions after logical reasoning. I can add that most people do not like Mathematics. I want to increase the number of people who are Mathematical orientated in South Africa who can boost the economy of the country.*

Participant B2: *In my teaching, I focus on aims, because aims contribute to the community in a way that learners can embark on scarce jobs. To achieve the aims, I prepare my lesson thoroughly, assess them and give my learners feedback.*

Participant C3: *My lesson is specifically designed based on aims, because at the end I want the learners to develop number sense and learners should be able to use numbers and number relationship in problem solving situations and communicate the reasoning used in solving these problems. According to my views, aims and objectives are important because you are able to see if the learners have achieved what were you teaching in the classroom. Also aims and objectives help me as a teacher to see if I need to add more effort or not, when I'm teaching geometry learners must be able to calculate using theorem of Pythagoras, calculating the angle and measuring and to prove similarity and congruence in a quadrilateral.*

Participant D4: *My lesson is based on objectives because it is what we test, and to let the learners to accumulate all the theorems e.g. calculating the distance between two points using distance formula, the main aim is to equip learners who want to become engineers and aims are promoted through the content they learn at school.*

Participant E5: *I think the aim of teaching geometry is: the learners need to be able to solve problems in the class, and also in real life situations, both as groups and as individual with a high level of competence. They must be able to measure, calculate, relate and deduce out of*

completed calculations. Ultimately they need to be versatile and even switch jobs as they wish and as per market demand.

The data generated from reflective activity and interviews on Mathematics teachers' experiences suggest that the participants are teaching geometry focusing on aims (long term goals) and objectives (short term goals). The objectives were designed in line with one of general aims of Mathematics curriculum that is to yield learners who are able "to identify, solve problems and make decisions using critical and creative thinking" (DoE, 2011, p. 5). This is an indication that short term goals need to be in line with the long terms goals in order to produce the intended results of the performance curriculum. Therefore, teachers were using objectives in their teaching. Hence, they design their lessons based on the objectives known as specific aims in the curriculum. The findings also indicate that teachers are teaching geometry to help the learners to be mature citizens and take sound decisions after analysing the situation. They explain aims as the most important goals of the curriculum. However, Participants C3, D4, and E5 mention the importance of objectives in teaching geometry because they use it as a mirror for the lesson.

These findings indicate that skills and knowledge acquired from Mathematics is needed in real life situation. This is an indication that teachers design their lesson having the aims in their mind since they mention that they want the learners to become better citizens in future. Thus, teachers reveal that long term goals are important and will help the learners to be able to discover themselves. Participant A1 states that '*to develop the independent matured citizens who can do things on his her own and do things independently'.* Therefore, geometry contributes in helping the learners to work independently and those learners will be able to take decision on their own. As a result, they use societal reasons to develop learners' self-discovery through independent matured South Africans. Therefore, the findings show that teachers are good in using aims in their teaching. Furthermore, Participant A1 states that, *'I want to increase the number of people who are Mathematical' orientated in South Africa who can boost the economy of the country'*. Participant E5 also states that, *'aim of teaching geometry is: the learners need to be able to solve problems in the classroom and also in real life situations, both as groups and as individual with a high level of competence'.* Therefore, the findings suggest that teachers' experiences are driven by societal reasons, which means that the teachers are pushing the curriculum towards competence curriculum, and South African curriculum is a performance curriculum, which is driven by content and uses aims and objectives as the reasons for teaching geometry (DoE, 2011). This is an indication that teachers who are driven

by content reasons are reading the studies on the subject they are teaching. Since they indicated more experiences of using aims and objectives that are promoted by CAPS which are: the use of theorem of Pythagoras, distance formula, prove similarity and congruence as well as the proofs on parallel lines (DoE, 2011).

In addition to the above, aims is broad general statement of teaching intention (Kennedy *et al*., 2009). Thus, the findings were in line with this general statement of problem solving. As a result, all the participants mention that geometry help the learners to develop the skill of solving problems in real life situation. This suggests that problem solving skills is learnt and acquired through Mathematics. Hence, learners will be able to participate as responsible South African in life and can compete internationally with other countries. This is one of the reasons that CAPS (2011) was intended for, to produce learners who can compete nationally and internationally. Furthermore, Anderson (2002) argues that aims outlines learning during teaching. This suggests that geometry aims should be understandable if they use properties of quadrilaterals, triangles and parallel lines to solve problems. Hence, geometry aims suggest that learners should be able to classify geometrical shapes according to their properties and be able to solve geometrical proofs with a good understanding. Therefore, if teachers are not aware of the aims of the intended curriculum, therefore outcomes of the subjects would not be achieved.

Thus, Mathematics teachers must understand the concepts of intended curriculum together with the implemented curriculum to bridge the gap of prescribed and practised curriculum, because it gives absolute perspectives of teaching process and teachers change the plan into practice as the interpreter of the curriculum (Hoadley & Jansen, 2012). Therefore, Mathematics teachers should experience teaching geometry in schools in a meaningful way for the learners to achieve the principles of the implemented curriculum. As a result, teachers are expected to design the lesson that will be meaningful to the learners and promote the aims and objectives of the curriculum (Chisholm, 2003). Furthermore, Mathematics teachers' experiences reveal that the implemented curriculum puts more pressure on teachers because it anticipates learners at this phase to obtain skills and abilities that may enable them to use spatial knowledge and features of geometrical figures and objects and solve problems productively and crucially. Therefore, teachers are teaching geometry irrespective of the aims and objectives prescribed for the intended for the performance curriculum (content reason) to be implemented. According to Khoza (2013a) teachers should be parallel with aims, objectives and outcomes to do fairness

to the learners. This suggests that teachers should promote objectives that are in line with aims of the performance curriculum known as specific aims and curriculum aims.

However, objectives were mentioned as important in teaching geometry, because they assess learners based on objectives instead of assessing learners according to their achievement of outcomes not objectives. This is an indication that teachers should assess the learners to see what the learners can demonstrate as a result of learning process (Hargreaves & Moore, 2000; Kennedy *et al*., 2009). According to Carl (2009), objectives tell what the teacher wants to achieve at the end of the lesson in terms of educational objectives. Hence, the findings from three participants indicate that teachers' main focus is on outcomes because they are worried about testing the learners and they were not able to differentiate between aims and objectives. For example, Participant D4 states that, *'my lesson is based on objectives because it is what we test, and to let the learners to accumulate all the theorems e.g. calculating the distance between two points using distance formula'*. Participant C3 *'learners must be able to calculate using theorem of Pythagoras, calculating the angle and measuring and to prove similarity and congruence in a quadrilateral'* and Participant E5 *'They must be able to measure, calculate, relate and deduce out of completed calculations'*. This is an indication that teachers were confusing the difference between the aims, objectives and outcomes towards the performance curriculum. The words used by the three participants *'calculate, measure'* are the key words for the outcomes. The study by Krathwohl (2002), defines objectives as an intended learning outcomes, the use of distance formula and theorem of Pythagoras are objectives (what the learner is expected to learn), and when the learner is able to calculate using the given formula that is what the learner can do as the result of the lesson taught. What is experience by the teachers in their teaching; is to see the learners calculating using the relevant formula, measuring the angles and be able to use properties of quadrilaterals in proving similarity. This suggests that teachers were not clear about the objectives and outcomes of the lesson. This is an indication that the teachers' experiences are on practical level where teachers are worried about classroom situation of everyday curriculum practice (Van Manen, 1977). Therefore, teachers are worried about objectives to be achieved.

In addition, Khoza (2013b) states that objectives-driven lesson used teacher-centred approach. Objectives driven teaching is align with Tyler's approach (Hoadley & Jansen, 2013). Based on the above findings, teachers' experiences indicate that they design the lesson based on the objectives between content, materials and learning activities. The objectives of the teaching rely on the teachers' intention. This suggests that teachers put more attention on objectives as

the curriculum is standards-driven instruction, and the teaching focus on standardized tests set by the department (Engelbrecht & Harding, 2008). This concurs with Participant 4D *'my lesson is based on objectives because it is what we test',* on the other hand, Participant C3 states that *objectives (calculate, measure and to prove on similarity and congruence in quadrilateral) help me as a teacher to see if I need to add more effort or not, when I am teaching geometry'*. This experience indicates that teachers use objectives instead of outcomes.

Further, the result for teaching geometry must develop reasoning and let the learners to discover mathematical problems on their own (Giacardi, 2010). This concurs with Participant D4 who states that objectives enable the learners to learn geometrical theorems. When learner are able to prove theorems independently, measure the angles and calculate using the given formula would mean that objectives of the lesson is accomplished. According to the specific skills set out by CAPS, learners should develop the use of "spatial skills and properties of shapes and solve problems creatively and critically" (DoE, 2011, p. 9). This suggests that the objectives of teaching geometry in schools are to develop spatial reasoning skills to the learners. The participants know about the learning outcomes, but fail to explain how the learning outcomes should be promoted. Hence, teaching geometrical theorem should be achieved through objectives of that particular lesson. Learners cannot learn all the theorems at the same time. The teachers teach one theorem at a time, and that is where objectives of the lesson are achieved. Hence, aims and objectives must demonstrate the outcomes from the learners (Berkvens *et al.*, 2014). Thus, teachers' experience shows that teachers are not aware of the learning outcomes.

However, teachers did not reveal their experiences on outcomes. Outcomes are what the learners can do in the real-life situation after learning process had occurred (Hargreaves & Moore, 2000; Kennedy *et a*l., 2009). According to Kennedy *et al*. (2009) learning outcomes should be in line with Blooms' levels of taxonomy namely: knowing, comprehension, application, analysis, synthesis and evaluation. The lack of knowledge between aims, objectives and outcomes showed by Mathematics teachers' experiences is also evident in Khoza (2014) where he reveals that teachers do not understand the difference between aims and objectives. This suggests that if teachers do not understand the outcomes of the performance curriculum, they manage to work with the curriculum. In other words, they favour the principles of the competence curriculum. Hence, learning outcomes should promote the learners' reasoning skills according to the cognitive domain (knowledge, comprehension, application, analyse, synthesise and evaluate). Therefore, geometry teachers should use the

simple verbs of cognitive levels (write, describe, solve, analyse and justify) as a means of helping the learners in achieving outcomes (Kennedy *et al*., 2009). The learning outcomes are what the learners can demonstrate as the product of learning. This suggests that geometry teachers should assess knowledge when the learners are able to define and identify, classify and construct, analyse and calculate, summarise and organise, justify and conclude any theorems of geometry. Therefore, this is an indication that teachers are using societal reasons (competence curriculum) and South African curriculum is based on content reasons (performance curriculum). Hence, teachers who are driven by professional/content reasons in teaching performance curriculum focus on professional/content reason in teaching performance curriculum driven by the content knowledge. If the teachers are more influenced by societal reasons and focuses on every day (general) knowledge, which would mean they are teaching focusing on the community context and culture. This is an indication that teachers are missing the point on CAPS because their responses are based on the society.

During group discussion, teachers' experiences signify that there is some misunderstanding on aims and objectives. Some participants agreed during group discussion that they do not read on the aims, they design the lesson based on objectives they want to achieve. The participants did not use the levels of learning outcomes where the learners need to achieve: understanding, analyse, use logical thinking, make arguments and question on what they have learnt. In addition, teachers should understand clearly Mathematics' specific aim to develop learners' knowledge and ability to use geometrical properties and theorems and promote the development of making conclusion and proof (Brown *et al*., 2004).

According to Khoza (2013b) for the teachers to do justice to the learners, their planning should be parallel to aims, objectives and outcomes. If Mathematics teachers are not aware of the specific aims, they won't be able to align the classroom activities with the specific aims of the intended curriculum. Mathematics teachers' experiences indicate that there is a need to call on the subject aims to make them clear and concentrate on what Mathematics as a subject want to attain. Therefore, aims objectives and outcomes should be promoted through the content of the curriculum.

4.2.3 Theme 3: Content (Euclidean and analytical geometry)

What are teaching in geometry?

Participant D4: *I teach theorem of Pythagoras which is mostly used to calculate the length of side in a triangle. I teach mid-point theorem, gradient, distance between the points and calculation of the unknown value of the points, when, I teach circle theorem I relate with rondavel which forms the basis of circular, I also teach calculating the volume, capacity and I also teach theorems on triangles (congruence and similarity), quadrilaterals and lines (parallel lines).*

Participant: C3: *I teach Euclidean geometry and analytical geometry. Euclidean geometry we teach theorems like Pythagoras because it is relevant in real life. Where they calculate the unknown side using the formula which says, the hypotenuse (longer side) is equal to the sum of the other two sides squared. When I teach this theorem I also taught them to calculate and relate to the equation of solving x. I teach theorems on quadrilateral and parallel lines. In analytical geometry, I teach mid-point theorem and calculations of the distance between the two points, but I can say that the learners are afraid of the word geometry, they work well with me in the classroom the problem start when they are working on their own.*

Participant A1: *In geometry most of the time I teach the learners to construct shapes so that they will be able to recognise shapes and with their properties and how to use those theorems and shapes they know practically in real world. I teach types of lines (parallel lines), angles, calculation the length of a sides in a triangle using theorem of Pythagoras and proofs of congruence and similarity in quadrilaterals and triangles. I teach calculating the distance between two points and mid-point theorem.*

Participant B2: *The content has Euclidean and Analytical geometry where I teach theorems in triangles, different types of lines and quadrilaterals. The theorems on triangles used properties of triangles and quadrilateral e.g. in an isosceles they have to know that two opposites are equal in length therefore base angles are also equal. When calculating the size of the angles or sides of any shape algebra is used as a means of calculating; in analytical geometry. I also teach midpoint theorem on triangles and between two points. Learners must learn mid-point theorem and gradient (slope) of the line, but the gradient start from Grade 9. What I experience in teaching these topics there is a high failure rate because of negative attitudes of the learners not based in geometry but towards the whole subject Maths. In trying to deal with this, I use different approach in teaching and design the lesson for the learners to understand although it is not guaranteed to give 100%. The problem in understanding is that*

they do not know the difference between the triangle and they are confused in naming the properties of each shape. In all they are having problems in geometrical concepts.

Participant E5: *Content has analytical and Euclidean geometry: Euclidean has parallel lines angles and triangles. In triangles, we do theorem on (similarity and congruence), theorem of Pythagoras in a right-angled triangle and mid-point theorem. I also teach theorems on quadrilateral and their properties e.g. square, rhombus, parallelogram etc. Investigating conjectures of quadrilaterals proofs and riders, and in analytical geometry there is distance, gradient and mid-point between points.*

From the above teachers' responses on the content of Grade 10 geometry, they teach Euclidean and analytical geometry. The teachers indicate that geometrical figures with their properties are the main concepts of teaching geometry in Grade 10. The teachers mention that properties of geometrical figures help the learners to draw, construct and differentiate the shapes according to their features. The participants mention the sub-topic under each topic they teach. They state that in Euclidean geometry they teach Pythagoras theorem, similarity and congruence in triangles and proof on quadrilaterals as well as theorem on parallel lines. According to analytical geometry they teach distance between two points, gradient of a line, and a mid-point theorem. This is an indication that teachers were clear of what are they teaching as prescribed in geometry. This concurs with Berkvens *et al*. (2014) who argue that content is the subject topics that need to be covered and should be in a suitable level with the peoples intended for in such a way that it develops creativity and critical thinking. The findings indicate that teachers are aware of the content they teach as structured in the policy document. They are also clear about the theorems they are supposed to teach in order to promote learners spatial reasoning ideas as specified for the Grade 10 learners. According to Naidoo (2012) geometry content in Mathematic promotes learners' reasoning on spatial ideas. This suggests that learners' spatial reasoning is developed when learners are able to draw, measure, and construction geometrical shapes.

The above teachers' experiences indicate that properties of geometrical shapes are important in proofs and theorem. Participant E5 states that *'I teach theorems on quadrilateral and their properties e.g. square, rhombus, parallelogram etc'.* Looking to Participant A1 states that '*I teach the learners to construct shapes, so that they will be able recognise shapes according to their properties.* This agrees with Achor *et al*. (2010); Naidoo (2012) who state that geometry in Mathematics deals with the measurement, properties of points, lines and other geometrical

figures This is an indication that although quadrilaterals differ according to their properties but, learners can be able to differentiate them using their properties. Therefore, learners can master and conduct proofs on quadrilateral with the help of properties. However, the two participants argue that when teaching the theorem in geometry, algebra is used as a tool of calculation. Participant B2 states that, '*When calculating the size of the angles and sides algebra is used as a means of calculating'* and Participant D4 states that '*I also teach calculating the volume, capacity'.* This suggests that algebra is used in calculating since there are so many calculations done in geometry. Algebra is the main source of numbers and operation mathematically into a classroom practice (Blanton & Kaput, 2005). This is an indication that, geometrical reasoning in learning geometrical theorems links with algebra. This agrees with Participant C3 when she reveals that using theorem of Pythagoras is related with the equation of finding the unknown value, '*when I teach this theorem I also taught them to calculate and relate to the equation of solving'.* Therefore, algebra is useful in Mathematics to communicate learning of any form.

In addition, Katz and Barton (2007) state that algebraic concepts are used geometrical in nature, where numbers are used in solving equations. They agree with the teachers where they state that theorem of Pythagoras and distance formula are in an algebraic form. This is an indication that the use of relevant formula is important, and that learners must be able to substitute in a given formula. Participant C3 argues that the theorem of Pythagoras is important for the learners to know that the longer side is equal to the sum of other two sides squared. "*They calculate the unknown side using the formula which says the hypotenuse (longer side) is equal to the sum of the other two sides square'.* This is an indication that properties of a triangle are vital so that the learners are able to identify the longer side of the triangle. Furthermore, teachers also indicate that Grade 10 learners should know all the geometrical figures with their properties, since they use properties when dealing with congruency in quadrilaterals.

However, Participant C3 response indicates that learners encounter difficulties when doing proofs on theorems. This gives the teachers a challenge of dealing with learners having negative attitudes towards Mathematics. Participant C3 states that *'learners are afraid of the word geometry'*. During group discussion teachers argue that, learners have a negative attitude towards geometry, this hinder them to develop geometrical reasoning skills. They also added that the learners' failure is caused by the lack of understanding geometrical concepts and symbols used in the geometry content. This is an indication that learners at this levels lack geometric concepts, and teachers need to start by teaching the content that should been taught in previous grades. They extend the understanding of geometry with trigonometry and algebra.

When calculating using the trigonometric ratios, the understanding of geometric concepts is used as well as Algebra in expressing trigonometric ratios (Birman & Nomizu, 1984; Catoni *et al*., 2005). They further state that Trigonometry is related to geometry. Calculating the angle of inclination in trigonometry, learners have to recall theorem on parallel line and perpendicular lines. Learners fail to apply knowledge learned in a new situation. This suggests that all geometrical aspects connect with each other in completing the proofs.

Mistretta (2000), argues that geometry is a vital portion in Mathematics that improves learners' reasoning skills. The geometry content taught by Mathematics teachers in Grade 10 depends on shape, space, movement and spatial ability (Jones, 2000). The space, shape in geometry should help the learners in developing visual and spatial reasoning skills. Looking to Participant A1 where he states that '*how to use theorems and shapes they know'.* This indicates that the geometry content taught in schools should be interesting and relevant to the real life situation. On the other hand, curriculum designers should design geometry that will be relevant to the learners and all the issues of the curriculum should be clearly stated in the intended curriculum for implementation (Hoadley & Jansen, 2012). During focus group discussion teachers argue that the content list which topic to teach in Euclidean geometry and in analytical geometry, but the teaching strategies are not mentioned. This suggests that teachers were driven by the societal reason from competence curriculum although they were supposed to be reading studies on geometry in order to teach geometry content (content reason from school knowledge) successfully. Jones (2000), states that the concerns should be on the content, aims, how geometry is acquired, methods utilise, and which proofs and theorems to emphasise. This is an indication that geometry should be taught in schools in a way that develops the reasoning skills, visual and spatial ability.

From the data generated during the three phases, I can conclude that if teachers lack pedagogical content knowledge of geometry, there will be a high failure rate of the learners. The way the content is delivered depends on the teachers' content knowledge of the subject. But there are factors that might contribute to poor performance namely: teaching strategies, content knowledge and understanding, motivation and interest, laboratory and syllabus non-completion, parental role and language (Mji & Makgato, 2006). This concurs with Participant B2 where he states that '*he had experienced the high failure rate of geometry in his teaching'*. This suggests that the failure can be caused by many factors other than the teachers' style of teaching geometry. However, during a focus group discussion teachers agree that geometry is a practical subject, so learners need to be hands on during teaching and learning in order to

communicate the content to be taught. Furthermore, teachers were also familiar with geometry topics that need to be covered in Grade 10. To sustain the topic taught, teachers need to develop learners' basic geometrical ideas and more complicated extraordinary attitude to solve geometrical problems and make conjectures on theorem (Giaquinto, 2007). Thus, teachers with deeper understanding of the content will be able to design learning activities in an interesting way to the learners.

4.2.4 Theme 4: Teaching activities

How do you teach geometry?

Formal activities versus Informal activities

Participant D4: *I use telling method, give all the theorems that exist within the problem and I give them worksheet to work on. I prefer learner-centred activity where I let them construct the triangles, draw and cut the triangles.*

Participant C3: *I use instruction method and assessment. I work separately with those having difficulties more especially those who are lost and do not have an idea of what to do, and give help to the other who managed to work on their own, but I usually use different method to accommodate all the learners and I give more examples if I see that there is something missing and it depends on lesson.*

Participant A1: *Learning activities must be based on the objectives I want to achieve in the lesson. There are many ways of designing the activities; it depends on what I am going to teach, because when I'm teaching theorems on shapes, lines, circular and quads that must be in line with the objectives for example in triangles they must know that it has 3 sides and differ according to its sides and angles, sum of the angles is equal to* 180^0*, have names according to their sides.*

Participant B2: *I use learner-centred activities, where they write down, but it depends on the lesson I have to teach on that particular day and I normally design a worksheet activity where learners can write down to reinforce some of the concepts, and to check if they were actively involved during the lesson.*

Participant E5: *I use assessment method by using previous question papers (Grade 9) to check pre-knowledge. When introducing the topic, I give explanations of applicable terms. I also let*

the learners to take the lead/do the activity following the examples given on the chalkboard. I also give the learners classwork and homework.

The above responses indicate that teachers use different learning activities when teaching geometry. Those activities can be group work, teacher-led and whole class activity where learners work as an individual (Mercer & Sams, 2006). The findings suggest that the use of different learning activity is valuable in accommodating different learners' abilities. This suggests that teaching should be part of active learning (Berkvens *et al*., 2014). The use of different activities helped teachers to recognise learners' strengths and weaknesses in learning geometrical concepts. When the activity is designed, they focus on objectives that need to be achieved under the supervision of a teacher. The lesson that is driven by objectives is more of teacher-centred approach, because learners have to follow instructions given and they cannot learn on their own (Engelbrecht & Harding, 2008). As a result, giving instructions and examples indicate that the lesson is design to promote objectives. Participant A1 states that, '*in triangles they must know that it has 3 sides and differ according to its sides and angles, sum of the angles is equal to* 180^0*, have names according to their sides'* This suggests that teachers are more concern about the achievement of objectives in their teaching. The findings indicate that teachers' perception is on technical level of educational experiences, where they are worried about the teaching methods to use, and the achievements of the objectives in the classroom (Yost *et al*., 2000).

However, teachers' experiences indicate that they design the lesson in the interest of the learners. Hence, Atebe and Schafer (2010) state that instructional methods in geometry classrooms provide learners with inadequate opportunity to learn geometry. As a result, Mathematics teachers reveal that they use different learning activities to help learners to learn and although instructions were used, the learners were given the opportunity to work on their own. Furthermore, the findings from reflective activity and semi-structured interview reveal that the teachers design activities for the learners. From the three participants' responses: B2 '*I use learner-centred activities, where they write down',* Participant D4 '*I prefer learner-centred activity where I let them construct the triangles'* and Participant E5 *'I also let the learners to do the lead/do the activity following the examples given on the chalkboard'.* This suggests that learners learn better when doing things on their own. Thus, teachers who use learner-centred activities gain learners' attention and that teaching encourages the learners to be part of learning (Berkvens *et al*., 2014).

Furthermore, during the focus group discussion teachers state that, it depends on the lesson for the day, on which activity to use. They also mention that they design the activities for classroom use only, since they are working in rural areas learners are not expose to learning technologies. Hence, Stols (2007) argues that on-line learning activities may be useful to learners who are expose to technology and can make geometry easier for learners with geometry comprehension difficulties. Using technology can contribute in helping learners to learn geometry with understanding. However, the above responses were based on the classroom practices; this type of experience is seen as a practical experience in the real classroom situation where teachers are concerned about their practices of everyday curriculum (Van Manen, 1977).

Therefore, I can conclude that teachers are teaching geometry using different activities as stated under CAPS. Different activities help to draw learners' interest of learning geometry and have better understanding. The use of different learning activities is important to accommodate learners with different learning disabilities. However, instructional method is use to cover the content than focusing on how learners learn geometry. Thus, the teachers design the activities for the learners. This is an indication that teachers are on track of the South African context (CAPS), because their focus is on performance-based curriculum rather than competence curriculum (Hoadley & Jansen, 2012). Furthermore, Handal and Herrington (2003), state that the way the learners learn Mathematics in the classroom is influenced by teachers' opinion and their experiences. The group discussion reveals that teachers have no control on the curriculum they teach and CAPS prescribe what to teach and what is to be achieve by the learners. This compels the teachers to follow the fixed curriculum prescribed nationally.

In addition, learners learn geometry from the way the teachers design their teaching. When learners are involved in their learning they learn better. Therefore, structured (formal) and unstructured (informal) learning activities should be used in designing the learning activities to accommodate learners' diversity (Khoza, 2012). However, Participant E5 states that, *'I use assessment method (previous question papers) to find previous-knowledge'*, assessment is use to find learners' previous knowledge to build on with the new knowledge. This is an indication that existing knowledge is vital in building new knowledge. I can conclude that, since CAPS does not outline informal activities a teacher can use in the classroom, they design the activities according to the available resources. Teachers design informal activities differently while using same CAPS document nationally. Therefore, learning activities determine the role played by the teacher during teaching and learning process.

4.2.5 Theme 5: Teacher role

How do teachers facilitate their teaching?

Participant C3: *When I am working with the learners, firstly I want them to understand the instruction given, because it is important to follow the instruction so that they will know what to do. I make them understand the information needed so that they will know how to calculate or what to prove and I give more class work.*

Participant A1: *I use instruction in the beginning of the lesson, to drive the lesson the way I want, and instruction helps to bridge the gap of previous knowledge and slowly get to the present lesson. I believe that a teacher must be a facilitator so that learners must be part of the lesson. As a teacher I give instructions, hints and support that is needed by the learners for example, when I introduce the lesson the learners must show passion, interest and eager to learn. If learners own the learning they feel important, and I pick up bits and pieces during the lesson. I noticed that that is what they like the most to find answer on their own. I use rope to make a triangle, then back to straight line, to show how the sum of angles of a triangle equal to $180^0$and I use different roles depending on the lesson I taught. Sometimes I assess the pre-existing knowledge before introducing the lesson.*

Participant B2: *I use instructions when introducing the lessons and give them activity to do based on the lesson taught, I facilitate during the lesson and give instructions, and my facilitation is mostly based on questions and answer, I give them work sheet designed after marking I give them the worksheet to make them realise where did they go wrong*.

Participant D4: *I give instruction step-by-step on what to do. I facilitate geometry because it is a hands-on topic. I want them to be able to see the entire theorem that will take them to the destination.*

Participant E5: *I lead the lesson in the introduction of the topic for the day, by giving explanation of the topic, then examples followed by the class work after marking the class work reflection on class work (correction). I give them worksheet to work on avoid going an extra mile as a teacher than I supposed to go in the classroom thereafter I give homework sometimes I use assessment method (previous question paper) to find the previous knowledge from the learners.*

The participants' responses on their experiences show that teachers use work sheet to work on during their teaching. The use of work sheet gave the learners an opportunity to find answers on their own. The findings also indicate that they are instructors. They mention that they give instruction to be followed by the learners when completing the task. Three participants mention that they use instruction when introducing the lesson. Participant D4 mentions that instructions are systematic. This indicates that learners learn geometry the way the teacher wants. Hence, the use of instructional approach in teaching geometry is associated with traditional approach. As such, teachers ought to change from using traditional approach when teaching geometry so that learners will participate in the learning to fulfil the outcomes of the performance curriculum (Mthembu, 2007). This suggests that, teachers who uses instructional approach are driven by teacher-centred approach of teaching which promote aims and objectives (Khoza, 2013a). The above findings show that these teachers are align with Tyler' approach which promotes objectives (Tyler, 2013). On the other hand, during group discussion teachers state that they instruct the learners when drawing and cutting of the triangles and quadrilaterals (cut and paste). Participant D4, states that *'I give instructions step by step'.* The participant' experiences indicate that learners are expected to follow teachers' instruction when completing the activities. They state that instruction is used because they work in the schools where there are no enough resources. This work well when learners are working in groups sharing resources. The findings also reveal that teacher use instructions to help the learners that find difficulties when working alone due to lack of geometrical understanding. As a result, Hannafin *et al*. (2001) state that due to geometrical language barrier, teachers tend to lead the lesson and to control the class while the learners are allowed to work on their own towards achieving geometrical concepts. This is an indication that teachers experience the use of instructional role helpful in controlling the classroom while learners learn at the same time.

From the above responses, teachers indicate that facilitating is commonly used when teaching. This indicates that learner-centred approach is also used when teaching geometry. The findings also indicate that teachers use learner-centred approach to involve the learners in their learning, but they are not aligning with CAPS which is more of content-centred. As a result, van der Walt and Maree (2007) state that learner-centred (meta-cognitive) approach helps the learners to develop geometrical cognitive skills. This is an indication that being a facilitator helps the teacher to involve learners into the learning process and develop their geometric ideas. Thus, teachers who use learner-centred approach are driven by competence curriculum (Khoza, 2014). Further, the participants state that they use instruction while facilitation takes place.

This suggests that facilitation is used together with instructional role. Participant B2 states that '*I facilitate during the lesson and give instructions, and my facilitation is mostly based on questions and answer'.* This suggests that the use of different role is necessary in teaching geometry. Thus, instruction helps in giving directions to the learners, and they claim that it helps the learners to bridge the information gap between the existing and new knowledge.

However, two Participants A1 and E5 indicate that they use assessment role in their teaching, no participant mention the use of a managerial role. Both participant state that assessing learners was used to find geometric knowledge learned from the previous grade. They indicate that pre-existing knowledge is needed to help the learners connect with new information. Participant A1 states that, '*I assess the pre-existing knowledge before introducing the lesson'*. The participant indicates that pre knowledge helps the teachers to find learners' understanding of the previous work, and it shows that teachers do not take the learners as empty vessels. This is an indication that, assessment is used to bridge the gap between previous and new knowledge. As a result, Weldeana (2008) argues that assessment is important when using the teacher-centred approach. This suggests that assessing learners' geometric knowledge needs accurate assessment in order to meet the learners' needs (Darling-Hammond & Snyder, 2000). Hence, Participant E5 states that he used previous question paper to assess the learners. The previous knowledge is used as a building block of information. Therefore, teachers need to know on how to link assessment with their teaching (Krishnannair & Christiansen, 2013).

In addition, teachers' experiences indicate that they just choose the role that will meet their teaching needs of geometry, since the findings on the rationale and on goals indicate that teachers are more influence by societal reasons. This is an indication that teachers do not read studies on the role to play when teaching geometry. Reading studies on the experiences of teaching geometry will help the teachers to choose the relevant role. This suggests that critical perception is needed when teaching geometry, this will helps to accommodate learners' social needs and political factors in the curriculum (Van Manen, 1977). Furthermore, the findings reveal that CAPS does not specify the role of a teacher, they decide on how to teach and which role to play in the classroom. Thus, geometry is a practical topic, but it relies on the material used in the classroom to keep the learners hands on (Herbst *et al*., 2011). Therefore, culture, places and individual practices are important in a public education to sustain teachers' role in teaching geometry (Chinn, 2007). This suggests that teachers need to understand the learners they are teaching with their culture so they will be able to choose the role that will fruitful to the learners.

During focus group discussion the findings reveal that due learners who lack geometrical understanding, it is not easy to choose which role will be fruitful. As a result, Mukucha (2012) states that those teachers who teach in black African schools should use bilingual instructions to define geometrical concepts and help the learners to understand the concept taught. Thus, teachers state that there is no good role to be played, but it is better to integrates the roles to accommodate different learners. Some roles are not effective because of overcrowding classroom and time constraints. For example, during group work learners took longer to settle down and work.

I can conclude that teachers are not aware that CAPS does not specify the role to play in teaching geometry. Therefore, teachers choose the role that is suitable for the resources they have in their schools in implementing the curriculum. Due to lack of resources in schools teachers prefer to use traditional approaches, while geometry needs to be practical more than theoretical (Jones, 2000). This suggests, that the role of a teacher should be the one that promotes geometrical ideas, critical reasoning in order to obtain the intended outcomes of the curriculum (Herbst & Miyakawa, 2008).

4.2.6 Theme 6: Materials and resources

What resources are using to teach CAPS geometry?

Participant D4: *I use chalkboard, I wish if we can have electronic device, but I improvise as a teacher sometimes I use GeoGebra in my laptop and when I brought my lap top at school find that learners are interested in learning and motivated to see something new. But I cannot take my computer every day to school, I can be targeted because there is high rate of theft, I can be targeted, but it will be better if we have Maths lab where we will keep all Maths model, because learners learn better when they see objects. Coming to a class where there is no model, theorem to use is discouraging.*

Participant 3C: *As my school is a public in rural area that means we do not have enough resources. I use learners' book, teachers' guide and chalkboard sometimes the learners' book is the only copy that I use. We do not have enough resources. There are no computers I draw on the board, it is not the same as teaching geometry with a computer the learner can see on the computer the learner can see, I wish we can get GeoGebra to use in teaching geometry.*

Participant A1: *The resources are not well provided in our schools, we do not have geometry' models and you have done models on your own and sometimes there are instruments that*

learners must have, because of unemployment of their parents they fail to buy the mathematical instrument. You find yourself working in that situation. I only use chalkboard, and I design work sheet for the learners. Fortunately, the department has provided us with books. I also use previous exam question papers and models I made model using wire and for drawing I use mathematical instruments (T-square and rulers). There is no theory that I use, but the lesson designed for the learners must be based on certain theory so that you will be on track. Theory helps to guide you on how you want to achieve those objectives.

Participant E5: *I use chalkboard, paper to draw and scissor to cut the drawings of different triangles, and it is difficult to teach geometry without relevant instruments, I sometimes post charts on the wall with different shapes and their properties.*

Participant 2B: *I use chalkboard textbooks and previous question papers, because of lack of resources you end up using chalkboard. Even if you like use technology classroom are vandalised, no electricity and we do not have overhead projector (OHP), we use chalk board, no calculators, maths sets. It is difficult to teach geometry without resources.*

Most of the teachers' experiences indicate that soft-ware is used to communicate learning. However, other participants indicate that they use hard-ware and only one participant who experience the use of ideological-ware. The participants indicate that the use of soft-ware/hard-ware materials like textbook, chalkboard question paper as the resources available in their school. Soft-ware works together with hard-ware to communicate learning (Khoza, 2012). Some of the participants use hard-ware resources like OHP, T-square, maths set, paper and scissor and charts were also used. Only Participant D4 who experience the use of soft-ware resources that works with hard-ware resources, '*I use GeoGebra in my laptop and when I brought my lap top I found that learners are motivated and interested'*. This suggests that the use of geometrical soft-ware is important in teaching geometry. One participant reveals that she uses GeoGebra to communicate learning. Technological soft-ware had become an important teaching instrument that helps learners to master geometry content (Solomon, 2009). Participant C3 indicates that the use of Technology in Education (TIE) would be fruitful to the learners. Teachers who use the GeoGebra find it easy to teach the learners geometry. This is an indication that GeoGebra links geometry and algebra to enhance learners' understanding (Edwards & Jones, 2006). Algebra is used to communicate geometrical ideas, hence the use of GeoGebra needs to be connected with ideological-ware. Soft-ware together with hard-ware cannot work separately with ideological-ware. Participant A1 states that, '*theory helps to guide*

you on how you want to achieve those objectives' the use of TIE does not alone, ideological-ware is needed to improve the use of TIE. Therefore, the use of ICT tools in the classroom together with ideological-ware helps in development of new activities (Trgalova *et al*., 2009).

Furthermore, the findings from the reflective activity and interviews indicate that chalk-board is used for drawing geometric shapes. Hence, chalkboard and textbooks were the main resources used. These findings indicate that participants were only aware of hardware resources and only Participant D4 and C3 who state that, they use computer with geometry software that will helps the learners to understand better. The data generated indicate that most of the schools in rural areas rely on textbooks. The provision of the textbooks should be improved since Participants C3 indicates that '*we do not have enough resources'.* They further indicate that to overcome the scarcity of resources they experience as teacher, they need to improvise by making chart and model using available resource. This suggests that teachers experience the improvisation of resources they need in order to communicate teaching. Looking to Participant D4 '*I improvise as a teacher'* and Participant B2 '*I sometimes post charts on the wall with different shapes and their properties'.* This is an indication that teachers need to be creative by using available resources to help learners to learn geometrical concepts.

In addition, Khoza (2013a) states that any tools used in teaching and learning are the hard-ware resources, and these resources are Technology in Education (TIE). These resources promote learners' understanding in their learning. Thus, TIE indicates the resources that teachers can see and touch (Khoza, 2012). Teachers' experiences on resources in teaching geometry suggest that the supply of hard-ware resources should be reviewed and upgraded in rural schools. Looking to the above findings, Participants D4 and C3 indicate that they wanted to work with computers so that they can teach geometry that is visible to the learners. This agrees with Choi-Koh (1999) who argues that learners who use computers in their schools gain deeper understanding of geometry. Further, Participant D4 indicates that she knows about geometry soft-ware, '*learners are exposed to technology, I sometimes bring my laptop to school and on that day they are interested in the lesson*'. Hence, participants mention that they have computer lab in their schools but they are not using it to teach Mathematics. This is an indication that rural schools should be supplied with mathematics soft-ware so that teachers can teach using soft-ware and hardware resources.

Furthermore, teachers mentioned that they do not have computers in their schools and some schools have no electricity in the classroom, which makes it difficult for teachers to use

computer. Software (TIE) is "any teaching/learning resources produced for hardware to display data or communicate teaching" (Khoza, 2012, p. 1). The findings indicate that some of the teachers want to use mathematics software in order to enhance learners' learning, but the problem is the availability of computers and its software. This is an indication that relevant mathematical soft-wares are needed as the resource of teaching geometry that can helps learners to master geometry content (Solomon, 2009). As Participants D4 indicates that learners become interested in the lesson when they saw the laptop, but the participant was not aware that soft-ware resources were used in conjunction with the laptop. This concur with Ndlovu, Wessels and de Villiers (2010) who argue that using Geometers' sketchpad creates positive experience for the learners to learn calculus and related concepts. This is an indication that GeoGebra links geometry and algebra. Participant D4 states that ICT is one of the resource that enhances and promotes learners to learn geometry (Edwards & Jones, 2006; Jarvis *et al*., 2011). Therefore, teachers who use GeoGebra find it useful when teaching geometry to develop better understanding from the learners.

However, ideological-ware (TOE) was indicated by one participant as the tool to communicate learning. During reflective activity phase no participant indicates on the use of ideological-ware until the second phase where Participant A1 states that '*the lesson designed for the learners must be based on certain theory so that you will be on track. Theory helps and guide you on what you want to achieve, those objectives'.* The participant indicates that although he did not mention the name of the theory he used during teaching of geometry, but he knows that the theory is important when designing teaching and learning. According to Khoza (2015) teachers are not aware of ideological resources they use during the implementation of intended curriculum. The participant indicates the theories as an important guide in teaching, but he was not aware that theory is regarded as teaching resources and some scholars called ideological-ware (Berkvens *et al*., 2014; Khoza, 2012). The participant indicates that theory can influence the learning and is important when designing the lesson. The participant states that *'the lesson designed for the learners must be based on certain theory so that you will be on track, theory helps to guide you'*. This concurs with De Villiers (2010) who states that learners are failing geometry because they are not well developed in all the levels of Van Hielle theory. This is an indication that theory would helps the learners to be able to recognise, analyse, order and deduce any geometrical concepts displayed in the classroom (Naidoo, 2007; Ndlovu, 2012; Ndlovu *et al.*, 2010). This agrees with the findings where teachers indicate that learners should be able to recognise and classify geometric shapes according to their properties.

During the group discussion, teachers argue that they design the lesson using available resources (papers when drawing and pair of scissor to cut). Using different teaching methods and theories can yields good results even where there are limited resources in school (Yost *et al*., 2000). They also wish if they have computers, stating that learners learn better when they see drawing in the computer. They state that they use waste materials to make models as the resources to help learners understand geometrical concepts. Hence, the use of sketchpad helps in building geometrical models that develop learners' understanding of geometrical concepts (De Villiers, 2004; Mudaly, 2004).

However, the participants were not aware of ideological-ware. Ideological-ware are the teaching strategies and theories that are used by the teachers during the teaching processes (Khoza, 2012). Therefore, teaching ideology plays an important role (Stuart & Thurlow, 2000). The above experiences indicate that the teachers while teaching geometry used no theories. The use of the relevant teaching method and theory helps the teachers in the development of learners 'understanding of geometry. Thus, the use of Van Hiele' levels of development help the learners to understand geometry concepts (De Villiers, 2010). This suggests that teachers who use the theory are better able to develop learners' geometrical ideas. The teachers indicated that learners lack geometrical concepts understanding. For the learners to able to learn geometry they should be able to recognise, analyse, order and deduce any geometrical concepts taught in the classroom (Naidoo, 2007; Ndlovu, 2012; Ndlovu *et al*., 2010)

Teachers as curriculum implementers should use the theory that best suit the learners to learn, CAPS does not explicitly state the theory that underpins the curriculum (Khoza, 2013b). Teachers need to read scholarly work on the theory to use in teaching geometry. Therefore, curriculum implementers should understand curriculum ideology in order to choose the best approach (teacher-centred, learner-centred and content-centred) for the achieved curriculum (Hoadley & Jansen, 2012). The findings reveal that teachers use different roles but the findings did not reveal the specific theory used that will best suit the role to play. Hence, the theory that underpins the curriculum is vital in attaining the intended outcomes. This can be achieved through the application of theory, existing knowledge together with teachers' pedagogical knowledge to give more understanding to different learners (Kirby, 1988). Furthermore, from the findings, teachers experience the scarcity of resources especially computers GeoGebra and Sketchpad were named as the resource that can best minimise the time wasted drawing on the board. Teachers see the scarcity of resources as the problem common to the schools in rural areas.

I conclude that teachers who use mathematical soft-ware with hard-ware together with relevant ideological-ware in the implementation of the intended curriculum find it easier to teach geometry. According to Ikle and Goertzel (2011) theoretical and mathematical materials are important in guiding the different learning drawings. Hard-ware, soft-ware and ideological-ware cannot work separately from each other while teaching geometry. This is an indication that South African CAPS developers need to provide rural schools with TIE and empower teachers in using TIE in order to enable the implementation of the intended geometry curriculum. Hence, teachers are teaching geometry while being unaware of the theory that underpins CAPS for implementation. Therefore, the availability of resources will ensure accessibility for all in learning and teaching geometry within CAPS.

4.2.7 Theme 7: Accessibility

With whom/who are you teaching?

Participant D4: *They are physically ok, but emotionally vulnerable, since they came from poor families. Some are brilliant and some are not teachable due to language difficulties in communication, there are those who lack understanding of signs (mathematics language). There are those who are physically disabled but they come to our school and you cannot discriminate against them, because it is nearby and there is no school for disabled learners in the area. Most of the learners do not have resources like calculators; they live on social grants because of poor family background. There is high rate of theft, some they are the head the families and they cannot concentrate because of family problems; teachers need to visit the learners' families. The rate of pregnancy is too high and the school is taken as a social centre. The culture of learning is very poor in the community.*

Participant C3: *The learners we teach lack geometrical concepts but others do participate with the less knowledge they have, and some need to attend special schools but they come to our school. They do not have calculators, come from poor families and community, most of them cannot count. Learners come from uneducated families you notice through their behaviour and some learners' parents are our former learners who were trouble at school and they lack discipline; they come late to school and smoke dagga inside the school premises. Financially they are poor, and sometimes they fail to pay even R1 when we are fundraising.*

Participant A1: *The community that I am working is in the lower ranks financially. Therefore, learners come from poor families and most of the children did not go to pre-school for early*

childhood development. According to their physical appearance they are ok, but mentally are behind with the knowledge anticipated from a Grade 10 learner. Some of the learners are slow learners, parents send them to our schools because they cannot afford to take them to relevant schools; as a teacher you have to find relevant ways of teaching that child. Some learners discriminate the disabled learners, as a teacher you become a parents so that the child won't leave the school. Socio-cultural they belong in same race that makes easy to refer to the culture they that dominates in the area, when I talk about circle I refer to rondavel and gradient I refer to the mountain that they see every day.

Participant B2: *Most of the learners in my Grade 10 class are repeaters. They are not motivated in learning. They are coming to school but do not want to learn. You see that with their age, according to the age they are supposed to be in tertiary level. They lack mathematical language (concept), it is like they never learn Mathematics in the previous grade. The feeding scheme tells that they are coming from poor families. Some they come to school because of food, not that they want to learn, and their parents are not committed to their children's' education; you noticed that by homework not done every day; and these learners are not responsible and ill discipline. The learners do not take the culture of learning seriously.*

Participant E5: *Our learners are coming from poor background families, as I have said before that they do not have resources and some are physical challenged, although in Maths you noticed that they are far behind with Maths language and they have problems to think geometrical when solving problems. Some came to school with poor Maths results from their primary education, and you notice that they are failing mathematics.*

The generated data show that teachers are teaching learners with different learning abilities and challenges. They mentioned that there are learners who need special schools but due to remote place, so they go to schools that is in the surround area. Hence, DoE (2011) states that education should be accessible to all the children no matter their affordability, ethnic group, gender, socio-economic status, physical abilities and socio-cultural factors. This raise the concern of a special school in rural area, so that these factors can not hinder the learners to learn (Berkvens *et al*., 2014). Teachers also experience teaching learners who lack geometrical concepts that were suppose to be done in lower grades. Therefore, teachers should be trained to teach learners with disabilities to accommodate diversity and promote inclusive education (DoE, 2011). However, the teachers indicate that poverty influenced the teaching and learning process.

Further, the findings indicate that teachers encounter working with Grade 10 learners lacking geometrical information and concepts. Participant D4 states that '*there are those learners who lack understanding of signs (mathematics language)'.* Participant C3 states that '*The learners we teach don't have geometrical concepts but others do participate with the less knowledge they have'* and Participant E5 says *'they are physical ok, although in Maths you see that they are far behind with Maths language and they have problems to think geometrical when solving problems'.* The three participant's responses indicate that teachers have challenges in developing learners' reasoning skills. Helping the learners to develop their geometry reasoning and spatial competence, instructions are used to give the learners an opportunity to change from one level to the other levels of Van Hiele (Unal *et al*., 2009). This suggests that teachers' pedagogical knowledge is needed in order to develop learners' geometrical ideas and if geometrical vocabulary is lacking from learners, they won't be able to communicate with teachers' instruction, follow order and think geometrical (Atebe & Schafer, 2010).

The findings indicate that teachers are working with learners that have low mathematical language and geometrical ideas. The way teachers handle the content they teach differentiate the accessibility of the learners (Lim & Moore, 2002). This suggests that the way they teach will limit learners in developing geometrical understanding. This can be done by the way the content is taught. From ideological-ware resources teachers indicate that there is no specific theory used in teaching geometry, this suggest the way the content is handled. Atebe and Schafer (2010), reveal that learners had only partial knowledge of the necessary geometric vocabulary. This concurs with Participant E5 who state that, '*they are far behind with Maths language and they have geometrical when solving problems'*.

Furthermore, learners' physical ability can hinder the learners to learn geometry, because if the learners cannot use drawing tools, it will be difficult for a teacher to teach learners on how to draw and to measure the angles using protractor (Engelbrecht & Harding, 2005). From the findings, teachers mentioned that they sometimes teach slow learners in their schools. Webb (2011), reveals that learners with dyslexia have difficulty in writing and learners with mental and physical tiredness lack concentration in the classroom. This concurs with the findings where teachers mention that they experience teaching learners who lack geometrical reasoning in the classroom. This suggests that learners who lack geometrical concepts will not be able to solve geometrical problems, because language plays the vital role in teaching and learning. Two-way communication is important between the teacher and learner, and learners need to read instruction and geometrical concepts to communicate their learning.

However, financial and cultural accessibility were revealed as the influence in teaching geometry, because learners who are coming from poor families cannot afford to buy resources that the school does not provide e.g. calculators. Working in the school which lacks resources, greatly hinders the learners' ability to learn geometry. If the school cannot provide learners with maths sets for example, the learners who come from poor families will have a problem. Learners tend to borrow amongst each other, this disturb teaching and learning. Hence, all the participants mention that they have feeding schemes in their schools which indicate the community's poor economic background. Looking to Participant B2's response, *'The feeding scheme tells that they are coming from poor families. Some they come to school because of food not that they want to learn'*. If the parents cannot afford to buy food, they won't be able to pay towards school's needs. This suggests that schools should provide learners with the relevant resources to learn geometry. However, the findings indicate cultural accessibility needs as the factor that can influence learners' ability to learn geometry. The findings indicate that the schools they are working in have the same race. Participant A1 state that, *'Socio-culturally, they belong in same race that makes easy to refer to the culture that dominate in the area, when I talk about circle I refer to rondavel and gradient I refer to the mountains that they see every day'.* This agrees with Gay (2004), who states that teachers must understand different cultures because culture entails different values and norms: how the community live, collaborative problem solving and how these can disturb schooling background, aim, and work routine. Further, the findings reveal that language is a barrier in accessing geometry by the learners. This is an indication that multilingual learners find difficulties in learning geometrical concepts presented to them in English (Duval, 2006).

During group discussion, teachers reveal that they are teaching learners with disabilities that they are not trained for. One of the participant mentions that some parents are aware of their children's disabilities but they send them to school even though they know that the school does not cater for their children's' disabilities. The parents want the school to keep the children because they cannot keep them at home. The participant mentions that the parents send their children to school, while they understand that their children need to attend the special school. A disability like dyslexia can hinder the learners from learning geometry (Webb, 2011). Learners with dyslexia find difficulties in learning when traditional approach is used, because they cannot take written work down fast. They also tend to forget easily, since they have short concentration span (Webb, 2011).

I conclude that socio-economic and socio-cultural components play a vital role in teachers' experiences of teaching geometry (Duval, 2006). Economic and culture has more influence on educational accessibility for all. The redress of the issues of the past is needed for the teachers to be able to implement CAPS, especially when considering the unequal provision of materials in rural schools versus urban schools Therefore CAPS might fail if public schools is not funded to meet the demands of the learners and the community (Lotfi & Koohsari, 2009). Thus, accessibility of teaching and learning geometry is influenced by learning environment and the time geometry is being taught in schools.

4.2.8 Theme 8: Time and Learning environment

When and where are you teaching?

Participant D4: *I teach in the classroom, the period is 60 minutes and is not enough, but it depends on topic and learners' participation, because our classes have different learners you need to accommodate all of them, but I would say 60 minutes is not enough and I have five periods per week in two classes. If we can have Mathematical laboratory it will be better because learners can learn better using computers. Sometimes I teach during early morning classes and afternoon classes to enforce concept.*

Participant C3: *The building of the school looks good, the problem is in the classroom I teach in the classroom that have no windows, and doors, shortage of furniture learners share one desks between 2 to 3 learners, but it is their irresponsibility because they broke the windows and in winter they get cold and get sick through their carelessness. There is no lab in my school. The period is 55 minutes according to the time-table given, 55 minutes is not sufficient to cover the topic and for the learners to understand the topic taught, because some learners need extra time to learn I think this is not being resolved because it is a challenge to Maths teachers, because we spend too much time in one concept, so that the learners will not be left behind. It can be better if geometry can be taught in first term when there is less work done. According to the document, geometry is taught in the first and second term.*

Participant A1: *As we are in a deep rural area, I use the ordinary classroom that have no suitable resources, furniture, windows and doors are broken. I use the class in a way that learners will enjoy learning. The classrooms are uncomfortable, in winter learners get very cold. The period is one hour but it depends on the lesson, sometimes the hour is not enough then I will complete the task the next day. Normally I do planning for a week, because we use*

five-day cycle and Mathematics is taught daily. If did not finish my lesson in that given hour I ask the period to my colleagues or sometimes I used morning classes or afternoon classes. Sometimes it does not work because the learners are walking long distances coming to school, that make morning class to be impossible. There is no computer laboratory in my school.

Participant B2: *I teach in the classroom with cracks on the wall when it is raining, the roof leaks; the period is 60 minutes, so the hour is not enough. I use afternoon classes and morning classes to cover the work and for the learner to catch up where they did not understand.*

Participant E5: *I teach in the classroom during my period of 55 minutes. 55 minutes is enough and our classes are overcrowded you cannot attend all of the learners as an individual. The duty load of a Maths teacher affects your performance in the classroom. Having four periods consecutive is strenuous. If the period is in the afternoon, it is difficult to introduce the new when the learners are tired and do not concentrate, I wish Maths period, would be in the morning only. There is computer lab, but we are not using computers to teach Maths, because they are not installed with a mathematics soft-ware.*

Most of the participants' experiences indicate that they are teaching geometry in the classroom using the formal time allocated in the weekly time table (Berkvens *et al*., 2014). Teachers feel that time allocated to teach geometry is not enough. The document provides 270 minutes then the participants feel it is not sufficient since they are teaching learners with different needs. Hence, the time allocated for Mathematics is the same as other subject, as the timetables are designed for the whole school. The participants suggest that more time is needed in teaching geometry. Thus, teachers follow allocated time according to the document, for example- Euclidean geometry is given 3 weeks in term two and analytical geometry is taught in term three and is given 1 to 2 weeks (DoE, 2011). This concurs with Participants D4 and A1, when they state that they use weekly planning. The findings indicate that an hour is not enough when teaching, because learners end up taking more time when drawing and cutting geometrical figures in the classroom. Participant B2 states that, '*the period is 60 minutes, an hour is not enough'*. Participant D4 states that, *'I teach in the classroom during my period of 60 minutes, one hour is enough'* and Participant E5 states that, *'55 minutes is not enough'* Hence, all the participants agree that they sacrifice their own time by working on weekends, morning classes and afternoon classes to help the learners.

In addition, teachers feel that floor space is problematic due to overcrowded classes. During group discussion, they state that there is a need for mathematical classrooms where they can

design and group the learners according to their will. One of the participant states that he changed the setup of the classroom and other teachers did not like the setup and change it back to a normal setting. The classroom should be set up in a way that learners will feel comfortable to work in (Aldridge *et al*., 2004). Thus, teachers also wish if the classroom was Mathematically orientated so that learners are able to see geometrical figures in front of them that will promote continuous spatial reasoning (Wilhelm *et al.*, 2008; Wohlhuter, 1998). This concurs with Participant D4 who states that, *'If we can have Mathematical laboratory it will be better because learners can learn better using computer'.* Aldridge *et al.* (2004), reveal that learners choose to learn in the environment that suits them than the one that is available. Teachers and learners prefer using laboratories which are not available in their schools, but Participant A1 indicates that *'I use the class in a way that learners will enjoy learning'* This suggests that teachers should use the classroom effective by designing the interesting lessons so that learners will learn, irrespective of the environment they are learning in.

During group discussion teachers wished that they had computer labs in their schools because learners become motivated when using computers (Sipos & Kosztolányi, 2009). They indicate that the use of an overhead projector (OHP) is possible but there is no electricity in the classroom. The participants state that technology is useful in teaching geometry and it can minimise the time of drawing on the board. Hence, drawing on a computer enhances learners understanding of geometrical concepts and a laboratory is conducive to teaching geometry (Okigbo & Osuafor, 2008). Therefore, using visual devices in the classroom help the learners to remember, recall and understand more easily (Naidoo, 2012).

I conclude that time allocated for teaching geometry topics is not enough as specified in the document. As a result, teachers tend to use morning, afternoon and weekend classes in order to meet the deadlines for the work schedule given. Further, learning environment must be conducive when teaching geometry and pupil teacher ratio needs to be considered in school, since the teachers mention that the classrooms are overcrowded. This can help the teacher to attend to learners as an individual.

4.2.9 Theme 9: Assessment

How do you assess your teaching?

Participant A1: *I use question and answer assessment during actual teaching, I give them homework, assignment, group work and presentation. In other words, I use both formal and*

informal assessment. When I test the learners, I want to check the learners' knowledge on the lesson taught. There are tests that we get from the department, and those tests are written at the end of the term and during exams. I use informal assessment to evaluate the strategies I used if it is good and if not I change to the other methods.

Participant D4: *I use previous question papers to check the understanding of the content. I use both formal and informal assessment, but informal assessment helps me to see if we follow each other, and I use assessment to check the method I used is productive, I also give the learners' time to present in class after they have done the problems in the group; this helps them to gain confidence. I use formal tests that come at the end of year or term, formal test is important for department to monitor learners' performance, and formal class tests are written as planned by the department.*

Participant B2: *I use both formal and informal assessment: I give the learners short tests and group work. I assess based on learners' performance, give remedial work, and reassess on the same concepts. Formal assessment I used is exam written half-yearly and the end of the year, and common tests set by the department.*

Participant C3: *I use formative assessment where I monitor the learners and to provide an on-going feedback. I use assessment to check their learning. Formative assessment is where I monitor learners to provide ongoing feedback. I also use summative assessment, the aim of using summative assessment is to evaluate learning at the end of the term and to promote learners at the end of the year. I use formal test and exam are also written. Formative assessment is for the learners to check if we are together, after that I give them a chance to raise their problem that need to be attended, then I repeat on problem identified.*

Participant E5: *I assess the learners using projects, investigations, class works, home works, assignment and informal tests. I assess the learners to get what they have grasped in the lesson and to get feedback of the lesson. So that when I go to the next lesson, I will be aware of what they know. Assessment helps me to give the platform of where to start. I also assess the learners through tests and examination set by the department.*

Most participants indicate that they use assessment for learning (formative assessment) and assessment of learning (summative assessment), and no participant indicates the experience of using assessment as learning (peer assessment). The findings indicate that informal assessment is used to test learners' previous knowledge and to see if they follow the instructions. The

findings indicate that assessment is used as a tool of helping learners to improve their learning (Carl, 2009). Hence, the participants did not mention how they design assessment used for the learners and which assessment theory is used. The theory helps the teachers when designing the assessment to know the reason for their assessment. Krathwohl (2002) states that geometry assessment must be designed using Bloom's Taxonomy level which: knowledge, comprehension, application, analysis, synthesis and evaluation. This will help the learners to develop all levels of cognitive development, where the learners will be able to identify, list the properties, attempt short and do axioms converse of the theorems. Hence, the participants indicate that they use the standardised tests set by the department. Common tests papers to assess learner's progress in geometry.

Thus, the findings indicate that assessment is used to check learners' progress and for the teachers to evaluate their teaching strategies. Participants D4 indicates that *'I use assessment to test the learners' knowledge and to check where they lack knowledge. I use assessment to check the method I used, if the method I used is productive'.* Participant A1 states that *'I use informal assessment to check their knowledge and to evaluate the strategies I used if it is good and if not I change to the other method'.* This agrees with Kennedy *et al*. (2009) where they state that assessment for learning is used as a formative assessment. Therefore, teachers use informal assessment to find the effective approach of teaching in the classroom (Akyeampong *et al*., 2006).

Smeets (2005), states that using traditional assessment helps to accommodates learners' different abilities. This agrees with the findings in which the teachers reveal that they use different forms of assessment. Participant E5 indicates that '*I assess the learners using projects, investigations, class works, home works, assignment and informal tests'.* This is an indication that teachers use different forms of assessment as stated in CAPS. Thus, Brown (2004) states that changing the forms of assessment helps the teachers to be specific on why they assess, who are they assessing and when to assess? The findings state that teachers assess the learners at the end of the lesson to see if the methods used have an impact to the learners. In addition, the experience of using previous question papers as a form of assessment in order to check the learners' understanding of the content, gave the teachers the opportunity to be aware on how much the learners know and where they lack understanding. Assessment must be designed using hierarchical levels of cognitive development and different methods as outlined in CAPS (Brown, 2004). Furthermore, Participant A1 states that, *"I use question and answer to find learners' understanding of the content"*. This suggests that assessment for learning is used by

the teachers to find out how much the learners know about geometrical concepts of the content they teach.

However, the findings show that assessment of learning is used as formal assessment. This assessment is used for learners' performance in the form of tests and exam. They are written as common tests papers set by the department to monitor learners' performance and to promote the learners to the next grade. Teachers state that the summative assessment is written quarterly, half-early and at the end of the year. See the response from Participant E5 who states that *'I also assess the learners through tests and examination set by the department'* and Participant B2 states that *'Formal assessment I used is exam written half-yearly and the end of the year, and common tests set by the department'.* The findings also reveal that summative assessment is used to promote learners to the next grade. Thus, Kennedy *et al*. (2009) describe assessment of learning as the summary of learners' performance and it uses traditional form of assessment. This suggests that teachers design their assessment in different ways depending on what is being assessed. Diverse forms of assessment within CAPS will help the teachers to accommodate different learners (Vandeyar & Killen, 2007). During the group discussion teachers reveal that they use assessment, as well as daily activities design in line with the curriculum goals (Marx *et al*., 2004). This suggests that teachers use assessment of learning based on the geometric concept or theorem learned in that specific time.

During the group discussion teachers agree that they use assessment of learning to judge learners' performance, especially the common tests from the department are designed to judge both the teacher and learners' performance. According to the DoE (2011) assessment of teaching and learning and its outcomes are needed when measuring the quality of the curriculum (Berkvens *et al*., 2014). Thus, teachers state that they assess the learners to check if they understand the topic taught. They further state that when the learners did not to do well, reassessment is written, but the learners who perform better, they become the best. Due to time constraints, they cannot re-teach the concept because they have to cover the content as stipulated in the document, and it is difficult to leave the learners behind.

I can conclude that the experience of using formal and informal assessment is not guaranteed to give the intended results of the CAPS. Yet teachers are unaware that CAPS is silent when it comes to informal assessment, teachers use different informal assessment while teaching the same geometrical concepts. This was indicated during group discussion, when one of the participant states that, he uses investigation as an assessment done in groups; all the groups got

higher marks. Hence, that investigation was used as a test with the same question and the same learners failed the test. Using different forms of assessment are acceptable in teaching geometry (Lavy & Shriki, 2014). Furthermore, teachers state that they design geometrical assessment with different level to accommodate all the learners, but most of the learners obtain level O on Van Hielle levels of geometrical ideas which is the lower level (Alex & Mammen, 2014). Hence, CAPS is on level 3 and 4 of the cognitive development, the learners' assessment should be specific on the levels of assessment and allocation of marks for formal and informal assessment. Teachers should assess the learners in all the levels specified by CAPS. Therefore, teachers should assess the learners to give feedback of the assessment, and reassess in a well-planned time will give meaning and positive change (Lu & Law, 2012; Maclellan, 2001). All the above themes were discussed under CAPS (2011).

4.2.10 What the teachers are saying about CAPS

Participant A1: *CAPS is new, it is not easy to evaluate, because we are all trying to fit and understand it, since we did not get proper training for CAPS, but there are so many changes as it is compared to the NCS, geometry was not compulsory but now it is compulsory, so refresher courses are needed in teaching geometry. The issue is that we are still looking for the books that follow exact requirement of CAPS. It is partially relevant and not consistent since some topics are difficult to teach within the schools that are lacking resources. Therefore, it will not sustain since it has gaps here and there. CAPS needs time to be practiced because all other systems that were there in SA took time to be felt by the teachers. I will be lying if I say CAPS is relevant or irrelevant. There are some parts of geometry that are practical because some outcomes are achievable and some are abstract. It will be bad if CAPS changed. It can be given time so that it will reduce its disadvantages, even the books are coming from different authors, we are not given the opportunity to decide on the books to use. Sustainability comes from tangible results our CAPS can be consistent. I used to say there is nothing about me, without me. To swallow something that we are given without having a say is not easy. It means that we are taken as empty vessels that need to take what is given and teach. It could be better if teachers were consulted because we are the one who is teaching and make a success of the curriculum.*

Participant D4: *CAPS has been designed to help learners become critical thinkers. CAPS is relevant as it is aimed at producing learners who are able to think positively. I don't think*

CAPS will produce good results since our learners are no longer focusing on school work. I think is impractical and very ideal.

Participant B2: *Teachers were not given proper training. Some topics are practical and some are abstract, so CAPS is like other systems we had used before. It won't sustain for a long period of time unless if they prune its disadvantages like having lots of publishers and suppliers of books are given tenders politically. Some books are not good but we have to use it because the department had brought it. There is no consistency, because learners are on and off, meaning they pass sometimes they fail, during the first and second term, and if teachers are not good achievers CAPS can change. So if the implementers are not producing what is expected by the curriculum designers, CAPS can change. Most of the learners are progressed at the end of the year because CAPS set papers that need learners to show critical thinking. It won't sustain for a long period of time.*

Participant C3: *CAPS is relevant to the teachers because it gives clear guidelines on the content to be taught in that particular subject. It won't sustain for long periods of time since our education system is more political. CAPS is practical but not suitable for the learners in rural area because of resources. If teachers were consulted it would be better, but CAPS is given to the teachers, but designers are away in the offices.*

Participant E5: *CAPS is ok except that educators need more workshops in some areas in especially in geometry, because before geometry was not taught in NCS and RNCS. There are teachers who did not learn geometry at schools but in CAPS they are expected to teach geometry.*

Most of the participants indicate that teachers are having different opinions about CAPS. See the response from Participant E5 states that, *'CAPS is ok except that educators need more workshops in some areas especially in geometry'.* Participant A1 states that, *'it is not easy to evaluate CAPS now because it is still new, we are all trying to fit in it'* and Participant B2 states that, *'CAPS is like other systems we had used before'.* This suggests that teachers are not clear about the vision of CAPS as a performance curriculum. They experience teaching curriculum that was designed by curriculum designers who did not consult with them. This concurs with Ayers (1992, p. 259) where he emphasised that "curriculum is the product of someone else's thoughts, knowledge, experience, and imagination". This is an indication that teachers were not consulted when CAPS was designed. Therefore, CAPS can be a challenge to curriculum implementers who communicate the teaching and learning. Hence, Participant A1 indicates

that teachers are taken as empty vessels when it comes to curriculum development. Thus, Hoadley and Jansen (2012) state that intended curriculum helps to give the teachers with the least information of the topic to teach. Thus, Participant C3 indicates that *'CAPS is relevant to the teachers because it gives clear guidelines on the content to be taught in that particular subject'.* Hence, Porter *et al.* (2011) argue that an intended curriculum should clearly state the common core standards of the curriculum designed.

Teachers' experiences indicate that CAPS has been designed to produce critical thinker, but teachers were not given enough training to implement geometry within CAPS. Participant E5 and Participant B2 indicate that, *'Teachers were not given proper training'.* Therefore, teachers must be trained to teach the intended curriculum designed for them to teach. Thus, workshops that is needed to help teachers meet the needs of the performance curriculum. They further, state that according to geometry, there is not much change when compared to NCS and RNCS, because some schools taught geometry although it was written as an optional paper during exams. During group discussion, teachers indicate that it is not easy to say that CAPS will be sustainable hence, if CAPS is producing the intended result it will sustain many more years to come and there are schools that produce good results. They further indicate that teachers underwent their training long time ago with different educational systems; this is an indication that teachers need to undergo training on CAPS that will help to understand what is expected in order to produce the intended results. The department need to provide proper training to teachers so that teachers will have better understanding of the content than the learners they teach. Participants state that CAPS standard is high so that learners can compete with the international countries. However, participants indicate that when CAPS was introduced, the curriculum implementers did not consider designing different grading level (e.g. standard grade and higher grade) as it was before 1994, to accommodate learners with low geometrical reasoning skills. They argue that Mathematics question paper come with different levels of Bloom's Taxonomy to accommodate learners with low reasoning skills, but it will be better if they can separate the exam paper with different levels of questioning (Krathwohl, 2002).

I conclude that curriculum implementers are still confused about the curriculum they are implementing. They need workshops and training in teaching performance curriculum and learn more about the subject discipline (Hoadley & Jansen, 2012). Therefore, teachers, parents and learners need to be consulted in the phase of curriculum development to avoid criticism of the curriculum implementation. Hence, the ideology of curriculum developers that every

learner can learn Mathematics is not working. Therefore, learners should be given an opportunity to choose the subjects they want to learn.

4.11 Conclusion

In this chapter I presented the data generated from reflective activity, semi-structured interviews and focus group interviews. The data written and recorded data were transcribed into text and analysed. The data transcription based on teachers' experiences and sorted according to the theme as mentioned above. The first theme indicates that society has an influence in teaching and personal interest contributes in performing the task of teaching geometry. The second theme indicates that objectives are the main focus of teaching in the classroom. Theme three indicates that learners' geometrical ideas are not yet well developed. Further, Theme four indicates that both teacher-centred and learner-centred activities are used but teacher-centred activities dominates in the teaching process in order to cover the syllabus. Theme five indicates that instructional and facilitation approach is used at the same time. Furthermore, learning environment and time constraints are seen as not conducive to the teaching of geometry. This was the impact of theme seven where the lack of resources indicate that teachers are driven by the competence curriculum instead of the performance curriculum they are given to teach.

Furthermore, it shows how the curriculum is vulnerable. As I presented a summary of my findings, theme nine indicates that teachers need inclusive education training since they are not prepared to teach learners with learning disabilities. Lastly, theme ten indicates that formative and summative assessment is used to check learner' progress and to promote the learners to the next grade. It became evident to me that teachers are not aware of the type of the curriculum they are teaching, and the curricular spider web components are not pulled together equally, some components are given more attention than the other. The spider web will collapse if the nothing is done on how to keep the components connected. Some teachers were driven by competence curriculum instead of the performance curriculum they are given to teach. Furthermore, I presented a summary of my findings and suggestions, with reflections on the research process and conclusion of the study. Chapter Five gives the summary, conclusion and recommendation of the findings on teachers' experiences in teaching geometry within CAPS

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

In this chapter I present the summary of the findings, conclusions and recommendations that emerged from transcribed data and discussion as based on the reflective activity, semi-structured interviews and focus group interview presented in the previous chapter. Based on the findings that emerged from data discussion in chapter four some suggestion and recommendation of this study have been considered in relation to the critical questions formulated in Chapter One

5.2 Summary

The study focused on exploring Grade 10 Mathematics teachers' experiences in teaching geometry within CAPS in the Umbumbulu area. The study further tried to understand why do Grade 10 teachers have those specific experiences?

Chapter One laid out the problem, stated objectives of the study and defined critical research questions. This chapter presented a short history of the education system in South Africa, and looked at the present intended curriculum and implemented curriculum. This helps to locate and understand the geometry curriculum within the context of rural area in Umbumbulu. The context of the study included a short background of education in South Africa. The attention on the FET phase covered the subject rationale, goals, content, learning activities, teacher role, resources, learning environment and time, accessibility and assessment framed by curricular spider web. The study also laid out the research structure used in the study to address the research questions.

Chapter Two is based on literature review on geometry curriculum and their implementation. The chapter begins by explaining curriculum and curriculum implementation. This covered the intended and implemented geometry curriculum in the South African context. The curricular spider web is used as the conceptual framework in this study and is described in this chapter. The curricular spider web has ten components that are used as themes that framed the literature review. These components are the rationale, goals, content, learning activities, materials and resources, learning environment, time, accessibility and assessment. The literature indicated that for curriculum implementation these components should be pulled together equally,

because if they are not connected in a balanced way the spider web will collapse. Therefore, curriculum implementers find difficulties in implementing the curriculum because the components of the curricular spider web are not given equal interest. The literature revealed that some components are given more attention than the other.

Chapter Three described the research methodology adopted by the study. The study adopted the qualitative approach under an interpretive paradigm. As such, it is a case study of five secondary schools offering pure Mathematics as a subject. The study used the reflective activity, one on one semi-structured interviews and focus group discussion to generate data. The chapter also discussed trustworthiness, data analysis, ethical considerations and limitations of the study encountered during data generation process.

Chapter Four displayed and discussed the research findings from the data generated. This was done through guided analysis and thematic analysis following the ten curricular spider web components. Data were analysed based on the themes and categories under curricular spider web to understand teachers' experiences on the phenomena studied. Curricular spider web components are vital in the effective implementation of the curriculum, they assisted geometry teachers' to recognise their impact regarding the implementation of geometry in Grade 10.

5.3 Conclusions

The conclusions are drawn from the research findings of teachers' perception and were discussed in connections with the themes drawn from the curricular spider web concepts using themes.

5.3.1 Rationale

The findings indicated that there is a need for strong rationale, which is based on professional reasons for teaching geometry that will bind together all components of curricular spider web, thereby promoting the implementation of geometry in Grade 10. If the rationale of teaching geometry is not visible to the curriculum implementers, everything will fail. The findings also indicate that there is a need to combine pedagogical and professional reasons in order for the society to benefit, because teachers' understanding of the content will develop the professional reasons for curriculum implementation. Hence, teachers' self-identity is vital in the interpretation and communication of curriculum by in the classroom during the process of teaching and learning.

5.3.2 Goals

The findings presented that teachers are not clear about the aims, objectives and outcomes of CAPS. This indicates that they are confusing the term aims, objectives and outcomes. They need to differentiate between the subject aims and what they intend to acquire because this will help minimise the shortcoming between the competence and performance curriculum. The aims and objectives of the implemented curriculum will not be acquired, if the teachers are promoting outcomes. When the teachers are not promoting aims of CAPS. That would mean they are still promoting the aims of the competence curriculum (NSC and RNCS).

5.3.3 Geometry Content

The study reveals that teachers understand the topic they teach. The content has geometrical theorems and proofs; learners need to know the geometrical figures with their properties as well as relevant formulae. Teachers indicate that theorems in the document are good for developing learners' reasoning skills. The findings indicated that geometry is a practical subject. Findings indicated that the content is designed to produce learners who compete with other countries. This is an indication that teachers' professional knowledge should be of a in higher levels than those of the learners in order to develop learners' geometrical ideas. If geometrical ideas cannot be developed this would spell a high failure rate.

5.3.4 Learning activities

The findings indicated that teacher-centred and learners-centred activities were used, but activities were teacher-centred as they were led by the teachers. Teachers follow formal activities with guidelines given to the learners to complete the activities. Therefore, learners learned geometry the way their teachers designed the lesson. The activities designed for the learners must not limit them in learning geometry the way they understand. Teachers should plan the lessons differently from those designed in the textbook. This indicates that teachers teach geometry the way they were taught in their schooling systems, and the activities they choose suited the teachers and examiners. Hence, the use of a learner-centred activity is embedded in the performance curriculum; it is recommended in the performance curriculum to accommodate learners' diversity. This suggests that there are things that were good in competence curriculum that can work in performance curriculum. The findings also indicated that performance curriculum should be demonstrated by the learners in completing their activities.

5.3.5 Teacher role

Geometry is a practical Mathematics topic where learners need to learn by doing rather than from the theory. Therefore, Mathematics teachers need to be versatile in using different teaching strategies that will accommodate different learners' abilities instead of using traditional approach to teaching geometry. Teachers must choose the role that develops geometrical ideas and geometrical concepts (Herbst & Miyakawa, 2008). The document does not prescribe the role that the teachers must fulfil while teaching geometry. Therefore, the teachers decide on the role to fulfil. The part played by the teachers might fail to yield the intended results of the geometry content. Some roles cannot be fulfilled, due to time allocated to teaching geometry. Failing to fulfil the teacher role will result in the poor performance of the performance curriculum.

5.3.6 Materials and resources

The findings indicated that there is a lack of mathematical resources in schools, which is problematic when teaching geometry. Thus, the resources they used are soft-ware and hard-ware resources that are available in their schools. The lack of ideological-ware would result in the failing of performance curriculum. The lack of ideological-ware used in teaching geometry, suggests that CAPS does not provide teachers with the relevant theory to use that underpins performance curriculum. Teachers deliver the intended curriculum in different ways that suit their practices. Hence, the literature indicated that ideological-ware is the most important resources that the teachers need to use in order to obtain the intended results of the performance curriculum.

The resources provided by the department, like textbooks and mathematical instruments are not well supplied because they are not equal to the number of the learners in the grade. This leads to teachers using books that are not suitable, and not well organised. This may cause teachers to become demotivated and restricts them to a small selection of choices on the activities available to their learners. However, the lack of repairs of resources was not given. This leaves the teachers with the problem caused by lack of electricity, scarce furniture, and rooms with no windows and doors. If the school's resources are not well cared for, it may mean the school will end up having no resources at all. Thus, the lack of computers with mathematical soft-ware affects the activities that could be done using GeoGebra and Geometers Sketchpad. As geometry is a practical part of Mathematics, it can be learned easily by using computers with relevant soft-ware.

5.3.7 Time and Learning environment

Geometry is taught as per timetable that includes all other subjects offered in that particular school. Based on the time allocated in the document, teachers feel there is a need of more time to be allocated to geometry. The lack of resources and inadequate learning environments affect the time needed for teaching geometry. This arises because there are no rooms designed for Mathematics in schools. The lack of mathematical laboratories in schools caused the problems and affected the use of technological software/hardware resources. Teaching geometry in an ordinary classroom means that the teachers have to move mathematics tools from class to class before and after the lesson. This exhaust the time allocated for teaching geometry. Therefore, those tools can be at risk of being damaged while moving around. Trying to change the classroom environment to accommodate Mathematics creates problems for other teachers who do not teach Mathematics. Again, the change of the setup also wastes the time allocated before and after the lesson. For performance curriculum to be productive, a review on time and learning environment for teaching geometry needs to be attended to.

5.3.8 Accessibility

The findings reveal that teachers are working in an overcrowded classroom. They are working with learners who have different learning disabilities, lack geometrical concepts of basic geometrical concepts. Teaching a wide group of learners with different education levels is challenging because the teachers need to begin with the basic geometrical concepts that Grade 10 learners are supposed to know at this level. As a result, Mathematics teachers often introduce Grade 10 in classes where the learners do not even know basic geometry. The large numbers in the classrooms affects one on one attention between teacher and the learner. This compels the teachers to move with the fast learners and under-serve those who need individual attention to develop their geometrical comprehension skills. A lack of geometrical tools in schools, due to financial status of the schools affect learning because learners are forced to share any tool they use. The problem faced with Mathematics teachers is that all learners are forced to do Mathematics, whereas not all the learners are interested in the subject.

5.3.9 Assessment

Grade 10 assessment is summative and formative. The assessment used by the teachers; are the set by themselves and the department. Thus, teachers are forced to follow the school programme in line with the department calendar for examinations since the common papers

must be written on a specific dates given by the department. Formative assessment was used for learners' progress and to evaluate teaching strategies used by the teachers. Thus, summative assessment is used to check learners' performance using tests and exams. Department tests and exams have a specific weighting for final assessment so teachers have to follow assessment policy. The summative assessment tools for geometry are standardized which results in teachers focusing only on the areas being assessed.

5.4 Suggestions for further research

The study explored Grade 10 teachers' experiences in teaching geometry in Umbumbulu circuit schools framed by curricular spider web components. Further studies can be conducted to get a deep understanding of geometry implementation needed in South African schools to meet the international education standards. Another study can be conducted on the limitation of the implementation of the performance curriculum in South Africa. A further study that can be conducted on Mathematics teachers' understanding of the performance curriculum versus competence curriculum implementation. The literature indicated that there are few studies conducted on the implementation of CAPS in South Africa. Therefore, there is need to conduct studies on the vulnerability of the curriculum by using the components of the spider web, especially on the learning environment, accessibility, resources and ideological-ware that underpins geometry within CAPS.

5.5 The study was trying to answer the following questions:

5.5.1 What are the Grade 10 teachers' experiences of teaching geometry in Umbumbulu circuit?

The findings indicated that teachers are teaching geometry under the influence of societal reasons. They also experience teaching geometry without relevant resources and materials. The lack of relevant resources in school might affect promotion of the aims and specific skills of the performance curriculum. Therefore, the affected component of the spider web affects the other components since they are connected through the rationale. The experience of teaching geometry without relevant geometrical resources affects the time allocated to teach geometry. Teachers tend to play the role of an instructor to minimise the work that should be done by the learners. The findings reveal that teachers encounter working in an environment that is inductive to teach learners with different learning abilities. This will affect the assessment method the teachers chose to use. Although using of summative and formative assessment was

indicated, they experience the problem of choosing the assessment that will accommodate learners' physical needs, but not their content needs. Hence, teachers' experiences indicated that they are using different activities; they tend to use teacher-centred learning activities.

5.5.2 Why do Grade 10 teachers have particular experiences of teaching geometry in Umbumbulu circuit?

The findings reveal that there is a lack of content reasons during the implementation of the performance curriculum. They indicated that the lack of resources is the main challenge undermining their ability to teaching geometry. Therefore, they are failing to deliver the content prescribed. When the content is not well delivered the aims and objectives won't be achieved. Thus, the content needs sufficient time allocated for teaching geometry in grade 10. Insufficient time in teaching geometry would mean that topics to be covered for summative assessment would not be fully taught. Summative assessment was compulsory for all Grade 10 learners because it is used by the department to check learners' progress. Thus, time also affects the type of learning activities the teachers use. Due to insufficient time allocated for teaching geometry, teacher-centred activities were used most prominently. They indicated that the learning environment compels them to employ teacher-centred approach. Due to the lack of resources and geometrical reasoning from learners, it becomes difficult to use the content-centred approach.

5.6 Recommendations

The following recommendations come from the above conclusions;

Recommendation 1

There is a necessity to remind teachers about the rationale for teaching geometry in order to stabilise the personal values and professional values. This will help the teachers to identify their strengths and weaknesses, and enjoy the teaching of geometry. This will benefit the teachers and the department of education as well as curriculum developers. A visible geometry rationale will help the teachers to advance their professional knowledge in teaching geometry which will help in the promotion of aims and objectives of the curriculum. There is a need for teachers to read studies on the content reasons for the teaching of geometry.

Recommendation 2

Mathematics teachers need to understand the subject aims, objectives, and they need to able to connect the objectives with the subject aims within performance curriculum. Once the aims are understood, teachers will connect the objectives with the subject aims and will be able to implement the performance curriculum. Geometry aims in Grade 10 need to be reconsidered in order to ensure that teachers are producing the intended results of the performance curriculum.

Recommendation 3

For a successful Grade 10 geometry implementation there is a need to provide content-based workshop to empower teachers' geometrical knowledge. This will help teachers to promote their understanding of the aims and objectives of CAPS based on the content, and develop new skills to implement the performance curriculum. The curriculum developers should provide teachers with resources and theory that is based on the content of the implemented curriculum. Curriculum dissemination should be between all the stakeholders that are involved, relevant to the learners' context and their interest in geometry.

Recommendation 4

There is a need for teachers to develop activities that will promote content reasoning. As a result, for school knowledge to be implemented the learning activities given to the learners must promotes the content knowledge of the curriculum. The literature indicated that school knowledge through instructional method limits the learners' ability to learn. This suggests that teachers' content knowledge should be developed as based on the content they teach. Therefore, teacher-centred activities should be discouraged in order for the learners to become active participants in their learning of geometry within CAPS.

Recommendation 5

For successful geometry content implementation, teachers should use teaching strategies that will accommodate learners' different learning abilities. Therefore, development courses should be provided through workshops and involve geometry specialists to assist teachers in developing their teaching skills.

Recommendation 6

There is a need to revise the prescribed text books. The use of different text books in one curriculum would mean unsuccessful implementation of the performance content curriculum. Since teachers are communicating the curriculum they should be given the opportunity to choose the materials used in order to produce the intended results of the implemented curriculum. Geometry resources should be provided in schools to accommodate learners who are coming from disadvantaged families.

Schools in rural areas should be supplied with technological resources. Those asserts will help the learners and teachers during teaching and learning. Even those provided needs to be maintained properly and repaired accordingly. Learners who used computers in learning geometry tend to have more interest in further learning. In addition, curriculum developers should provide teachers with the relevant Geometry theory that underpins CAPS. This will help to produce the intended results of the implemented curriculum.

Recommendation 7

There is a need to provide proper Mathematical classrooms that will be conducive in teaching geometry. The classroom should be provided with proper geometrical equipment that will be useful in instilling learners with geometrical concepts. Using proper geometrical equipment will help in minimising the time lost trying to set-up equipment. The 60-minute teaching time allocated for teaching geometry may only be enough when there is no time lost during the set-up of equipment. Learners will develop the interest of learning geometry in a mathematical orientated environment. Therefore, a laboratory, stocked with relevant resources should be built in rural schools.

Recommendation 8

Geometry should be taught thoroughly in Primary level so that all learners develop geometrical concepts at an early age. Teaching learners with different geometry abilities would be challenging. The teacher pupil ratio needs to be considered in a Mathematics classroom, because overcrowded prevents teacher from giving learners individual attention.

Recommendation 9

Teachers should assess the learners and use Van Hiele's levels of development in assessing learners' geometrical understanding (Smeets, 2005). Formative and summative assessments

used as standardised tests should develop learners reasoning skills, so that learners will be able compete with other countries. Mathematics teachers should be trained in using the different assessment tools used in geometry in order to guarantee that learners are assessed on the same geometry content.

Recommendation 10

There is a need to conduct more studies on the factors contributing in teaching geometry in Secondary school, especially in rural areas. This can help teachers to understand how to teach geometry across diverse conditions in the different schools the mathematics teachers' encounter. Teachers as curriculum implementers need to have a better understanding on how to deal with factors that affects their teaching. This will help the teachers to overcome the problems cause by factors that hinder them from implementing the intended curriculum. This would also enable the curriculum developers to see the advantages and disadvantages of the implemented curriculum and work on the elements that work well for the implemented curriculum.

5.7 Conclusion

The Mathematics teachers' experiences of implementing geometry in Grade 10 within Umbumbulu circuit have indicated that time and learning environment play a vital role in producing the intended results of the implemented curriculum. This suggests that spider web components will be affected because each component is attached to each other. A conducive learning environment creates the positive attitude and motivates the learners to fully use the available resources (Berkvens *et al.*, 2014). A conducive learning environment provided with geometrical resources needed for curriculum implementation, should be implemented in all black African schools. Once the classroom is conducive the teachers will be able to use professional content knowledge by incorporating the content reasons for teaching performance curriculum (Ball *et al.,* 2008). The teachers' experiences suggest that content should promote the aims and objectives of geometry through logical reasoning, proofs on theorems, and geometrical properties (Brown, Jones, Taylor, & Hirst, 2004). Hence, the teachers' experience indicated that there is a need to move from using activities that are competence based to performance based as it will promote the content of the implemented curriculum.

Furthermore, Mathematics is believed to be difficult but important subject within Sciences hence, little is done to empower teachers in the implementation of performance curriculum.

Furthermore, subject policy should be followed and teachers must practice the roles that will promote the content knowledge of the implemented curriculum. Thus, content knowledge should be the key element in assessing learners. The type of summative assessment used should help the learners to develop the content knowledge instead judging teachers and learners' performance. Therefore, teacher development in the implementation of CAPS is needed in order to yield the intended results of the curriculum.

5.8 Final conclusion of the study

The purpose of this study was to explore teachers' experience in teaching geometry in Grade 10 CAPS. The study indicated that content is important in promoting the aims of the curriculum. Mastering the topic helped the implementers to incorporate the objectives of their teaching with the goals of the curriculum. Curriculum developers would be able to see what is working and rectify what is not working with CAPS. The promotion of aims would mean that South Africa's main goal of producing learners who can think critically is achieved. Therefore, teachers will produce learners who can compete with other countries for example TIMMS.

The encounters reveal that there is a lack of technological and mathematical resources in schools which hinders the teachers from designing the activities that will encourage learners to learn on their own. Shortage of teaching materials hinders the participants in delivering their work using technological resources. They drive their practices into teacher-centred approaches. The study reveal that learning dominated by the learners is more likely to produce good results, because they learn to conduct proofs on their own. Availability of resources will help in promoting a positive learning attitude towards learners. Providing schools with resources will help learners to meet the demands of the 21st century and be able to compete in the world of technology. The study reveals that socio-economic factors is problematic in rural schools. Although the study was conducted in Umbumbulu, this can be common factor of rural schools throughout the country. The use of a spider web as a conceptual framework of the study reveals that curriculum developers would be able to identify the area that needs to be improved for better implementation of the intended curriculum. The curricular spider web indicated that all of its components are helpful in the development of the curriculum (van den Akker, 2009). If one of the components is given less attention, that would cause the curriculum to become vulnerable. Hence, during the evaluation process all the sectors of the syllabus should be monitored to find the shortcomings that might jeopardise the intended results of the curriculum

References

Achor, E., Imoko, B. I., & Ajai, J. T. (2010). Sex differentials in students' achievement and interest in geometry using games and simulations technique. *Necatibey Faculty of Education Electronic journal of Science and mathematics Education, 4*(1), 1-10.

Adler, J. (2005). Mathematics for teaching: What is it and why is it important that we talk about it. *pythagoras, 62*, 2-11.

Akyeampong, K., Pryor, J., & Ampiah, J. G. (2006). A vision of successful schooling: Ghanaian teachers' understandings of learning, teaching and assessment. *Comparative education, 42*(02), 155-176.

Aldridge, J. M., Fraser, B. J., & Sebela, M. P. (2004). Using teacher action research to promote constructivist learning environments in South Africa. *South African journal of education, 24*(4), 245-253.

Aldridge, J., Fraser, B., & Ntuli, S. (2009). Utilising learning environment assessments to improve teaching practices among in-service teachers undertaking a distance-education programmme. *South African Journal of Education, 29(2*), 147-170

Alex, J., & Mammen, K. (2014). An Assessment of the Readiness of Grade 10 Learners for Geometry in the Context of Curriculum and Assessment Policy Statement (CAPS) Expectation.

Anderson, L. W. (2002). Curricular alignment: A re-examination. *Theory into practice, 41*(4), 255-260.

Archer, D., & Goreth, N. M. (2004). Participation, literacy and empowerment: the continuing evolution of Reflect. *Participatory Learning and Action, 50*, 35-44.

Atebe, H. U., & Schafer, M. (2010). Beyond teaching language: towards terminological primacy in learners' geometric conceptualisation. *pythagoras*(71), 53-64.

Atebe, H. U., & Schäfer, M. (2011). The nature of geometry instruction and observed learning-outcomes opportunities in Nigerian and South African high schools. *African Journal of Research in Mathematics, Science and Technology Education, 15*(2), 191-204.

Ayers, E. L. (1992). *The promise of the new South: Life after reconstruction*: Oxford University Press.

Ball, D. L. (2003). What mathematical knowledge is needed for teaching mathematics. *Secretary's Summit on Mathematics, US Department of Education*.

Ball, D. L., Thames, M. H., & Phelps, G. (2008). Content knowledge for teaching what makes it special? *Journal of teacher education, 59*(5), 389-407.

Bantwini, B. D. (2010). How teachers perceive the new curriculum reform: Lessons from a school district in the Eastern Cape Province, South Africa. *International Journal of Educational Development, 30*(1), 83-90.

Baumert, J., Kunter, M., Blum, W., Brunner, M., Voss, T., Jordan, A., Tsai, Y.-M. (2010). Teachers' mathematical knowledge, cognitive activation in the classroom, and student progress. *American educational research journal, 47*(1), 133-180.

Benson, C. (2004). Bilingual schooling in Mozambique and Bolivia: From experimentation to implementation. *Language Policy, 3*(1), 47-66.

Berkvens, J., van den Akker, J., & Brugman, M. (2014). Addressing the quality challenge: Reflections on the Post-2015 UNESCO Education Agenda. *Netherlands National commission for UNESCO*.

Bernstein, B. (1999). Vertical and horizontal discourse: An essay. *British Journal of Sociology of Education, 20*(2), 157-173.

Birman, G. S., & Nomizu, K. (1984). Trigonometry in Lorentzian geometry. *American Mathematical Monthly*, 543-549.

Blanton, M. L., & Kaput, J. J. (2005). Characterizing a classroom practice that promotes algebraic reasoning. *Journal for Research in Mathematics Education*, 412-446.

Botes, A., & Otto, M. (2003). Ethical dilemmas related to the HIV-positive person in the workplace. *Nursing Ethics, 10*(3), 281-294.

Botha, L. R. (2010). Indigenous knowledge as culturally-centred education in South Africa. *Africa Education Review, 7*(1), 34-50.

Brown, M., Jones, K., Taylor, R., & Hirst, A. (2004). Developing geometrical reasoning.

Carl, A. E. (2009). *Teacher empowerment through curriculum development: Theory into practice*: Juta and Company Ltd.

Catoni, F., Cannata, R., Catoni, V., & Zampetti, P. (2005). Hyperbolic trigonometry in two-dimensional space-time geometry. *arXiv preprint math-ph/0508011*.

Chinn, P. W. (2007). Decolonizing methodologies and indigenous knowledge: The role of culture, place and personal experience in professional development. *Journal of Research in Science Teaching, 44*(9), 1247-1268.

Chisholm, L. (2003). *The politics of curriculum review and revision in South Africa.* Paper presented at the Oxford International conference on education and development.

Choi-Koh, S. S. (1999). A student's learning of geometry using the computer. *The Journal of Educational Research, 92*(5), 301-311.

Church, W., & Skelton, L. (2010). Sustainability education in K-12 classrooms. *Journal of Sustainability Education, 1*(0).

Clausen-May, T., Jones, K., McLean, A., Rowlands, S., & Carson, R. (2000). Perspectives on the design of the school geometry curriculum. *Proceedings of the British Society for Research into Learning Mathematics, 20*(1-2), 34-41.

Cohen, L., Manion, L., & Morrison, K. (2011). *Research methods in education*. Seventh edition: London: Routledge.

Collier, S. T. (1999). Characteristics of reflective thought during the student teaching experience. *Journal of teacher education, 50*(3), 173.

Creswell, J. W. (2013). *Research design: Qualitative, quantitative, and mixed methods approaches*: Sage publications.

Crosby, R. H., Joy. (2000). AMEE Guide No 20: The good teacher is more than a lecturer-the twelve roles of the teacher. *Medical teacher, 22*(4), 334-347.

Da Ponte, J. P., & Chapman, O. (2006). Mathematics teachers' knowledge and practices. *Handbook of research on the psychology of mathematics education*, 461-494.

Darling-Hammond, L., & Snyder, J. (2000). Authentic assessment of teaching in context. *Teaching and teacher education, 16*(5), 523-545.

Dawson, C. (2007). *Introduction to research methods.* A practical guide for anyone undertaking a research project, Hachette UK.

De Villiers, M. (2004). Using dynamic geometry to expand mathematics teachers' understanding of proof. *International Journal of Mathematical Education in Science and Technology, 35*(5), 703-724.

De Villiers, M. (2010). *Some reflections on the van Hiele theory.* Paper presented at the Invited plenary from 4th Congress of teachers of mathematics.

DiCicco-Bloom, B., & Crabtree, B. F. (2006). The qualitative research interview. *Medical education, 40*(4), 314-321.

DoE. (2002). Revised national curriculum statements grades R-9 (Schools). *Government gazette* 443 (23406) 31 May.

DoE. (2007). *National Policy on Assessment and Qualifications for Schools in the General Education and Training Band*. Government Notice No 124 in Government Gazette 29626, 12 February. Pretoria: Government Printer.

DoE. (2011). *Curriculum and Assessment Policy Statement.* Mathematics. Further and Education and Training Phase. Grade 10-12. Pretoria.

Duval, R. (2006). A cognitive analysis of problems of comprehension in a learning of mathematics. *Educational studies in mathematics, 61*(1-2), 103-131.

Edwards, J. A., & Jones, K. (2006). Linking geometry and algebra with GeoGebra. *Mathematics Teaching, 194*, 28-30.

Engelbrecht, J., & Harding, A. (2005). Teaching undergraduate mathematics on the internet. *Educational studies in mathematics, 58*(2), 253-276.

Engelbrecht, J., & Harding, A. (2008). The impact of the transition to outcomes-based teaching on university preparedness in mathematics in South Africa. *Mathematics Education Research Journal, 20*(2), 57-70.

Ensor, P. (2001). From preservice mathematics teacher education to beginning teaching: A study in recontextualizing. *Journal for Research in Mathematics Education*, 296-320.

Fauzan, A., Plomp, T., & Gravemeijer, K. (2013). The development of an rme-based geometry course for Indonesian primary schools. *Educational design research–Part B: Illustrative cases*, 159-178.

Fomunyam, K. G. (2014). Curriculum theorizing and individualism: An exploration of the curriculum's relation to the social, personal and political dimensions of schooling.

Gay, G. (2004). The importance of multicultural education. *The curriculum studies reader*, 315-320.

Gawlick, T. (2002). On dynamic geometry software in the regular classroom. *ZentralblattfurDidaktik der Mathematik, 34(3)*, 85-92.

Gellert, U., Jablonka, E., & Morgan, C. (2010). Mathematical Education and Society. *In Proceedings of the Sixth International Mathematics Education Conference. 20th-25th March 2010, Berlin, Germany.*

Giacardi, L. (2010). The Italian school of algebraic geometry and mathematics teaching: Methods, teacher training, and curricular reforms in the early twentieth century. *International Journal for the History of Mathematics Education, 5*(1), 1-19.

Giaquinto, M. (2007). Visual thinking in mathematics: An epistemological study. *New York: Oxford*.

Gladys, S., Nicholas, Z., Graciuos, Z., & Mirirai, C. (2013). Incorporating Religious Mathematics. In the Teaching and Learning of Formal Geometry: A Case of The Apostolic Church Sector In Zimbabwe.

Graneheim, U. H., & Lundman, B. (2004). Qualitative content analysis in nursing research: concepts, procedures and measures to achieve trustworthiness. *Nurse education today, 24*(2), 105-112.

Gvirtz, S., & Beech, J. (2004). From the intended to the implemented curriculum in Argentina: Regulation and practice. *Prospects, 34*(3), 371-382.

Handal, B., & Herrington, A. (2003). Mathematics teachers' beliefs and curriculum reform. *Mathematics Education Research Journal, 15*(1), 59-69.

Hannafin, R. D., Burruss, J. D., & Little, C. (2001). Learning with dynamic geometry programs: Perspectives of teachers and learners. *The Journal of Educational Research, 94*(3), 132-144.

Hargreaves, A., & Moore, S. (2000). Curriculum Integration and Classroom Relevance: A Study of Teachers' Practice. *Journal of Curriculum and Supervision, 15*(2), 89-112.

Hatton, N., & Smith, D. (1995). Reflection in teacher education: Towards definition and implementation. *Teaching and teacher education, 11*(1), 33-49.

Herbst, P., & Miyakawa, T. (2008). When, how, and why prove theorems? A methodology for studying the perspective of geometry teachers. *ZDM, 40*(3), 469-486.

Herbst, P., Nachlieli, T., & Chazan, D. (2011). Studying the practical rationality of mathematics teaching: What goes into "installing" a theorem in geometry? *Cognition and Instruction, 29*(2), 218-255.

Hill, H. C., Rowan, B., & Ball, D. L. (2005). Effects of teachers' mathematical knowledge for teaching on student achievement. *American educational research journal, 42*(2), 371-406.

Hoadley, U., & Jansen, J. D. (2012). *Curriculum*: Organising knowledge for the classroom. 3rd Edition.Oxford University Press. Cape Town

Hockman, M. (2005). Curriculum design and tertiary education. *International Journal of Mathematical Education in Science and Technology, 36*(2-3), 175-191.

Howie, S., & Plomp, T. (2002). Mathematical literacy of school leaving pupils in South Africa. *International Journal of Educational Development, 22(6),* 603-615.

Howie, S. J. (2003). Language and other background factors affecting secondary pupils' performance in South Africa. *African Journal of Research in Mathematics, Science and Technology education, 7(1),* 1-20

Howie, S., Scherman, V., & Venter, E. (2008). The gap between advantaged and disadvantaged students in science achievement in South African secondary schools. *Educational Research and Evaluation, 14*(1), 29-46.

Howie, S. J., & Pietersen, J. J. (2001). Mathematics literacy of final year students: South African realities. *Studies in Educational Evaluation, 27*(1), 7-25.

Hytti, U., & O'Gorman, C. (2004). What is "enterprise education"? An analysis of the objectives and methods of enterprise education programmes in four European countries. *Education+ Training, 46*(1), 11-23.

Ikle, M., & Goertzel, B. (2011). Nonlinear-dynamical attention allocation via information geometry *Artificial General Intelligence* (pp. 62-71): Springer.

James, A., Naidoo, J., & Benson, H. (2008). *CASME's Approach to the sustainability of Science Education in South Africa.* Paper presented at the XIII IOSTE Symposium on the use of Science and Technology Education for Peace and Sustainable Development.

Jarvis, D., Hohenwarter, M., & Lavicza, Z. (2011). Geogebra, Democratic Access, and Sustainability *Model-Centered Learning* (pp. 231-241): Springer.

Jones, K. (2000). Critical issues in the design of the school geometry curriculum.

Jones, K., & Mooney, C. (2003). Making space for geometry in primary mathematics.

Julie, C., & Mbekwa, M. (2005). What would Grade 8 to 10 learners prefer as context for mathematical literacy? The case of Masilakele Secondary School: research article: mathematics and science education. *Perspectives in Education: Speaking the Curriculum: Learner Voices and Silences-Challenges for Mathematics and Science Education in the Twenty First Century: Special Issue 3, 23*, p. 31-43.

Kardos, S. M., & Johnson, S. M. (2010). New teachers' experiences of mentoring: The good, the bad, and the inequity. *Journal of Educational Change, 11*(1), 23-44.

Katz, V. J., & Barton, B. (2007). Stages in the history of algebra with implications for teaching. *Educational studies in mathematics, 66*(2), 185-201.

Kauffman, D., Moore, J. S., Kardos, S., Liu, E., & Peske, H. (2002). " Lost at Sea": New Teachers' Experiences with Curriculum and Assessment. *The Teachers College Record, 104*(2), 273-300.

Kennedy, D., Hyland, A., & Ryan, N. (2009). Learning outcomes and competences. *Bologna Handbook, Introducing Bologna Objectives and Tools*.

Khoza, S. B. (2001). *The Outcomes of students studying a computer literacy course at Unischool* (Doctoral dissertation, Med dissertation. Durban University of Durban-Westville)

Khoza, S. B. (2013a). Can they change from being digital immigrants to digital natives? *Progressio, 35*(1), 54-71.
Khoza, S. B. (2015). Student teachers' reflections on their practices of Curriculum and Assessment Policy Statement. *South African Journal of Higher Education, 29*(4), 179-197.
Khoza, S. B. (2012). Who helps an online facilitator to learn with students in a day. *Mevlana International Journal of Education, 2*(2), 75-84.
Khoza, S. B. (2013b). Learning Outcomes as Understood by" Publishing Research" Facilitators at a South African University. *Online Submission, 3*(2), 1-11.
Khoza, S. B. (2014). Lecturers' Views On Experiences Of A Post Graduate Honours Research Module Implemented Curriculum. *Melvana International Journal of Education (MIJE)*.
Kirby, P. C. (1988). Reflective Teaching and Teacher Effectiveness: Measurement Considerations.
Klopfenstein, K. (2005). Beyond test scores: The impact of black teacher role models on rigorous math taking. *Contemporary Economic Policy, 23*(3), 416-428.
Krathwohl, D. R. (2002). A revision of Bloom's taxonomy: An overview. *Theory into practice, 41*(4), 212-218.
Krishnannair, A., & Christiansen, I. (2013). Assessment Alternatives—Compliance versus Custom? A Case Study of Five South African Mathematics Teachers. *African Journal of Research in Mathematics, Science and Technology Education, 17*(3), 255-264.
Lauer, P. A. (2006). *An education research primer: How to understand, evaluate and use it*: Jossey-Bass.
Lavy, I., & Shriki, A. (2014). Engaging prospective teachers in peer assessment as both assessors and assessees: The case of geometrical proofs. *International Journal of Mathematics Teaching and Learning. From< http://www. cimt. plymouth. ac. uk/journal/lavey2pdf>(Retrieved on 1 June 2014)*.
Leshem, S., & Trafford, V. (2007). Overlooking the conceptual framework. *Innovations in education and Teaching International, 44*(1), 93-105.
Lim, E. L., & Moore, D. W. (2002). Problem solving in geometry: Comparing the effects of non-goal specific instruction and conventional worked examples. *Educational psychology, 22*(5), 591-612.
Lombardi, M. M. (2007). Authentic learning for the 21st century: An overview. *Educause learning initiative, 1*(2007), 1-12.
Lotfi, S., & Koohsari, M. J. (2009). Measuring objective accessibility to neighborhood facilities in the city (A case study: Zone 6 in Tehran, Iran). *Cities, 26*(3), 133-140.
Lu, J., & Law, N. (2012). Online peer assessment: effects of cognitive and affective feedback. *Instructional Science, 40*(2), 257-275.
Maclellan, E. (2001). Assessment for learning: the differing perceptions of tutors and students. *Assessment & Evaluation in Higher Education, 26*(4), 307-318.
Mapolela, D. C. (2003). Case studies of changes of beliefs of two in-service primary school teachers. *Assessment & Evaluation in Higher Education,, 264*(4), 307-318.
Marx, R. W., Blumenfeld, P. C., Krajcik, J. S., Fishman, B., Soloway, E., Geier, R., & Tal, R. T. (2004). Inquiry-based science in the middle grades: Assessment of learning in urban systemic reform. *Journal of Research in Science Teaching, 41*(10), 1063-1080.
Mayer, R. E. (2002). Rote versus meaningful learning. *Theory into practice, 41*(4), 226-232.
McMillan, J. H., & Schumacher, S. (2014). *Research in education: Evidence-based inquiry*: Pearson Higher Ed.
Mercer, N., & Sams, C. (2006). Teaching children how to use language to solve maths problems. *Language and Education, 20*(6), 507-528.

Mezirow, J. (1990). How critical reflection triggers transformative learning. *Fostering critical reflection in adulthood*, 1-20.
Milrad, M., Wong, L.-H., Sharples, M., Hwang, G.-J., Looi, C.-K., & Ogata, H. (2013). Seamless learning: An international perspective on next generation technology enhanced learning. *Handbook of mobile learning*, 95-108.
Mistretta, R. M. (2000). Enhancing geometric reasoning. *Adolescence, 35*(138), 365.
Mji, A., & Makgato, M. (2006). Factors associated with high school learners' poor performance: a spotlight on mathematics and physical science. *South African journal of education, 26*(2), 253-266.
Mollo, V., & Falzon, P. (2004). Auto-and allo-confrontation as tools for reflective activities. *Applied ergonomics, 35*(6), 531-540.
Motshekga, A. (2010). Curriculum News. Improving the quality of learning and teaching. *Basic education*.
Motshekga, M. A. (2009). Report of the Task Team for the Review of the Implementation of the National Curriculum Statement: Statement by Minister of Basic Education on Curriculum Review Final Report.
Msibi, T., & Mchunu, S. (2013). The knot of curriculum and teacher professionalism in post-apartheid South Africa. *Education As Change, 17*(1), 19-35.
Mthembu, S. G. (2007). *Instructional Approaches in the teaching of Euclidean Geometry in Grade 11*. University of KwaZulu-Natal.
Mudaly, V. (2004). Modelling of real-world problems is often the starting point for proof. *pythagoras, 60*, 36-43.
Mukucha, J. (2012). *The mathematics definition discourse: teachers' practices in multilingual classrooms.* Dissertation.
Naidoo, S. (2007). *Mathematical knowledge for teaching geometry to Grade 10 learners*. University of Witwatersrand Johannesburg.
Naidoo, J. (2011). *Scaffolding the teaching and learning of mathematics.* Paper presented at the Proceedings of the 17th Annual Nafional Congress of the Associafion for Mathemafics Educafion of South Africa.
Naidoo, J. (2012). Teacher reflection: the use of visual tools in mathematics classroom: original research. *Pythagoras, 33(1)*, 1-9.
Ndlovu, B. R. (2012). *Exploring Pre-service Teachers' Knowledge of Proof in Geometry*. University of KwaZulu-Natal, Durban.
Ndlovu, M., Wessels, D. C., & De Villiers, M. D. (2010). *Modelling with Sketchpad to enrich students'concept image of the derivative.* Paper presented at the Proceedings of the 16 th Annual Congress of the Association for Mathematics Education of South Africa.
Neuman, W. L. (1997). Social research methods: qualitative and quantitative approaches. Allyn & Bacon. *Needham Heights, USA*.
Noor, K. B. M. (2008). Case study: A strategic research methodology. *American journal of applied sciences, 5*(11), 1602-1604.
Oguzor, U. C. (2014). Consideration of culture in development of home economics curriculum in Nigeria. *International Letters of Social and Humanistic Sciences*(04), 97-104.
Okigbo, E. C., & Osuafor, A. M. (2008). Effect of using mathematics laboratory in teaching mathematics on the achievement of mathematics students. *Educational Research and Review, 3*(8), 257-261.
Panagiotis, S. (2009). The role of teaching in development of basic concepts in geometry, the concept of similarity and intuitive knowledge. *Colección Digital Eudoxus, 1*(2).
Patton, M. Q. (2005). *Qualitative research*: Wiley Online Library.

Penuel, W. R., Fishman, B. J., Yamaguchi, R., & Gallagher, L. P. (2007). What makes professional development effective? Strategies that foster curriculum implementation. *American educational research journal, 44*(4), 921-958.
Porter, A., McMaken, J., Hwang, J., & Yang, R. (2011). Common core standards the new US intended curriculum. *Educational Researcher, 40*(3), 103-116.
Reddy, V. (2005). State of mathematics and science education: schools are not equal: conversations. *Perspectives in Education: Speaking the Curriculum: Learner Voices and Silences-Challenges for Mathematics and Science Education in the Twenty First Century: Special Issue 3, 23*, p. 125-138.
Roberts, N., & Vänskä, R. (2011). Challenging assumptions: Mobile learning for mathematics project in South Africa. *Distance Education, 32*(2), 243-259.
Rowlands, S., & Carson, R. (2002). Where would formal, academic mathematics stand in a curriculum informed by ethnomathematics? A critical review of ethnomathematics. *Educational studies in mathematics, 50*(1), 79-102.
Rowley, J., & Slack, F. (2004). Conducting a literature review. *Management Research News, 27*(6), 31-39.
Sarma, M. (2008). *Index of financial inclusion*: Indian Council for Research on International Economics Relations.
Schön, D. A. (1983). *The reflective practitioner: How professionals think in action* (Vol. 5126): Basic books.
Setati, M., & Barwell, R. (2008). Making mathematics accessible for multilingual learners. *pythagoras*(67), 2-4.
Sipos, E. R., & Kosztolányi, J. (2009). TEACHING GEOMETRY USING COMPUTER VISUALIZATION.
Smeets, E. (2005). Does ICT contribute to powerful learning environments in primary education? *Computers & Education, 44*(3), 343-355.
Solomon, P. G. (2009). The curriculum bridge. From the Standards to Actual clssroom Practice. 3rd edition.
Spencer, L., Ritchie, J., Lewis, J., & Dillon, L. (2003). Quality in qualitative evaluation: a framework for assessing research evidence.
Spooner, M., Flowers, C., Lambert, R., & Algozzine, B. (2008). Is more really better? Examining perceived benefits of an extended student teaching experience. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas, 81*(6), 263-270.
Sriprakash, A. (2010). Child-centred education and the promise of democratic learning: Pedagogic messages in rural Indian primary schools. *International Journal of Educational Development, 30*(3), 297-304.
Stols, G. (2007). Designing mathematical-technological activities for teachers using the Technology Acceptance Model. *pythagoras, 65*, 10-17.
Stuart, C., & Thurlow, D. (2000). Making it their own: Preservice teachers' experiences, beliefs, and classroom practices. *JOURNAL OF TEACHER EDUCATION-WASHINGTON DC-, 51*(2), 113-121.
Taber, K. S. (2012). Prioritising paradigms, mixing methods, and characterising the 'qualitative' in educational research. *Teacher Development, 16*(1), 125-138.
Trgalova, J., Jahn, A. P., & Soury-Lavergne, S. (2009). *Quality process for dynamic geometry resources: the Intergeo project.* Paper presented at the Proceedings of CERME.
Tyler, R. W. (2013). *Basic principles of curriculum and instruction*: University of Chicago press.
Unal, H., Jakubowski, E., & Corey, D. (2009). Differences in learning geometry among high and low spatial ability pre-service mathematics teachers. *International Journal of Mathematical Education in Science and Technology, 40*(8), 997-1012.

Van den Berg, S. (2008). How effective are poor schools? Poverty and educational outcomes in South Africa. *Studies in Education Evaluation,* 34(3), 145-154.

van der Walt, M., & Maree, K. (2007). Do mathematics learning facilitators implement metacognitive strategies? *South African journal of education, 27*(2).

Van den Akker, J. (2003). *Curriculum perspectives: An introduction*: Springer.

Van der Akker, J. (2006). Curriculum design research. *An introduction to educationa design research, 37*

Van den Akker, J., de Boer, W., Folmer, E., Kuiper, W., Letschert, J., Nieveen, N., & Thijs, A. (2009). Curriculum in development. *Enschede: Netherlands Institute for Curriculum Development*.

Van der Sandt, S., & Nieuwoudt, H. D. (2003). Grade 7 teachers' and prospective teachers' content knowledge of geometry. *South African journal of education, 23*(3), 199-205.

Van Manen, M. (1977). Linking ways of knowing with ways of being practical. *Curriculum inquiry, 6*(3), 205-228.

Vandeyar, S., & Killen, R. (2007). Educators' conceptions and practice of classroom assessment in post-apartheid South Africa. *South African journal of education, 27*(1), 101-115.

Webb, S. D. (2011). Accessibility of university mathematics. *MSOR Connections, 11*(1), 42-47.

Webster, J., & Watson, R. T. (2002). Analyzing the past to prepare for the future: Writing a literature review. *Management Information Systems Quarterly, 26*(2), 3.

Weldeana, H. N. (2008). *The effect of problem based teaching and learning on the achievement of high school mathematics learners.* University of South Africa.

Wilhelm, J., Sherrod, S., & Walters, K. (2008). Project-based learning environments: Challenging preservice teachers to act in the moment. *The Journal of Educational Research, 101*(4), 220-233.

Wilson, E. (2009). *School-based research: A guide for education students.* London: Sage

Wilson Thompson, B. (2006). *Factors influencing teachers' choice and use of tasks for formative assessment of mathematics in grades 2-6.*

Wohlhuter, K. A. (1998). Geometry classroom pictures: What's developing? *The Mathematics Teacher, 91*(7), 606.

Xie, Y., Ke, F., & Sharma, P. (2008). The effect of peer feedback for blogging on college students' reflective learning processes. *The Internet and Higher Education, 11*(1), 18-25.

Yegambaram, P. (2012). *The effectiveness of computer-aided teaching on the quality of learning geometric concepts by grade 7 learners at a selected primary school in KwaZulu-Natal.* Durban University of Technology.

Yost, D. S., Sentner, S. M., & Forlenza-Bailey, A. (2000). An examination of the construct of critical reflection: Implications for teacher education programming in the 21st century. *Journal of teacher education, 51*(1), 39.

Youngs, P. (2007). How elementary principals' beliefs and actions influence new teachers' experiences. *Educational Administration Quarterly, 43*(1), 101-137.

Zakaria, E., & Iksan, Z. (2007). Promoting Coperative Learning in Science and Mathematics Education: A Malaysian Perspective. *Online Submission,* 3(1), 35-39.

Appendices

Appendix 1: Permission to conduct the study

education

Department:
Education
PROVINCE OF KWAZULU-NATAL

Enquiries: Nomangisi Ngubane Tel: 033 392 1004 Ref.:2/4/8/503

Mrs DS Shange
381 Kenyon Howden Road
39 Westwood Gardens
WOODLANDS
4004

Dear Mrs Shange

PERMISSION TO CONDUCT RESEARCH IN THE KZN DoE INSTITUTIONS

Your application to conduct research entitled: **"AN EXPLORATION OF TEACHERS' EXPERIENCES IN TEACHING GRADE 10 GEOMETRY WITHIN A CURRICULUM AND ASSESSMENT POLICY STATEMENT (CAPS) IN THE UMBUMBULU CIRCUIT",** in the KwaZulu-Natal Department of Education Institutions has been approved. The conditions of the approval are as follows:

1. The researcher will make all the arrangements concerning the research and interviews.
2. The researcher must ensure that Educator and learning programmes are not interrupted.
3. Interviews are not conducted during the time of writing examinations in schools.
4. Learners, Educators, Schools and Institutions are not identifiable in any way from the results of the research.
5. A copy of this letter is submitted to District Managers, Principals and Heads of Institutions where the intended research and interviews are to be conducted.
6. The period of investigation is limited to the period from 15 August 2015 to 31 August 2016.
7. Your research and interviews will be limited to the schools you have proposed and approved by the Head of Department. Please note that Principals, Educators, Departmental Officials and Learners are under no obligation to participate or assist you in your investigation.
8. Should you wish to extend the period of your survey at the school(s), please contact Miss Connie Kehologile at the contact numbers below.
9. Upon completion of the research, a brief summary of the findings, recommendations or a full report / dissertation / thesis must be submitted to the research office of the Department. Please address it to The Office of the HOD, Private Bag X9137, Pietermaritzburg, 3200.
10. Please note that your research and interviews will be limited to schools and institutions in KwaZulu-Natal Department of Education.

UMbumbulu Circuit

Nkosinathi S.P. Sishi, PhD
Head of Department: Education
Date: 11 August 2015

KWAZULU-NATAL DEPARTMENT OF EDUCATION
POSTAL: Private Bag X 9137, Pietermaritzburg, 3200, KwaZulu-Natal, Republic of South Africa
PHYSICAL: 247 Burger Street, Anton Lembede House, Pietermaritzburg, 3201. Tel. 033 392 1004
EMAIL ADDRESS: kehologile.connie@kzndoe.gov.za / Nomangisi.Ngubane@kzndoe.gov.za
CALL CENTRE: 0860 596 363; Fax: 033 392 1203 WEBSITE: WWW.kzneducation.gov.za

Appendix 2: Ethical clearance

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

31 August 2015

Mrs Dumazile Sylvia Shange 208526300
School of Education
Edgewood Campus

Dear Mrs Shange

Protocol reference number: HSS/0285/015M
Project title: An exploration of teachers' experiences in teaching Grade 10 geometry within Curriculum and Assessment Policy Statement (CAPS) in Umbumbulu Circuit.

Expedited Approval

In response to your application dated 7 April 2015, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol have been granted **FULL APPROVAL.**

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number.

Please note: Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for a period of 3 years from the date of issue. Thereafter Recertification must be applied for on an annual basis.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

.....
Dr Shenuka Singh (Chair)

/px

cc Supervisor: Dr SB Khoza
cc Academic Leader Research: Professor P Morojele
cc School Administrator: Ms B Bhengu, Ms T Khumalo & Ms PW Ndimande

Humanities & Social Sciences Research Ethics Committee
Dr Shenuka Singh (Chair)
Westville Campus, Govan Mbeki Building
Postal Address: Private Bag X54001, Durban 4000
Telephone: +27 (0) 31 260 3587/8350/4557 **Facsimile:** +27 (0) 31 260 4609 **Email:** ximbap@ukzn.ac.za / snymanm@ukzn.ac.za / mohunp@ukzn.ac.za
Website: www.ukzn.ac.za

Appendix 3: Principals consent letter

381 Kenyon Howden Road

39 Westwood Gardens

Woodlands

4004

13 August 2015

Dear Sir/Madam

REQUEST TO CONDUCT A STUDY

My name is D. S. Shange, I am a Curriculum MED candidate studying at the University of KwaZulu-Natal, Edgewood campus, South Africa.

I am interested in exploring the teachers' experiences in teaching Grade 10 geometry within Curriculum and Assessment Policy (CAPS) in Umbumbulu circuit. I am studying cases of 5 High School in Umbumbulu area. Your school is one of my case studies. To gather the information, I am interested in asking your Grade 10 mathematics teachers some questions. I would like you to allow your mathematics teacher to participate in my study.

Please note that:

- Your confidentiality is guaranteed as your inputs will not be attributed to you in person, but reported only as a Mathematics teachers' experience.
- The interview may last for about 30 minutes and may be split depending on teachers' preference.
- Any information given by your teacher cannot be used against you, and the collected data will be used for purposes of this research only.
- There will be no limit on any benefit that the participants may receive as part of their participation in this research project;
- Data will be stored in secure storage and destroyed after 5 years.
- The teachers have a choice to participate, not participate or stop participating in the research. You will not be penalized for taking such an action.
- The participants are free to withdraw from the research at any time without any negative or undesirable consequences to themselves;
- Real names of the participants will not be used, but symbols such as A, B, C, D, E and 1, 2, 3, 4, 5 will be used to represent participants' names;
- The research aims at knowing the teachers' experiences in teaching Grade 10 geometry framed by curricular spider web.

I can be contacted at:

Email: makhosid123@gmail.com

Cell: +2839578724 or +2728257408.

My supervisor is Dr. S.B. Khoza who is located at the School of Education, Edgewood campus of the University of KwaZulu-Natal.

Contact details: email: khozas@ukzn.ac.za Phone number: +27312607595.

Discipline Co-ordinator is Dr. L.R. Maharajh,
Curriculum Studies, School of Education,
Edgewood College, University of KwaZulu-Natal
(Tel) 0312602470 (Cell) 0822022524, Email: maharajhlr@ukzn.ac.za.

You may also contact the Research Office through:

P. Ximba

HSSREC Research Office,

Tel: 031 260 3587 E-mail: ximbap@ukzn.ac.za

Yours faithfully

Mrs D. S. Shange

DECLARATION

I…… (full names of principal) hereby confirm that I understand the contents of this document and the nature of the research project, and I consent to allow grade 10 mathematics teacher to participate in the research project.

I understand that I am at liberty to withdraw from the project at any time, should I so desire.

SIGNATURE OF PRINCIPAL **DATE**

…… **.....**

Appendix 4: Participant consent letter

381 Kenyon Howden Road

39 Westwood Gardens

Woodlands

4004

13 August 2015

Dear Participant

INFORMED CONSENT LETTER

My name is D. S. Shange, I am a CurriculumMED candidate studying at the University of KwaZulu-Natal, Edgewood campus, South Africa.

I am interested in exploring the teachers' experiences in teaching Grade 10 geometry within Curriculum and Assessment Policy (CAPS) in Umbumbulu circuit. I am studying cases of 5 High School in Umbumbulu area. Your school is one of my case studies. To gather theinformation, I am interested in asking you some questions.

Please note that:

- Your confidentiality is guaranteed as your inputs will not be attributed to you in person, but reported only as a Mathematics teachers' experience.
- The interview may last for about 30 minutes and may be split depending on your preference.
- Any information given by you cannot be used against you, and the collected data will be used for purposes of this research only.
- There will be no limit on any benefit that the participants may receive as part of their participation in this research project;
- Data will be stored in secure storage and destroyed after 5 years.
- You have a choice to participate, not participate or stop participating in the research. You will not be penalized for taking such an action.
- The participants are free to withdraw from the research at any time without any negative or undesirable consequences to themselves;
- Real names of the participants will not be used, but symbols such as A, B, C, D,E and 1, 2, 3, 4, 5 will be used to represent participants' names;

- The research aims at knowing the teachers' experiences in teaching Grade 10 geometry framed by curricular spider web.
- Your involvement is purely for academic purposes only, and there are no financial benefits involved.
- If you are willing to be interviewed, please indicate (by ticking as applicable) whether or not you are willing to allow the interview to be recorded by the following equipment:

	willing	Not willing
Audio equipment		
Voice recorder equipment		
Video equipment		

I can be contacted at:

Email: makhosid123@gmail.com

Cell: +2839578724 or +2728257408.

My supervisor is DrS.B. Khoza who is located at the School of Education, Edgewood campus of the University of KwaZulu-Natal.

Contact details: email: khozas@ukzn.ac.za Phone number: +27312607595.

Discipline Co-ordinator is Dr L.R. Maharajh,
Curriculum Studies,School of Education,
Edgewood College,University of KwaZulu-Natal
(Tel) 0312602470(Cell) 0822022524, Email: maharajhlr@ukzn.ac.za.

You may also contact the Research Office through:

P. Ximba

HSSREC Research Office,

Tel: 031 260 3587 E-mail: ximbap@ukzn.ac.za

Thank you for your contribution to this research.

DECLARATION

I…… (full names of participant) hereby confirm that I understand the contents of this document and the nature of the research project, and I consent to participating in the research project.

I understand that I am at liberty to withdraw from the project at any time, should I so desire.

SIGNATURE OF PARTICIPANT **DATE**

…… **……**

Appendix 5: Reflective activity

REFLECTIVE ACTIVITY

1. **Gender…….**
2. **Age……**
3. **Qualifications…….**
4. **Number of years in teaching……..**

5. **Briefly explain why are you teaching Mathematics (geometry)?**

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6. **Towards which goals are you teaching geometry?** (aims and objectives)

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7. **What are you teaching in geometry?** (content)

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8. **How do you teach geometry?** (learning activities you design)

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9. **How do you facilitate your teaching?** (your role as a teacher during the lesson)

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10. **With what are you teaching? (**materials and resources)

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11. Where is teaching take place? (learning environment)

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12. Who are you teaching? (accessibility)

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13. When are you teaching? (time)

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14. How do you assess your teaching? (assessment strategies)

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15. How would you evaluate the quality of CAPS in terms of: relevance, consistency, practicality and sustainability?

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Appendix 6: Interview questions

INTERVIEW QUESTIONS

1. **Rationale:** Why are you teaching Mathematics (geometry)?
2. **Aims and objectives**: Towards which goals are you teaching?
3. **Content:** What are you teaching in geometry?
4. **Learning activities**: How do you design your teaching?
5. **Teacher role**: How do you facilitate your teaching?
6. **Materials and resources**: With what are you teaching?
7. **Learning environment**: Where are you teaching?
8. **Time:** When are you teaching?
9. **Accessibility**: Who are you teaching?
10. **Assessment:** How do you assess your teaching?
11. How would you evaluate the quality of CAPS in terms of: relevance, consistency, practicality and sustainability?