THE PERCEPTIONS OF EDUCATORS AND SUBJECT ADVISORS ON THE BEARING THAT THE SOUTH AFRICAN MATHEMATICS CURRICULUM DESIGN HAS ON UNDERACHIEVEMENT IN SCHOOLS IN THE KING WILLIAMS TOWN EDUCATION DISTRICT OF THE EASTERN CAPE

A THESIS SUBMITTED IN FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

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DECLARATION

I, Bonani Sibanda declare that a study of The perceptions of educators and subject specialists on the bearing that the South African Mathematics curriculum design has on underachievement in schools in the King Williams Town education district of the Eastern Cape is my own work and that all sources I have cited or used are indicated and acknowledged by means of complete references.

BS-banda

SIGNATURE

28/1/2013

DATE

ABSTRACT

The present study investigates the National Curriculum Statement (NCS) Mathematics curriculum Design issues which have a bearing on underachievement at Grade 12 in selected schools in the King Williamstown Education District. It stems from the premise that curriculum design is plausible explanation for Mathematics achievement. In pursuit of this line of thought, the study looked at curriculum design types such as linear, sequential, and spiral arrangement of contents, as well as curriculum design aspects such as sequencing, progression, integration, pacing and organisation of contents. The study also looked at the perceptions educators and subject advisors have with respect to the bearing that these aspects have on underachievement in Mathematics.

The interpretive paradigm was used to frame and focus the study. The sample included five schools selected on purpose, with underperformance in Mathematics as an inclusion criterion. These schools constituted the cases of this research. Data was obtained from the interviews which were conducted with the Mathematics educators of the selected schools, and the Mathematics subject advisor of the district to find out about their perceptions with regard to the impact of Mathematics curriculum design on students' underachievement in Grade 12. In addition, the contents of the National Curriculum Statement for Mathematics documents were analysed.

The findings revealed that the scope (contents coverage) is too wide, and that the skills which are supposed to be developed in learners per term are not fully developed. Time allocation is unreasonably limited as a result learners are unable to cover the scope for the term. Revisiting of topics done every year in a spiral fashion

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is good but the balance between superficiality and depth is not achieved, and that it is done without checking and understanding learners' previous knowledge on the topic. The sequencing of certain topics has to be looked into and revised. The study also revealed that Mathematics curriculum design, link and progression from primary to high school is good but not all details covered which leave students with content gaps that impede the learning of certain topics.

The researcher came out with the following recommendations:

From this case study, it appears that teachers still need more empowerment in NCS. Educators still need training on the NCS so they can be confident with the Mathematics NCS content. In most schools the scope is not covered and skills that are supposed to be developed in learners every term are not developed because of slow learners and the time factor. Therefore, the Department of education needs to give the scope taking into consideration the slow learners and make sure that the time they give every term also takes into consideration the time used for tests.

It also appears that the learners are slow because of the language barrier. Educators spend a lot of time saying the same things to the learners so that they can understand. Since the learners do almost all the subjects in English and write their examination in English if they are from an English medium school, it would be a good idea for the DOE to introduce English to the learners as early as grade R, as in the model C schools. If that is done, it might remove the language barrier and hence reduce underachievement in Mathematics. It appears that the educators revisit topics every year but do not balance superficiality and depth. Educators should be encouraged to take every topic seriously every year and not just repeat what they

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covered in the previous grade. They should use it as a base for the new content. If that is done, it might help the achievement in Mathematics.

KEY WORDS:

National Curriculum Statement for Mathematics, Curriculum design, sequencing, integration, pacing, scope, assessment standards, link/ progression, process skills, articulation, spiral curriculum, achievement.

ACRONYMS

:	Assessment Standard
:	Constructive alignment
:	Curriculum Assessment Policy Statement
:	Centre for Development and Enterprise
:	Council of Mathematics Education Ministers
:	Department of Education
:	Eastern Cape Department of Education
:	Further Education Training band
:	General Education and Training
:	Intended Learning Outcomes
:	King Williams Town District of Education
:	Legitimation Code Theory (LCT)
:	Learning Outcome
:	Monitoring Learning Achievement
:	National Curriculum Statement
:	Outcome Based Education
:	Organisation for Economic Cooperation and Development
:	Quality Improvement, Development Support and Upliftment
	Programme
:	Southern and Eastern African Consortium for Monitoring
	Education
:	Trend in International Mathematics and Science Study
	· · · · · · · · · · · · · · · · · · ·

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

Mathematics is the one subject that most high school students identify as their "least favourite". It is a barrier to some students' success in high school, as well as to admission into post-secondary education. Meanwhile, information technology presents an increasing demand for a mathematically literate workforce. Mathematics has been called a "critical filter" for 70% of career choices at the university level not only in the hard sciences, but also in rapidly expanding areas such as health care, commerce, and computing sciences. The discrepancy between students' disdain for mathematics, and society's growing demand for mathematical competency presents a challenge both for students, in seeking employment, and for society as a whole, in meeting its needs for a mathematically-literate workforce. (Jesse, 2003:12).

According to Bruning, Scraw, and Ronning (1999), in American society, the importance of Mathematics knowledge is apparent in the employment arenas as well as in everyday activities. Despite its importance, many persons continue to find that the application of mathematical knowledge at even basic levels is difficult and therefore, many people lack the skill to secure employment in Mathematics related fields. Miller (1995) asserts that when students of particular groups are absent from advanced Mathematics courses, they are not only denied a Mathematics education but also the opportunity to experience economic freedom and choice.

According to Gorard and Smith (2003), many pupils underachieve during the years of compulsory education, especially in Wales. Gorard and Smith (2003) also state that West Indian children as a group are underachieving in the education system and this should be a matter of deep concern not only for all those involved in education

but also to the whole community. Weiner (1997) states that underachievement has been described as the predominant discourse in education in recent times.

In South Africa, the Mathematics pass rate at Further Education Training band (FET) is always very low as compared to some other subjects. The lowest overall pass rate in 2007 for the Senior Certificate Examination was for Mathematics 52,8%, which was 0,6% higher than in 2006 (Education Statistics in South Africa 2007). The poor performance of South Africa's FET students in the subject awakens one's interest in pursuing research in this area, as there might be many causes of this dismal performance. The performance of FET students shows that some of them lack the basics. They cannot solve even what one considers a very simple mathematical problem.

The submission by the Mathematics Education Community to the council of Mathematics Education Ministers (CEM) (2007) stated that, at the heart of economic stability, growth and effective functioning of a democracy lies the Nation's need for:

- Numerically literate citizens able to engage with and understand Mathematics as it touches their daily lives.
- A numerically literate workforce. In all Science and Technology (S&T) related careers in industry, Mathematics is the key that opens doors. People are employed for their ability to solve problems and to contribute, through careful analysis, to the production process.
- A growing community of Mathematicians able to develop the knowledge base of Mathematics and to train future generations of experts in the field and work in mathematically related scientific and industrial enterprises'.

Some heads from the Western Cape's poorest schools published an article on page 6 of the Cape Argus on October 12, 2007. They painted a bleak picture of the future of Mathematics. Jimmy Kruger, principal of Tafelsig Secondary school in Mitchells Plain, said that the main problem is literacy and numeracy levels. The learners arrive at high school without the necessary skills. He said his school had a 0% matric Mathematics pass rate in 2006. Star Geldenhuys, principal of Qhayiya Secondary school in Hermanus said "learners go to high school but they cannot write, read or speak properly. If they cannot master language, they cannot master Mathematics." He said "in 2006, 27 of the 30 pupils who wrote the Mathematics examination failed". Geldenhuys also said, "the department should not place all its efforts on Grade 12, but focus on primary schools to ensure that the basics were covered". John Majiet, a Mathematics teacher at Rusthof Secondary in Strand, said that many of the pupils in Grade 12 were still battling with Mathematics calculations. He said, "For Grade 10 and 11 learners, one should assume that they know the basics. Surprisingly, you find learners who do not know the difference between multiplication and division". He advised, "Methodologies at primary schools should be revisited". Mogamad Ismail, principal at Phakama Secondary in Philippi, said "high school teachers spend hours trying to complete the backlog of work that should have been covered in lower grades". He said," this took up time that was meant to be spent on covering the curriculum". He said, "In 2006, only 9 of the 67 pupils who sat for Mathematics at Grade 12 in his school passed."

Kopolo (2009) states that the South Africa schooling system in general and the Eastern Cape in particular continues to produce far fewer passes in Mathematics and Science than the country's economy requires. Kopolo (2009) also states that the cause of this underachievement is that highly qualified Mathematics and Science

teachers having left the teaching profession for various reasons such old age, some dying due to HIV/AIDS and other diseases and some exploring other avenues.

A research carried out by Booi (2000) in the Eastern Cape Province of South Africa found that no one interviewed at the College of Education had enough knowledge pertaining to Outcome Based Education (OBE) and they would welcome being empowered to restructure their curriculum to meet the OBE specifications. They felt that OBE was still theoretical. Kopolo (2009) who investigated the same Province also states that some schools and teachers are still uncertain about the NCS or how best to cover the syllabus although they have been given training in it.

Sau (2008) found the following barriers to learning Mathematics in King Williams Town: "educators seemed to lack the Mathematics competencies to handle their teaching, learners experienced difficulties in comprehending mathematical texts because of inadequate vocabulary and reading skills, learners experienced a lack of support in their home environments, learners lacked the basic prerequisite numeracy skills that should have been acquired at the necessary levels in earlier grades."

In 1995, the Department of Education intervened by introducing a number of strategies reported during the National Report on the Development of Education at the 48th International Conference on Education, in 2008. The White Paper had referred to the fact that "only one in five black students choose Physical science and Mathematics in Standard 8, and the trend of performance in the senior certificate examination has been low, overall (Department of Education, 2006). Three international learning achievement assessments, namely, the Monitoring Learning Achievement (MLA) project, Trend in International Mathematics and Science Study (TIMSS) and the Southern and Eastern African Consortium for Monitoring Education

Quality (SAQMEC), indicate that South African children perform exceptionally poorly as compared to other countries (OECD 2008). The MLA project was conducted in several African countries in 1999 and measured the competences of Grade 4 learners in numeracy. Of the 12 participating countries, South Africa scored the lowest average in numeracy. The TIMSS studies measured Grade 8 learning achievement in Mathematics and Science in several countries in 1995, 1999 and 2003. South Africa's performance was disappointing in both the 1999 and 2003 TIMSS studies. Learners attained lower average test scores in both Mathematics and Science than all the participating countries. Out of an imputed maximum score of 800, the average South African mathematics score was 275 in TIMSS 1999 and 264 in 2003 (OECD, 2008).

Howie (1997) states that in the 1995 TIMSS, the Standard 5 Eastern Cape Mathematics learners scored lower than the South African average with 341 points compared to 354, also lower than the international average of 513. According to Howie (1997), the Standard 6 Eastern Cape Mathematics learners scored 7 points less than the South African average, with 341 points compared to 348. Both these scores were below the international average of 484. Table 1.1 below shows the students achievement in TMSS Mathematics questions in the Eastern Cape Province.

Table 1.1: Students achievement in TMSS Mathematics questions in the Eastern Cape Province.

Year level	No. of learners	Average score	Minimum	Maximum	Standard
		ge eene			
	who participated	scored in	score	score	deviation
	in the Eastern	mathematics	recorded	recorded	
	Cape Province				
A I I -	- / -		4-0		
Standard 5	515	341	179	577	58
Standard 6	546	341	196	583	56

Source: Howie 1997.

In South Africa, to tackle the issue of underachievement in schools, the Department of Education intervened by introducing a number of strategies reported during the National report on Development of Education at the 48th International Conference on Education in 2008. Among other strategies the following were reported:

- The Quality Improvement, Development Support and Upliftment Programme (QIDS UP), which provides support for the provision of resources to support learning and teaching, improved learner competences in literacy and numeracy.
- 2. A foundation for learning campaign, according to the Minister of Education "a call to schools and communities to focus on reading, writing and calculating". It indicates and provides the resources needed for effective teaching and gives guidance to teachers, principals and district education officials on how to promote literacy and numeracy skills et cetera. In 2002, the Dinaledi ("star") schools were adopted as a strategy to promote Mathematics, Science and technology, to increase the pass rate and achievement in Mathematics and science in grades 10 12.

Despite all these efforts, Mathematics achievement at Grade 12 in the King Williams Town district has not improved.

1.2 STATEMENT OF THE RESERCH PROBLEM

Although the Government of South Africa invited Mathematics and Science educators from other countries to alleviate the problem of the shortage of Mathematics and Science teachers," there are also shortages related to specific learning areas, especially Mathematics" (National Report on the development of Education, 2008). There is still underachievement in Mathematics amongst students in South Africa.

The report by the Centre for Development and Enterprise (CDE) (2008) revealed that in 2004, more than half of South Africa's secondary schools failed to produce even a single higher grade pass in Mathematics. For about 80% of the schools, the average number of higher grade Mathematics passes was one. In 2006 there were fewer higher grade Mathematics and Science passes than in the previous year. Approximately 4, 8% of all Matric candidates passed higher grade Mathematics and approximately 21% passed standard grade. In 2007, the higher grade Mathematics pass rate dropped to 4, 5%.

Higher Education institutions such as the University of Fort Hare have also expressed concern at the level of preparedness of students from Matric for university work and have designed their own placement tests in addition to the Matric results as shown in the below table.

Table 1.2: Placement tests conducted on students at the University of FortHare in Mathematics and Mathematical Literacy for the 2010 intake producedthe results below.

	<u>Total Written</u>	Below 40% Maths	Below 40% Numeracy	As a percenatge
MOG	126	02	NT / A	72.0
M&C	126	93	N/A	/3.8
S&A	162	137	N/A	84.6
EDU	62	N/A	39	62.9
SSH	241	N/A	184	76.3
LAW	74	N/A	51	68.9
<u>Totals</u>	<u>665</u>	<u>230</u>	<u>274</u>	<u>75.8</u>

Source: Alanna Collins Coordinator: Placement and Access Tests University of Fort Hare.

Table 1.3 below shows 2008 Grade 12 Mathematics end of year results (per district).

	Table 1.3: 2008 Grade 12 Mathematics end of	year results (per district).
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District	Mathematics pass rate (%)
Mount Fletcher	41.96
Mount frere	29.49
Maluti	37.02
Lusikisiki	29.23
Mbizana	27.87
Skertspruit	38.06
Queenstown	42.79
Lady Frere	33.04
Cradock	49.19
Mthatha	32,46
Qumbu	34.45
Libode	42.39

Ngcobo	25.11
Cofimvaba	29.11
Dutywa	31.34
Butterworth	24.71
Fort Beaufort	28.53
East London	42.58
King WilliamsTown	29.39.
Graaff Reinette	47.85
Grahamstown	53.09
Port Elizabeth	53.09
Uitenhage	54.04

Source: Kopolo (2009)

From the above table it is clear that Mathematics results for the Eastern Cape Province for 2008 were bad and even worse for the King Williams Town education district.

The tables below show part of Mathematics Matric statistics for 2007 and 2008 results for schools in the King Williams Town District (information from KWT DoE).

Table 1.4: 2007 Mathematics Matric statistics for 95 out of 113 schools in KingWilliams Town District.

Pass range	No. of learners in pass	% of learners in pass range
	range	
0-49%	1852	87
50% and above	281	13
	Total 2133	

(Source: King Williams Town Department of Education)

Table1.5: 2008 mathematics Matric statistics for 35 out of 113 schools in King

Pass range	No. of learners in pass range	% of learners in pass range
0-49%	915	84
50% and above	180	16
	Total 1095	

Williams Town district.

(Source: King Williams Town Department of Education).

Results in table 1.4 and 1.5 have been used even though they appear to be dated because at the time the researcher started this study the results in those tables were very current and they served as the trigger to the research problem of this study.

The above results include all types of schools in the King Williams Town District; that is, they also include independent and former model C schools. From the above tables it is clear that there is underachievement in Mathematics in schools in the King Williams Town District. While various attempts have been made, as shown in the background to the study, to address underachievement in Mathematics, achievement has continued to be low. One area that does not seem to have received attention in the literature is the issue of the curriculum and whether or not underachievement could be the result of deficiencies in the curriculum itself. Hence, there is the need for a study that examines in some detail the nature of the Mathematics curriculum design, the link and progression from primary to high school curriculum, and the appropriateness of the curriculum for this level of students.

1.3 PURPOSE OF THE STUDY

The purpose of the study is to investigate the perceptions of the teachers and subject advisors on the bearing that the South African Mathematics school curriculum design has on enhancing or inhibiting achievement in Mathematics at the Grade 12 level. The study sought to check whether the design of the Mathematics curriculum explains the underachievement in Mathematics in Grade 12.

1.4 RESEARCH QUESTIONS

The study was guided by the following research questions:

1.4.1 Main Research Question

Which NCS Mathematics curriculum design issues have a bearing on the underachievement in Mathematics at Grade 12?

1.4.2 Sub questions

1) How do teachers perceive the impact of the Mathematics curriculum design on students' underachievement at Grade 12?

2) What are the subject advisors' and curriculum specialists' perception of the bearing that the Mathematics curriculum design has on Grade 12 underachievement in Mathematics?

3) How does the Mathematics curriculum design, link and progress from primary to high school bear on Mathematics underachievement in Grade 12?

4) How appropriate is the NCS Mathematics curriculum for the level of Grade 12 students?

1.5 SIGNIFICANCE OF THE STUDY

Studies cited in the background show that there is underachievement in Mathematics amongst learners in South Africa. Some studies carried out nationally and internationally, have shown factors that lead to underachievement in Mathematics.

Studies carried out in South Africa, especially in the King Williams Town District have not investigated how the NCS Mathematics curriculum design explains achievement and/or underachievement in the NCS Mathematics at Matric level. The study filled this gap.

The results of this study might help education policy makers, programme administrators, curriculum specialists, subject advisors and in-service provisioning in the King Williams Town District by pointing out trouble spots in the Mathematics curriculum design, and the device of means of dealing with them. It can contribute knowledge to the Department of Education about how Mathematics curriculum design issues bear on, justify and explain the NCS Mathematics achievement at Matric level.

1.6 RATIONALE OF THE STUDY

For the past 2 years, the researcher has been teaching Mathematics in the Eastern Cape where the pass rates at the Matric (Grade 12) level have been the lowest nationwide (52,8% for 2007) (DoE 2009). With the Eastern Cape having the lowest Mathematics pass rate among all other provinces, the King Williams Town District's Mathematics Matric results have not been surprising. The researcher has been an educator for the General Education and Training (GET) and Further Education and Training (FET) phases, and has observed that there is a big gap in content between the GET and FET phases of the Mathematics curricula. The combination of poor results at Matric and the differences in Mathematics content between the GET and the FET aroused the researcher interest in finding out what the explanation might be.

After reviewing a lot of literature both nationally and internationally, it became obvious that a lot of factors contributing to underachievement in Mathematics had

been documented. For example, Makgato and Mji (2006) reported the following factors: teaching strategies, content knowledge, motivation and interest and non completion of the syllabus in a year. Mpofana (1989), Masilela (1988) and Mayekisa (1989) came to conclusion that the majority of Mathematics teachers in South Africa had not been adequately trained and were consequently unable to teach effectively. But, nothing, in particular, about the NCS Mathematics curriculum design as a plausible explanation for Mathematics underachievement has been documented. Thus, the researcher posits that NCS Mathematics curriculum design might explain and account for the lower achievement levels in Mathematics, particularly in the King Williams Town District. Therefore, this research is warranted on the basis of the limited research on the NCS Mathematics curriculum design as an explanatory variable for Mathematics underachievement, owing to the relative newness of the NCS curriculum. Furthermore, a district specific research on the issues of Mathematics underachievement, particularly those that relate to curriculum design is yet to be undertaken in the King WilliamsTown Town education district.

1.7 DELIMITATION OF THE STUDY

The study focused on Mathematics teachers from 5 purposively sampled schools in the King Williams Town Education District in the Eastern Cape Province of South Africa, covering both rural and urban schools. It also focused on Mathematics Subject Advisors from the KWT District. Performance in Mathematics was the criterion for the selection and inclusion of schools in the sample. Therefore, only schools that are underperforming in Mathematics were selected. Mathematics underperforming schools are schools obtaining less that a 50% pass rate in Mathematics. Since the study concentrated on only five schools in only one District

and only Mathematics Subject Advisors it narrowed the scope of the study in terms of generalization.

1.8 DEFINITION OF TERMS

Underachievement: This study adopts the 'psychologist's' definition given by Gorard and Smith (2004) which says "underachievement is a school of performance, usually measured by grades, that is substantially below what would be predicted on the basis of the student's mental ability, typically measured by intelligence or standardized academic tests".

Investigation: Shall refer to an examination, study, searching, tracking and gathering factual information that answers questions or solves problems, (Sennewald, 2006).

Curriculum: There are many definitions given for curriculum. This study adopts the definition given by Schubert (1987), which defines curriculum as the content of a subject, concepts and tasks to be acquired, planned activities, the desired learning outcomes and experiences, product of culture and an agenda to reform society.

Curriculum Design: Shall refer to the attention to ideas that matter, skills that count and means through which students and programs interact (Lunenbury, 2011).

Perceptions: Process of interpreting information about another person (Nelson and Quick 1997 p.84). This study also adds that perception interprets information about anything, the opinion you form about another person or something depending on the amount of information available to you or the extent to which you are able to correctly interpret the information you acquire.

1.9 METHODOLOGY

This part concentrates on research paradigm, research design, sample, data collection, data analysis, measures to ensure trustworthiness and ethical considerations.

1.9.1 The Research Paradigm.

This study adopted the interpretive paradigm. According to Creswell (2003) the general aim of the interpretive paradigm is to describe phenomena and, to some extent, explain them. The goals of the type of research informed by this paradigm rely on the participants' views of the situation studied. This can only be fulfilled through interaction with people, finding out from them the behaviour one wants to understand. Creswell (2003) states that the basic and general meaning of an interpretive paradigm is always social, arising in and out of interaction with human community. Therefore, the process of qualitative research is largely inductive, with the inquirer generating meaning from the data collected in the field. All procedures of this type of data collection of qualitative research were followed in this research. A case study was used to gain information from subject specialists and educators. Interviews were conducted with the Mathematics educators and Mathematics subject specialists so that they could express their perceptions about the link between progression in Mathematics curriculum design and achievement at Grade 12. According to Creswell (2003) qualitative researchers seek to understand the context or setting of the participants through visiting and gathering information personally. Therefore, the researcher went to schools to interview teachers, and visited offices to interview subject specialists. This enabled the researcher to develop a level of detail about the teachers' and the subject specialists' perception of the bearing that the NCS curriculum design has on underachievement in Mathematics. Since the

researcher went to the participants' sites, ethical considerations and gaining entry to the research site were considered. Connections between the researcher and the participants on the research sites are mentioned to create reader confidence in the accuracy of the findings. More of this aspect is discussed in chapter 3

1.9.2 Case Study research design

The study adopted an interpretive paradigm, and followed a qualitative case study design. Hammersley (1998: 93) defines a case study as a collection of detailed, relatively unstructured information from a range of sources about a particular individual, group or institution, usually including the accounts of the subjects themselves. The cases in the study are the selected schools in the King Williams Town District. Within the selected schools, teachers formed part of the case. Subject advisors as well as curriculum specialists also formed part of the case. These were interviewed to get their perceptions about Mathematics curricula design, taking into account the scope, sequencing, progression and integration, and their bearing on Grade 12 Mathematics achievement. More elaboration of this part is done in chapter 3.

1.9.3. Sampling and sample

Kumar (1996) defines sampling as the process of selecting a few (a sample) from a bigger group (the sampling population) to become the basis for estimating or predicting a fact, situation or outcome regarding the bigger group. In this case study, the sample was selected purposively from Mathematics teachers at the FET phase. The number of participants that comprised the sample is stated in chapter 4. These were from the selected schools in the King Williams Town District. Five (5) schools were selected from schools from King Williams Town and its outskirts. The schools

were selected purposively. According to Patton (1990), the power of purposive sampling lies in selecting information-rich cases for in-depth analysis related to central issues being studied. For the purpose of confidentiality, schools which are the cases are referred to as P, Q, R, S, and T. Schools P, Q and R are from the townships and school S and T are from rural areas where most learners are from disadvantaged backgrounds. From the above selection, an attempt was made to provide variation with regards to educators' perceptions as far as the link between Mathematics curriculum design and Mathematics achievement. Therefore, under purposive sampling, the maximum criterion case was considered. Patton (1990) considers this as picking cases that meet some pre-specified criterion. Only Mathematics educators and Mathematics subject advisors were chosen. More elaboration of this part is done in chapter three. The number of participants is stated in chapter 4.

1.9.4 Instrumentation

Semi-structured interviews were used to collect data from teachers, curriculum specialists and subject advisors. A semi- structured interview consists of a list of prepared questions which the researcher asks the research participants to respond to during a one-on-one interaction (Phuthego, 2007). According to Hofstee (2006:132), the purpose of an interview is to gather reliable information relating to the problem being investigated. Therefore, for this particular study, the interviews helped the researcher get a deeper understanding from the teachers, curriculum specialists and subject advisors of Mathematics teachers' perceptions in relation to the link and progression between primary school and high school Mathematics curriculum design, and their bearing on achievement in Mathematics amongst the

Grade 12 learners in the King Williams Town District. More detail provided on this is in chapter 3.

1.9.5 Data analysis

For the proposed study the qualitative method was used. Qualitative data from the case study were coded. Coding is a procedure that disaggregates the data, breaks them down into manageable segments and identifies or names those segments, (Schwandt as cited in Phuthego, 2007). Emerging themes, categories, and patterns were also considered. This part is explained in more detail in chapter three.

1.9.6 Trustworthiness, Validity and Reliability

Carlson (2010) asserts that reliability and validity are conceptualized as trustworthiness, rigor and quality in the qualitative paradigm. For validity, member checking and participant review were used. Creswell and Miller (2000) state that member checking is a validity procedure which consists of taking data and interpretations back to the participants in the study so that they can confirm the credibility of the information and the narrative account. Creswell and Miller (2000) also state that researchers may have participants view raw data and comment on their accuracy. In turn, researchers incorporate participants' comments in the final narrative. In this way, participants add credibility to the qualitative study by having a chance to react to both the data and the final narrative.

Audit trails were also created. According to Carlson (2010), creating an audit trail refers to keeping careful documentation of all components of the study, e.g. keeping field notes, interview notes, calendars, et cetera. Reflexivity will also be taken care of. Carlson (2010) states that one way to engage in reflexivity is for researchers to

keep a journal that is specifically for recording thoughts, feelings, uncertainties, values, beliefs and assumptions that surface throughout the research process. Therefore, in the final report it should be stated what went well, what did not and what should be avoided in future.

Thick and rich descriptions were solicited from the research participants. According to Carlson (2010), one of the main strengths of thick and rich descriptions is to provide an understanding of the relevance to other settings. Detailed descriptions of setting, participants, data collection and analysis procedures were employed as a way of making researchers' accounts more credible.

1.9.7 Ethical considerations

Letters were written to the Department of Education, school principals for the selected schools seeking permission to use the selected schools for carrying out this research and explaining the importance of the research, and also asking for the maximum cooperation. Burn (2000) considers that informed consent is the most fundamental ethical principle for those involved in the research. Burn (2000) states that the importance of the consent form is that it makes the situation clear and provides a degree of proof that the person was informed and consented to take part. Therefore, a consent form was given to the participants to sign. Only those who agreed to sign it participated in the study.

Data collected by researchers should be anonymous, that is, not related to names or other forms of identification (Sarantokos, 1998). It is not possible for the participants in interviews to remain anonymous, but researchers can maintain confidentiality about who has been interviewed and what was disclosed (Reid, 2001). Considering

the above, participants were assured of anonymity as well as the confidentiality of the information obtained from them.

1.10 CHAPTER SUMMARY

In this chapter background information on the study was given. A statement of the research problem, the purpose of the study, research questions, the significance of the study, and definition of terms was done. A brief methodology of the study was also outlined.

In the next chapter the literature will be reviewed.

1.11 CHAPTER OUTLINE OF THE STUDY

Chapter 1 contains the introduction and background to the study. The contents of this chapter are: the statement of the research problem, research questions, purpose of the study, and significance of the study, delimitation of the study and definition of major concepts.

Chapter 2 presents the literature review. The first part of this chapter outlines the theoretical framework, and the second part reviews the literature relevant to the study.

Chapter 3 describes the research design and methodology. This chapter elaborates on the methodology used in the study, that is, the research paradigm, research design, sampling, data collection methods, data analysis methods, measures to ensure trustworthiness, and ends with ethical considerations.

Chapter 4 presents data presentations and analyses. Findings from documents are presented first, followed by the presentation of findings from the interviews. The findings are interpreted using insights gained from the literature review.

Chapter 5 presents the findings, conclusions and recommendations. This chapter brings the study to an end by providing a synthesis of its findings, conclusions reached, and provide recommendations regarding the findings and further research.
CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

The theoretical frame work and literature review are the main parts for this chapter. The review of literature for the study is organised around underachievement in Mathematics, the Mathematics curriculum, the Mathematics curriculum design and the sub- research questions. Underachievement as a theoretical construct is interrogated followed by a look into explanations for underachievement in Mathematics. Thereafter, Curriculum models are interrogated. The insights from the curriculum models are then used to view the South African curriculum in general. Curriculum design types or arrangements are reviewed followed by a reflection on the NCS Mathematics. Issues that might have a bearing on Mathematics achievement are framed on each of the curriculum design aspects reviewed.

Below, all the sub topics mentioned above are discussed starting with the theoretical framework.

2.2 THEORETICAL FRAMEWORK

The study is guided by the Attribution theory. Attribution theory is concerned with how individuals interpret events and how this relates to their thinking and behaviour (Weiner 1974). Heider (1958) first to introduced the attribution theory, but Weiner and colleagues Jones, Kannouse, Kelly, Risbette, Valins, Weiner,(Eds). (1972), developed the theoretical framework that has become a major research paradigm in Psychology. "The Attribution theory assumes that people try to determine why

people do what they do. A person seeking to understand why another person did something may attribute one or more causes to that behaviour" (Morristown, 2004).

According to Kloosternman (1984), the causal attribution theory deals with the reasons, or attributions, individuals give for succeeding or failing at a task. The causal attribution theory varies on at least two parameters, internal and stability. Events which are both internal and stable are perceived to be the result of a person's inner capabilities which Weiner (1972) called capability. Internal but unstable outcomes are the result of the effort a person exerts. External, stable outcomes vary as task gets more difficult and external, unstable events are simply the result of luck (Weiner, 1972). Help from a teacher, peers, or parents seems to be the most logical type of external, unstable attribution that students would make reference to for success or failure in Mathematics (Kloosterman, 1984).

According to attribution theory, high achievers will approach rather than avoid tasks related to succeeding because they believe success is due to high ability and effort which they are confident of. Failure is thought to be caused by bad luck or poor examination, thus failure does not affect their self-esteem but success builds pride and confidence. On the other hand, low achievers avoid success-related chores because they tend to a) doubt their ability and/ or b) assume success is related to luck or to "who you know" or to other factors beyond their control (Morristown, 2004).

According to Morristown, (2004) attribution is a three-stage process:

1. (a) behaviour is observed (b) behaviour is determined to be deliberate and (c) behaviour is attributed to internal or external causes. Morristown (2004) goes further to argue that a person seeking to understand why another person did something may attribute one or more causes to that behaviour. The person must determine if they believe the person was forced to perform the behaviour, (in which case, the

cause is attributed to the situation) or not (in which case the cause is attributed to the other person).

2. Achievement can be attributed to (a) effort (b) ability, (c) level of task difficulty, or (d) luck.

"Students with higher rating self – esteem and with higher school achievement tend to attribute success to internal, stable, uncontrollable factors such as ability, while they attribute failure to either internal, unstable, controllable factors such as effort, or external, uncontrollable factors such as task difficulty. On the other hand, students with learning disabilities more likely attribute failure to ability, a stable, uncontrollable factor." (Morristown, 2004).

3) Causal dimensions of behaviour are (a) locus of control (b) stability and (c) controllability.

According to Morristown (2004), locus of control has two poles, internal versus external locus of control. The stability captures whether causes change over time or not. For example, ability can be classified as a stable, internal cause, and effort classified as an unstable internal one. Controllability contrasts causes one can control, such as skill/ efficacy, from causes one cannot control, such as mood, other's actions and luck.

The theory was relevant in the study, which focused on underachievement in Mathematics amongst learners because learners always give reasons for succeeding or failing regardless of the validity or invalidity of those reasons. Their reasons always depend upon how they perceive success or failure. Since this study sought to find out whether the NCS Mathematics Curriculum design has a bearing or not on underachievement, the attribution theory was found to be relevant to this part because the curriculum design issues raised by individuals who have different views

and also, the curriculum design is viewed by different individuals with different perceptions. The curriculum design might be considered good by some people and bad by others depending on their perceptions.

In this study educators and Subject Advisors might perceive the curriculum design aspects differently. This will help the researcher after data analysis to draw conclusions on whether underachievement in Mathematics can be attributed to the curriculum design aspects or not.

No research has been found where the attribution theory has been applied in Mathematics. A study by Frieze, Irene and others (1977), sought to determine whether the achievement attribution model is supported in an actual classroom setting, with college students actually taking an important exam. It was found that students did slightly worse than they expected or wanted to do. The majority of the learners attributed the cause of their exam outcome to effort.

In another study by Neumeister (2004), which investigated the interpretation of success and failure by perfectionism in gifted college students, it was found that socially prescribed perfectionists tended to minimize their success. They made internal attributions for failure. In contrast self-oriented perfectionists took pride in their success and made internal attributes for them. With regard to their failures, they made attributions that were situation-specific and they were able to keep them in perspective.

In another study by Darom (2001) which compared causal perceptions of teachers and pupils regarding pupils' success or failure on a test, teachers attributed failure to the pupils' lack of preparation, to pupils' low ability and to test difficulty. It was found that the causal perception of pupils was similar to that of their teachers.

This research makes use of the attribution theory to explain Mathematics underachievement from the perspective of the teachers. The study seeks to find out whether Mathematics underachievement should be attributed to curriculum design. Therefore, attribution theory in this study is used as an interpretive/explanatory framework for the findings.

2.3 UNDERACHIEVEMENT AS A THEORETICAL CONSTRUCT

According to Reis and McCoach (2000), underachievement is commonly defined as the discrepancy between potential and performance, although simple failure to selfactualize also has been offered as a definition. Gorard and Smith (2003) say that underachievement is used to refer to nations, home nations and regions, to types and sectors of schooling, to physiological, ethnic and social groups, and individuals. They also say that underachievement has been used to mean simply low achievement relative to another of these groups, and also lower achievement than would be expected by an observer.

Coil (1992) believes that while signs of underachievement often begin by third or fourth grade, middle school or junior high school usually marks the highest point of consistent underachievement. A two year study of secondary school students found that when underachieving students were placed with high achieving peers they made greater gains than when they were placed with other underachievers (Karnes, MaCoy, Zehrbach, Wollerscein and Clarizio, 1996). "When teachers are planning remedial interventions for pupils with severe learning difficulties, they must evaluate individual differences carefully, paying attention not only to difficulties but also to potentialities and points of strengths" (Dettori and Ott, 2006).

This study agrees with this statement because not all underachievers are at the same level. Some underachievers, when compared to the same group of underachievers might be better academically. However, Meyer (2000) asserts that children's achievement and ability are not always dependent on each other, so they should be regarded as separate aspects. Some scholars have identified some causes of underachievement. Morakingo (2003) found that teachers' non-use of the verbal reinforcement strategy, teachers' poor lesson attendance, lateness to school, poor methods of teaching contribute to underachievement. Aremu and Sokan (2003) stated that the causes of underachievement are motivational orientation, self-esteem, self efficacy, emotional problems, study habits, teacher consultation and poor interpersonal relationships.

Aremu (2000) categorized factors contributing to poor academic performance into four principal areas as follows:

- (a) Causation resident in the child such as basic cognitive skills, physical and health factors, psycho-emotional factors, lack of interest in the school programme.
- (b) Causation resident in the family such as the type of discipline at home, the lack of role models and finance.
- (c) Causation resident in the school such as a school's location and physical buildings and the interpersonal relationship among the school's personnel.
- (d) Causation resident in the society such as instability in the education policy, underfunding of educational sector, leadership and job losses.

Reis and McCoach (2000) suggest that the impact of culture on academic performance should not be ignored when considering underachievement in schools

especially for foreigners, as these students face unique barriers to achievement, such as language problems. Chukwu-etu (2009) states that adequate attention should be given to reading and writing when the issue of underachievement arises, especially in countries where English is a second language. He says that if pupils do not learn how to read effectively early on in school, they may have difficulties at later stages and may withdraw from learning rather than risk being exposed to shame.

Gallagher (1991), Reis and McCoach, (2000), Sousa (2003) found that a lack of motivation provided by either teachers or parents could have a negative impact on children's' performance. Chukwu-etu (2009) summarised the following as causes of underachievement: the lack of Motivation, parental/ home influence, the lack of nurturing of intellectual potential, conflict of values, disabilities or a poor state of health, life experiences of specific groups of pupils, for example, resulting from brain damage/ cerebral dysfunction of neurological impairment and an inability to recruit and also retain highly qualified personnel in schools.

However, the literature on underachievement does not mention curriculum design issues, that is, whether the Mathematics curriculum design has any bearing on achievement. This study attempts to fill this gap.

The literature reveals that there is general underachievement amongst learners in schools. Below, underachievement in Mathematics and particularly in schools in South Africa is discussed.

2.4 UNDERACHIEVEMENT IN MATHEMATICS

A number of factors have been found in other countries that influence achievement in mathematics. Some of those factors have been reported by Fuller and Clarke (as cited in Howie and Plomp, 2001). These are textbooks, teacher quality, and time.

Bol and Berry (2005) state that teacher expectations, teacher quality, testing, family characteristics and student characteristics are some of the causes of underachievement. Oakes (1990), Secada (1992), Strutchens and Silver (2000), Tate (1997) found that factors such as socioeconomic status, school policies, allocation of human and material resources, and classroom instructional practices may account for performance disparities. Kusum, Mido, and Tech, (2008) state that teacher quality, family, teacher support, school learning environment influence Mathematics achievement.

It is clear from the above researchers that some of the factors they found coincide. McDill (1996) and Oakes (1990) state that when students of similar backgrounds and initial achievement levels are exposed to more or less challenging curriculum material, those given the richer curriculum opportunities outperform those placed in less challenging classes. This study agrees with the above to a certain extent, but also considers that students are different individuals with different capabilities. When all conditions are equal, as above, except for the difference in curriculum material, considering that students dealt with are gifted, even when some students are placed in less challenging classes, they can still perform well if they are motivated, seeking help from other students from different classes, or different schools, doing extra lessons etcetera.

All other factors (being female, having parents with a higher level of education, having aspirations to finish University education, not usually speaking the language of testing at home, having one or more bookcases at home, regularly using computers, having a high index of students' perception of being safe in school, having self- confidence in learning mathematics, placing value on Mathematics, and spending time on Mathematics homework) were positively associated with high

Mathematics achievement at the international level (Ismael, 2009). The family environment, parental style, intense outside interest and commitment to self-selected work, integrity related to rejecting unchallenging work are factors which were found by Peterson (2006) to affect achievement.

In South Africa, a number of factors have been reported pertaining to poor performance of pupils in Matriculation examinations and in general (Howie, 2003; Adler, 1998; Monyana, 1996). Setati and Adler (2000) state that these factors include teachers' inadequate subject knowledge, the inadequate communication ability of pupils and teachers in the language of instruction, the lack of instructional materials, heavy teaching loads, overcrowded classrooms, poor communication between policy-makers and practitioners, as well as the lack of support as a result of a shortage of professional staff in the ministries of Education. Makgato and Mji (2006) report the following factors: teaching strategies, content knowledge, motivation and interest and non completion of the syllabus in a year. Mpofana (1989), Masilela (1988) and Mayekisa (1989) came to a conclusion that the majority of black Mathematics teachers in South Africa had not been adequately trained and were consequently unable to teach effectively. According to DoE (2001), a Mathematics and science audit revealed that more than 50% of Mathematics and 68% of Science teachers have no formal subject training.

Gorard and Smith (2004) state that the educational press is replete with descriptions of the attempts of schools to eliminate the 'underachievement' of a certain group of pupils. The list of related initiatives is considerable: homework clubs, school trips, information and communication technology programmes to get fathers more involved with their sons' education, mentoring schemes and so on.

The literature on Mathematics underachievement does not mention the NCS Mathematics curriculum design as one of the factors contributing to underachievement. This study seeks to investigate whether the NCS Mathematics curriculum design has any bearing on achievement at Grade 12 level.

The paragraphs below articulate what curriculum design entails.

2.5 CURRICULUM DESIGN

According to Lunenbury (2011), curriculum design involves decisions made by the responsible curriculum planning group(s) for a particular school centre and student population. Having collected and analysed essential data and identified goals and objectives, curriculum planners create or select a general pattern - a curriculum design - for the learning opportunities to be provided to students. Among their alternatives is a subject design utilising specific studies in the specified curriculum area, a scope and sequence plan built around a selection of persistent topics or themes, an analysis of essential skills necessary for knowledge and competence in the area, and a selection of problems related to the area of study. Pratt (1980:5) defines a curriculum design as a deliberate process of devising, planning and selecting the elements, techniques and procedures that constitute the endeavor.

Curriculum design is a process which involves a lot of thinking. According to the University of Zimbabwe (1995), there are factors that should be considered that influence curriculum design. These are:

 Political factors – Politics determine and define the goals, content, learning and experiences and evaluation strategies in education. Curricular materials, hiring of personnel, funding of education and examination systems, et cetera.

- ii) Social factors Society has a perception of what the product of the school system should look like. The curricular materials and their presentation should accommodate the culture of the society that the curriculum is seeking to serve.
- iii) Economic factors the market forces dictate what should be included in the national curriculum. The skills needed by the industry should be translated into the content and learning experiences of children.
- iv) Technological factors Curriculum designers should also consider technology and its influence on the curriculum. For example, the computer is the latest technological innovation that will have a significant impact on education and society.
- v) Environmental Factors- Consideration for the environment must, of necessity, influence curriculum design to ensure the survival of future generations.

Child psychology- theories of learning and child development have to be considered when designing the content of a curriculum and how it is delivered. Activities and experiences should be introduced at the right time. There are theories and models that should guide the development of a curriculum. Therefore, some of those curriculum design theories and models are looked at in-depth in the paragraphs below.

2.6. CURRICULUM DESIGN THEORIES AND MODELS.

2.6.1 Dick and Carey's Components of the Systems Approach Model

Using a model to develop a curriculum design can result in greater efficiency and productivity. There are many curriculum design models and theories. For example Dick and Carey's Components of the Systems Approach Model

According to Dick and Carey (1990), the model is based not only on theory and research but also on a considerable amount of practical experience in its application. It consists of the following components:

1. Assess needs to identity goal (s)

The first step in the model is to determine what one wants learners to be able to do when they have completed the instruction. The instructional goal may be derived from a list of goals, from a needs assessment, from practical experience with learning difficulties of students, from the analysis of people who are doing a job, or from some other requirement for new instruction.

2. Conduct Instructional Analysis

After one has identified the instructional goal, one determines step-by- step what people are doing when they perform the goal. The final step in the instructional analysis process is to determine what skills, knowledge, and attitudes, known as entry behaviors, are required of learners to be able to begin the instruction.

3. Analyze Learners and Contexts

In addition to analyzing the instructional goal, there is a parallel analysis of the learners, the context in which they will learn the skills, and the context in which they will use them. Learners' current skills, preferences, and attitudes are determined along with the characteristics of the instructional setting and the setting in which the skills will eventually be used. This crucial information shapes a number of the succeeding steps in the model, especially the instructional strategy.

4. Write performance objectives

Based on the instructional analysis and the statement of entry behaviors, the educator writes specific statements of what the learners will be able to do when they complete the instruction. These statements, which are derived from the skills identified in the instructional analysis, will identify the skills to be learned, the conditions under which the skills must be performed, and the criteria for successful performance.

5. Develop assessment Instruments

Based on the objectives specified, the educator develops assessments that are parallel to and measure the learners' ability to perform what she/he has described in the objectives. Major emphasis is placed on relating the kind of behavior described in the objectives to what the assessment requires.

6. Develop instructional Strategy

Based on information from the five preceding steps, the educator identifies the strategy that he/she will use in the instruction to achieve the terminal objective. The strategy will include sections on pre-instructional activities, presentation of information, practice and feedback, testing, and follow-through activities. The strategy will be based on current theories of learning and results of learning research, the characteristics of the medium that will be used to deliver the instruction, content to be taught, and the characteristics of the learners who will receive the instruction. These features are used to develop or select materials or to develop a strategy for interactive classroom instruction.

7. Develop and Select Instructional Materials

In this step, the educator will use his/her instructional strategy to produce the instruction. This typically includes a learner's manual, instructional materials, and tests (the term instructional materials include all forms of instruction such as instructor's guides, student modules, overhead transparencies, videotapes, computer-based multimedia formats, and web pages for distance learning). The decision to develop original materials will depend on the type of learning to be taught, the availability of existing relevant materials, and developmental resources available to the educator. The criteria for selecting from among existing materials are provided.

8. Design and conduct the formative evaluation of the instruction

Following the completion of a draft of the instruction, a series of evaluations is conducted to collect data that are used to identify how to improve the instruction. The

three types of formative evaluation are referred to as one-to- one evaluation, smallgroup evaluation, and field evaluation. Each type of evaluation provides the designer with a different type of information that can be used to improve the instruction. Similar techniques can be applied to the formative evaluation of existing materials or classroom instruction.

9. Revise instruction

The final step (and the first step in a repeat cycle) is revising the instruction. Data from the formative evaluation are summarized and interpreted to attempt to identify difficulties experienced by learners in achieving the objectives and relate these difficulties to specific deficiencies in the instruction. The phrase "Revise Instruction" indicates that the data from a formative evaluation are not simply used to revise the instruction itself, but are used to reexamine the validity of the instructional analysis and the assumptions about the entry behaviors and characteristics of learners. It is necessary to reexamine statements of performance objectives and test items in light of the collected data. The instructional strategy is reviewed and finally all this is incorporated into revisions of the instruction to make it a more effective instructional tool.

10. Design and conduct summative evaluation.

Although summative evaluation is the culminating evaluation of the effectiveness of instruction, it generally is not a part of the design process. It is an evaluation of the absolute and/ or relative value or worth of the instruction and occurs only after the instruction has been formatively evaluated and sufficiently revised to meet the standards of the designer. Since the summative evaluation usually does not involve the designer of the instruction but instead involves an independent evaluator, this

component is not considered an integral part of the instructional design process per se.

According to (McGriff, 2001:2) the Systems Approach model is based on an instructional theory that says that there is a predictable and reliable link between a stimulus (instructional materials) and the response that it produces in a learner (learning of the materials).According to The Herridge Group (2004) the model views instruction as a systematic process in which every component (i.e. teacher, students, materials, and learning environment) is crucial to successful learning. The Herridge Group (2004) goes on to state that a system is technically a set of interrelated parts, all of which work together toward a defined goal. According to Dick and Carey (1990, p.3) the parts of the system depend on each other for input and output, and the entire system uses feedback to determine if its desired goal has been reached. The Herridge group (2004) states that each model component is critical. None can be skipped. Some steps can be completed concurrently but all must be completed. The Herridge Group (2004) further states that, because of its systematic and sequenced nature, this model allow for the standardisation of project design efforts making them task specific.

By viewing the development of instruction as a systematic process one considers the role of each component and, through formative and summative evaluation, identifies what corrections must be made to ensure the instructional goal is met.

2.6.1.1 Criticism of the Systems Approach model

According to the Herridge Group (2004) one criticism of the model is that it presumes that learning is based on mastering a set of behaviors which are predictable and

therefore, reliable yet according to McGriff (2001, p.3) behavior is not predictable. The following limitations to the model were stated by Dick (1996):

- The model does not include procedures for a total performance systems analysis, nor does it include procedures for implementing and maintaining instruction.
- According to Wedman and Tessmer in Dick (1996), some researchers have indicated that practitioners do not necessarily follow all the steps in the model in a sequence and sometimes ignore some of the steps.

Willis (1995) states that the model is a fixed and linear approach to designing instruction.

2.6.2 Tyler's Objective Model

According to Posner (1998 p.80), Tyler's approach to curriculum planning poses 3 questions which are as follows:

- The procedural question: What steps should one follow in planning a curriculum?
- The descriptive question: How do people actually plan curricula i.e what do they do?
- The conceptual question: What are the elements of curriculum planning and how do they relate to one another conceptually?

According to Posner (1998), Tyler suggests that when planning a curriculum, four questions must be answered. First planners must decide what educational purposes the school should seek to attain. The objectives should be derived from systematic studies of the learners, from studies of contemporary life in society and from an analysis of the subject matter by specialist. These three sources of objectives are then screened through the schools philosophy and through the knowledge available about the psychology of learning. Secondly, planners must determine what educational experiences can be provided that are most likely to attain these purposes. Thirdly, the planner must find ways that these educational experiences can be organized effectively.

The planner attempts to provide experiences that have a cumulative effect on students. Posner (2011) asserts that Tyler recommends that experiences build on one another and enable learners to understand the relation among their learning activities in various fields. Therefore, attention should be given to the sequence of experiences within each field (e.g. Mathematics and integration of knowledge across fields). Certain concepts, skills and values are sufficiently complex to require repeatedly study in increasing degrees of sophistication and breadth of application, and sufficiently pervasive to help the student relate one field to another. The planner uses these organizing elements to provide the sequence and integration the curriculum requires. Finally, the planner must determine whether the educational purposes are being attained by using objective evaluation instruments such as tests, work samples, records, et cetera.

2.6.2.1 Disadvantages of Tyler's Model

According to Posner (1998), the disadvantages with Tyler's model are that it ignores content in favour of learning skills in cognitive, affective and psychomotor domains yet the understanding of a key concept is as much a learning objective as the development of skills in analysis and synthesis. Posner (1998) goes on to say that it also undervalues statements of aims or goals, and in consequence, the effects of the

institutional mission on the curriculum, and causes teachers to ignore process in favour of product.

According to Posner (1998), it is difficult to implement Tyler's model, as it has weaknesses in its basic approach. According to Haung and Yaung (2004), Tyler's model does not have a feedback mechanism to tell people how to correct it. It seems to lack a procedure between evaluation and organization and this procedure is execution. This means that it does not help students achieve the evaluative outcome or expected objective. The difficulty of execution also comes about because it is a behavioural objective. Behavioural objectives do not apply to all subjects or the design of a subject's content.

Therefore Haung and Yaung (2004) summarised the limitations of Tyler's model as follows:

- (a) It has a behavioural orientation; therefore it has some limitations on execution
- (b) It is too narrow because it judges the outcomes as successful or not based only

on whether the objective has been achieved or not

(c) It has limitations of choices of objectives.

These are often limited to some behaviour which can be easily quantified, but excludes some objectives that cannot be quantified, e.g. some objectives such as increasing respect for others in children cannot be objectively quantified. Which means that much of what makes people moral or ethical cannot be included in measurable objectives.

2.6.2.2 Advantages of Tyler's model

The advantages of Tyler's model are, according to Posner (1998), that of schooling and curriculum planning. Schooling is conceived as a production system in which individual learning outcomes are the primary product. Curriculum planning is assumed to be an enterprise in which the planner objectively and if possible, scientifically develops the means necessary to produce the desired learning outcomes. According to Haung and Yaung (2004), Tyler's model is aimed at developing students' behaviour as the target goal of teaching. It shows that the planning done takes into consideration the long-term view of outcomes for the learners. Secondly, it has the function of carefully managing objectives; therefore it is easy to observe the customs of attained objectives. In addition, it is easy to find the suitability of subjects' content, activity, and teaching methods based on the objective evaluation.

In terms of understanding the bearing that curriculum design has on Mathematics achievement, this model might be very useful because it takes into account many aspects which are needed in any learning environment. It might only give educators problems on its implementation since the literature reviewed states that it has a problem on execution.

2.6.3 Taba's Instructional Strategies Model.

It is also worth considering Taba's model. Lunenburg (2011) states that it includes organisation of and relationships among five mutually interactive elements so that a system of teaching and learning is represented. These are, objectives, content, learning experiences, teaching strategies, and evaluative measures. This model also

has external factors. These external factors are those that may affect its internal components. According to Lunenburg (2011) such external factors include:

- The nature of the community in which the school is located, its pressures, values, resources
- (2) The policies of the school district.
- (3) The nature of a particular school, its goals, resources and administrative strategies.
- (4) The personal style and characteristics of the teachers involved, and
- (5) The nature of the student population.

The process of determining objectives begins with the development of overall goals, originating from a variety of sources e.g. demands of the society, the needs of students, *et cetera*. The content for each grade level in the curriculum is contained within a number of teaching-learning units. The content contained in the units within a years' work is incorporated into the learning experiences selected and organized in accordance with clearly specified criteria. Learning experiences develop multiple objectives which include thinking, attitude, knowledge and skills.

Lunenburg (2007) states that the uniqueness of Taba's model is that specially designed teaching strategies which identify specific procedures that teachers may use, are included within the curriculum. According to Lunenburg (2011), Taba (1962) reversed the commonly accepted procedure for curriculum development by suggesting that instead of developing a general plan for the school programme as the scholars in tradition of deductive models do e.g. Tyler's, it would be more profitable to begin with the planning of teaching-learning units. Lunenburg (2011)

goes on to say that in such a system, teaching learning units would provide the basis for curriculum design and thus the curriculum would emerge from instructional strategies. According to Lunenburg (2011) the advantages of Taba's model are that it is applicable to many types of curricula and it can be used in many different kinds of school settings and school levels; elementary school, middle school, and high school. Taba's model has the same advantages as that of Tyler, 'since they are both objective oriented. According to (Haung and Yaung, 2004), like Tyler's model, Taba's model also has a disadvantage of execution.

Although Taba's model does not offer insight into the issues of curriculum design and Mathematics achievement, it might be useful in directing Mathematics educators to what needs to be done in class. Like Tyler's model it also gives educators problems on the implementation side of things.

2.6.4 Walker's Naturalistic Model

According to Kessels and Plomp (1999), Walker's (1971) model identified three basic planning phases as follows: platform, deliberation and design. This model is not a normative model of how curriculum designs should take place but a description of how it often occurs in reality. According to Kessels and Plomp (1999) in the platform phase, participants talk, discuss and argue about their beliefs, ideas, theories, aims and potential procedures concerning the curriculum. The process of deliberation includes exploring specific conditions, generating alternatives, examining costs and consequences, and selecting a feasible alternative. The platform and deliberation phases involve an intensive exchange of ideas and beliefs, coming to a consensus, before moving into the design phase. The design phase includes decision making about specific content, instructional strategies and materials.

According to Kessels and Plomp (1999), the importance of Walker's deliberation approach is that it recognizes the variety of beliefs, aims, and images that participants in a project on a curriculum adhere to. This variety of perception may frustrate a rational, systematic and linear design process as proposed by the various sets of design instructions that promote a unilateral internal consistency.

Its disadvantages according to Posner (1998), is that Walker's model relegates objectives to a less central position in the curriculum development process. Objectives constitute only one type of component (i.e. aims) of walker's platform. Therefore, there is no clear separation of ends and means. According to Duncan & Powers (1992), Walker's approach may often seem fuzzy, using informal networks, balancing power and influence, and striving for consensus within the limits of culturally determined feasibility. Warshauer (1988) states that political awareness; cultivating support, developing relationships and gaining visibility seem to be ingredients of this curriculum design.

Since walker's model is a descriptive model of how curriculum design often occurs in reality it does not say anything about the curriculum design aspects and, as a result, nothing about Mathematics achievement. According to the literature reviewed, Walker's approach may be fuzzy and this fuzziness might, in the end, confuse educators and, when applied to the teaching of Mathematics, might lead to underachievement in the subject.

2.6.5 Biggs Constructive Alignment Theory

According to Biggs and Tang (1998) the teacher decides the objectives, and initially selects teaching activities and the format for assessment. In aligned instruction, the objectives are embedded in the assessment tasks, which, for the students, are the

most salient aspects in determining what they learn and how. According to Biggs (1963), in a good system, all aspects of teaching and assessment are tuned to support high level learning, so that all students are encouraged to use higher-order learning processes. Biggs (1963) states that 'Constructive Alignment' (CA) is such an approach to curriculum design that optimises the conditions for quality learning. Watts (2007) states that Constructive Alignment is a combination of constructivist theory and aligned instruction, which requires that instructional tasks or learning activities be aligned appropriately with learning objectives and assessment.

Biggs (1963) identifies two aspects of 'Constructive alignment'. Firstly, there is the 'constructive' aspect which refers to the idea that students construct meaning through relevant learning activities. That is, meaning is not something imparted or transmitted from teacher to learner, but is something learners have to create for themselves. Teaching is simply a catalyst for learning. If students are to learn desired outcomes in a reasonably effective manner, then the teacher's fundamental task is to get students to engage in learning activities that are likely to result in their achieving those outcomes. Biggs (1963) states that it is helpful to remember that what the student does is actually more important in determining what is learned than what the teacher does.

Secondly, the 'alignment' aspect refers to what the teacher does, which is to set up a learning environment that supports the learning activities appropriate to achieving the desired learning outcomes. Biggs (1963) states that the key is that the components in the teaching system, are aligned with the learning activities assumed in the intended outcomes, especially the teaching methods used and the assessment tasks.. The learner is in a sense 'trapped', and finds it difficult to escape without learning what he or she is intended to learn.

In setting up an aligned system, educators want students to achieve specified goals, which are the desired outcomes of teaching, not only in terms of topic content, but in the level of understanding. An environment that maximises the likelihood of students engaging in the activities designed to achieve the intended outcomes is set up. Finally, assessment tasks are chosen that tell the educators how well individual students have attained outcomes, in terms of graded levels of acceptability.

According to Biggs (1963) the above mentioned form four major steps which are as follows:

1. Defining the intended learning outcomes (ILOs);

2. Choosing teaching/learning activities likely to lead to the ILOs;

3. Assessing students' actual learning outcomes to see how well they match what was intended;

4. Arriving at a final grade.

Defining the ILOs

Biggs (1963) states that when educators teach they should have a clear idea of what they want students to learn. More specifically, on a topic by topic basis, they should be able to stipulate how well each topic needs to be understood. First, they need to distinguish between declarative knowledge and functioning knowledge.

Biggs (1963) states that declarative knowledge is knowledge that can be 'declared': we tell people about it, orally or in writing. Biggs (1963) states that declarative knowledge is usually second-hand knowledge; it is about what has been discovered.

Knowledge of academic disciplines is declarative, and our students need to understand it selectively.

Biggs (1963) further states that we do not acquire knowledge only so that we can tell other people about it; more specifically, so that our students can tell us - in their own words of course - what we have recently been telling them. Our students need to put that knowledge to work, to make it function. Understanding makes one see the world differently, and behave differently towards that part of the world.

Biggs (1963) states that after graduation, all our students, whatever their degree programmes, should see a section of their world differently, and behave differently towards it, expertly and wisely. Accordingly, educators have to state objectives in terms that require students to demonstrate their understanding, not just simply tell us about it in invigilated exams. Biggs also states that the first step in designing the curriculum objectives is to make clear what levels of understanding educators want from students in what topics, and what performances of understanding would give educators this knowledge.

It is helpful to think in terms of appropriate verbs. Each discipline and topic will have its own appropriate verbs that reflect different levels of understanding, the topic content being the objects the verbs take. The same verbs need to be embedded in the teaching/learning activities and in the assessment tasks as they keep educators on track.

Choosing teaching/learning activities

According to Biggs (1963), teaching and learning activities in many courses are restricted to lecture and tutorial: lecture to expound and package, and tutorial to

clarify and extend. Biggs states further that, these contexts do not necessarily elicit high level verbs. Students can get away with passive listening and selectively memorising.

Assessing students' learning outcomes

Biggs (1963) states that faulty assumptions about and practices of assessment do more damage by misaligning teaching than any other single factor. Ramsden (1992) in Biggs (1963) assert that assessment is the curriculum, as far as the students are concerned. Students will learn what they think they will be assessed on, not what is in the curriculum, or even on what has been 'covered' in class. Biggs (1963) goes on to state that the educator should make sure that the assessment tasks mirror the LOs. Biggs (1963) states that the LOs cannot sensibly be stated in terms of marks obtained. Intended outcomes refer to sought-for qualities of performance, and it is these that need to be stated clearly, so that the students' actual learning outcomes can be judged against those qualities. If this is not done, then, aligning of objectives and assessments is not done.

According to Westwood (2004), if one subscribes to the constructivist philosophy, then the teacher's task is no longer one of developing instructional strategies to present information to students directly, but rather to discover ways of creating exploratory activities in which students may engage. The constructivist theory of learning leads to a process centred teaching approach, with the role of the teacher changing from instructor to facilitator of the children's own explorations and discoveries. Learning occurs as students make connections between new insights they obtain and their existing foundation of knowledge.

2.6.5.1 Critics of the Biggs Model

Since the Biggs theory is also a combination of constructive and aligned instruction, the criticisms directed to the constructivist theory also apply to the constructive alignment theory. Cobb in Westwood (2004) refers to the fact that the justification for constructivism is often reduced to the mantra-like slogan, 'students must construct their own knowledge'; but no hard evidence is provided to support the claim that all students are effective in learning and 'making meaning' for themselves, nor is much specific practical advice given to teachers, beyond the need for using child-centred activities and discussion, perhaps leaving teachers to assume that student engagement in an activity always equals learning. Westwood states that this brave assumption is sometimes very far from reality.

According to Westwood (2004), the use of child-centred, process-type approaches to the total exclusion of direct teaching is unwise, particularly in the teaching and learning of basic skills such as reading, writing and Mathematics. Westwood (2004) states that activity-based and problem-solving curricula are not easy to implement, particularly where there are large classes or when behaviour management is a problem.

Jonassen in Westwood (2004) presents a three-stage model of knowledge acquisition in which 'initial knowledge acquisition' is stage one, followed by 'advanced knowledge', and finally 'expertise'. He strongly supports the view that initial knowledge acquisition is served best by direct teaching, while advanced knowledge and expertise develop best through a practical application of constructivist principles. Graham and Harris (1996) argue that excellent teaching

often begins with explanation and modelling, and continues with teacher scaffolding of students' more independent efforts.

According to Creemers in Westwood (2004) direct teaching is often the most efficient method for first imparting new information and skills.

Graham & Harris (1996) state that perhaps the most serious problem associated with an exclusive use of constructivist principles in the classroom is that some children do not cope particularly well with unstructured tasks. They experience failure and frustration when the demands of learning tasks are not made clear to them and when they are not taught appropriate strategies to use. According to Westwood (2004) not all children discover for themselves the many strategies they need to use when coping with the academic demands of the school curriculum.

For some students, discovery methods are inefficient at best – requiring far longer time than it would take to teach the same strategies to children using direct explanation. Westwood (2004) opines further that problem-based learning and discovery methods may increase the cognitive load and misdirect the use of available learning time to a detrimental level for lower ability students. On the other hand, many children are capable of making new ideas of their own quite quickly when these ideas are transmitted clearly to them. According to Westwood (2004), good quality instruction from a teacher, including the key components of modelling, direct explanation and guided practice actually stimulates rather than restricts constructive mental activity in students. Presenting knowledge directly to a learner does not prevent the individual from making meaning. Westwood (2004) holds the opinion that being told something by a teacher might be just what learners require at a particular moment in order to help them construct meaning and that the most

effective lessons are likely to contain an appropriate balance between teacher direction and student activity. Westwood (2004) also asserts that the balance must be achieved in the planning stage when the teacher takes account of the types of learning involved in the particular lesson and the characteristics of the students. The two viewpoints on learning and teaching — direct instruction vs. student-centred, constructivist learning models — are not mutually exclusive.

2.6.6 Subject –Centred Designs

Some curricula have been designed to encourage students to examine their individual attitudes and values. O'Neill (2010) states that there is a range of more specific models that can suit specific programme designs. In this case if they become more specific they are referred to as subject- centred designs. The table below gives an example of such.

Discipline Based	Centred on conceptual structures of all
	the discipline and inform the work of
	people in the discipline.
Broad Fields	Merge several disciplines into an
	interdisciplinary subject area(allow
	more correlation, integration, holism)
Conceptual Clusters	Broad field can have clusters e.g
	science, technology and society.
Theme- based	Emphasizes importance of finding
	patterns/relationships between
	concepts based on culture and
	experiences.

Table 2.1: Subject - Centred Designs

Source: O'Neill (2010)

Below Saylor (1981) curriculum design model is discussed. That is the: Student/ child-centred

2.6.7 Student Centred designs

This type of curriculum emphasizes the interest and needs of students. In these designs, the curriculum plan is based on the knowledge of learners' needs and interests. The learner is consulted and instructed individually at appropriate points of the curriculum and instructional process. The disadvantages in this type of design, according to Urebvu (2001) are as follows:

- The mind of the child will be expanded, enlightened and extended only as far as his current interests and curiosities will permit.
- 2) Only seldom do educators listen to the learner and even if they did, it is by no means clear that students would have a correct perception of the field.
- 3) Students adopt very different learning styles, so that what is good for one may be totally inappropriate for another.

2.6.8 Contemporary Curriculum Designs

According to Jansen (2009), Bernstein describes two distinct types of approaches to curriculum, which he calls the 'competence' model and the 'performance' model.

Competence curriculum

Jansen (2009) states that the key characteristic of a competence curriculum is named in the title, it is interested in learner's competences which are believed to be innate.

Thus, knowledge is not imposed from the outside, but the competences that learners already have are sought on the inside. Thus, it encourages teaching that draws from a learner's own experiences and 'everyday knowledge' and, in turn, assists learners in using their new learning in their lives and work.

According to Jansen (2009), the focus on the learner and everyday experience tends to affirm learners and build their confidence, whatever their background. It also provides the teachers and learners with important 'ways into' the formal 'school knowledge' that is to be taught, and later with the basis for applying that formal knowledge. Jansen (2009) suggests that learning tends to be organized around themes and projects and to be based on experience. Learners also have a large measure of control over:

- What they learn (selection);
- When they learn it (sequence);
- How quickly they progress through the learning (pacing).

Jansen (2009) also expounds that the competence approach is learner-centred. Learners take control of their own learning, and the teacher's role tends to be covert.

Jansen (2009) states that, rather than directly transmitting learning, the teacher acts as a guide and facilitator. Pedagogy is personalized and process-orientated. Knowledge in a competence curriculum is often horizontally organized.

It introduces themes, projects and problems which don't necessarily link to each other. In other words, rather than focusing overly on a curriculum that progresses vertically – where new work builds on old work, and becomes increasingly difficult – it organizes teaching around one theme, and then moves to another theme that may

not be connected in any way to the first .Jansen (2009) also says that in competence approaches, all learners are regarded as essentially competent, and able to arrive at a certain outcome. How they arrive there, and how long it takes them, will vary from learner to learner, and learners may express the outcome in a number of different ways.As a consequence, the focus in evaluation is on 'presences' – on what the learners know or have achieved rather than what they don't know (absences).

Performance curriculum

According to Jansen (2009), for Bernstein, a performance curriculum is characterized by developing high levels of understanding, often in particular subjects. As a consequence, the curriculum tends to:

- be very specific about what content must be learnt, and in what order;
- focus on depersonalized, formal 'school knowledge' rather than on everyday knowledge and experience;
- be more vertically organized than a competence curriculum. In other words, it builds knowledge and understanding in a specific sequence.

(Each bit of knowledge becomes more complex than the previous bit of knowledge). Jansen (2009) argues that the process of learning in the performance curriculum is more strongly defined and controlled by the teacher. The role of the teacher tends to be overt. He or she has a lot more control over the selection, sequence, and pace of learning than teachers teaching within a competence curriculum model.

He further argues that performance approaches are, thus, more content- and teacher-centred than competence approaches. Consequently, teaching tends to take place in specific learning places – the classroom, lab, or training workshop –where

access to formal school knowledge is easier. Therefore in performance approaches, learners have less control over the selection, sequence, and pacing of their learning.

According to Jansen (2009) performance approaches base evaluation on deficits ('absences'), or what is missing. The aim is to develop a clearly defined behaviour or understanding– a performance rather than the more general competence required in a competence model – and so teaching and assessment focus on refining this by pointing out what still needs to be mastered. Jansen argues further that in performance approaches learners may still be active, but their activities are based on an external goal, rather than driven from within. They will also tend to be directly related to the performance that must be attained, and this will be clearly specified in the curriculum.

Maton (2009) argues that the issue of how to enable cumulative learning, where new knowledge builds on and integrates past knowledge, is becoming increasingly salient; and that contemporary policy debates suggest that education must prepare the young for 'lifelong learning' to meet the fast-changing demands of working in a 'knowledge economy'. Maton (2009) also states that policy rhetoric emphasises the capacity of workers to continually build knowledge, add new skills, and give new meanings to existing abilities – a form of cumulative learning. Segmented learning – where students learn a series of ideas or skills that are strongly tied to their contexts of acquisition, problematising, transfer and knowledge-building – remains a pressing concern in educational debates (Maton, 2009).

Bernstein (1999) distinguishes between forms of 'discourses',

 Horizontal discourse: refers to everyday or 'commonsense' knowledge and 'entails a set of strategies which are local, segmentally organised, context specific and dependent'. . Bernstein states that this is said to be common sense knowledge for the following reasons:

- All potential or actually, have access to it.
- It applies to all.
- It has a common history in the sense of arising out of common problems of living and dying. According to Bernstein (1999) the features of common sense are:
- It is likely to be oral
- Local
- Context dependent
- Specific
- Tacit
- Multi-layered
- Contradictory across but not within context.
- Segmentally organized

The knowledge comprising this discourse is characterised by 'functional relations of segments or contexts to the everyday life; that is, meaning is dependent on its social context, so the knowledge acquired in one context does not necessarily have meaning or relevance in other contexts.

Bernstein (1999) further states that the segmental organization of the knowledge of horizontal discourse leads to segmentally structured acquisitions. There is no necessary relation between what is learned in the different segments. According to Bernstein (1999), the emphasis of segmental pedagogy of horizontal discourse is directed towards acquiring a common competence rather than a graded performance. Competitive relations may develop as in the peer group on the basis of these common competences. Horizontal discourse relayed through a segmental pedagogy facilitates the development of a repertoire of strategies of operational knowledges activated in contexts whose reading is unproblematic (Berstein, 1999).

ii) Vertical discourse refers to 'specialised symbolic structures of explicit knowledge, or scholarly, professional and educational knowledge, and 'takes the form of a coherent, explicit, and systematically principled structure'. The official pedagogy of vertical discourse is not consumed at the point of its contextual delivery but are an ongoing process extended in time (Bernstein, 1999. Here meaning is less dependent on relevance to its context, and instead is related to other meanings hierarchically. Bernstein (1999) then distinguishes within vertical discourse between 'hierarchical' and 'horizontal' knowledge structures.

Hierarchical knowledge structures develop through new knowledge integrating and subsuming previous knowledge, whereas horizontal knowledge structures develop through adding on another segmented approach or topic area. Maton (2009) states that educators can distinguish between hierarchical and horizontal curriculum structures according to whether a unit of study (lesson, module, year, etc.) builds upon the knowledge imparted in previous units through integration and subsumption or through segmental aggregation. Similarly, one can distinguish the ways in which students' understanding develops over time (as evidenced by, for example, their work products), according to whether they build on their previously learned knowledge that is strongly bounded from other knowledges and contexts. This is to distinguish between what can be termed cumulative learning, where students are
able to transfer knowledge across contexts and through time, and segmented learning, where such transfer is inhibited.

Bernstein (1999) states that in education, as part of the move to make specialized knowledges more accessible to learners, segments of horizontal discourse are recontexualised and inserted in the contexts of schools subjects. These insertions are subject to distributive rules, which allocated these insertions to marginal knowledges and/or social groups and Maton (2000) described and analyzed this movement as a discursive shift in the legitimation from knowledge to knower. Segments of horizontal discourses are resources to facilitate access usually limited to the procedural or operational level of a subject and may also be linked to improving the students ability to deal with issues arising (or likely to arise) in the student's everyday world issues; for example, health, work, domestic skills etc. Horizontal discourse may be seen as a crucial resource for pedagogic populism in the name of empowering or unsilencing voices to combat the elitism and alleged authoritarianism of vertical discourse. In education vertical discourses are reduced to a set of strategies to become resources for allegedly improving the effectiveness of the repertoires made available in horizontal discourse. Maton (2009) states that Bernstein's mapping of knowledge can be criticised for the following reasons:

- For offering dichotomous ideal types whose differences are too strongly drawn.
- It raises questions of whether all horizontal discourse is the same, whether there are quantum shifts between the two forms of the discourse and between the two forms of knowledge structures, and where particular disciplines and curricula fit within the model.

- The concepts also highlight what kind of discourse or knowledge structure one might discover in research, but not what makes a discourse 'horizontal 'or 'vertical' or a knowledge structure 'hierarchical' or 'horizontal'.
- The terms are more suggestive than they are explanatory.

Muller (2007) argues that Bernstein's concepts remain 'locked into an early (lexical) metaphorical stage of discussion, where the terms are more suggestive than they are explanatory. Maton (2009) states that to overcome these dichotomies necessitates developing the framework to theorise the underlying principles generating discourses, knowledge structures, curriculum structures and forms of learning. One such development can be found in the Legitimation Code Theory, which builds on the insights of Bernstein, among others (Maton 2000, 2006, 2007; Moore and Maton 2001). Maton (2009) states that this approach views the practices and beliefs of actors as embodying competing claims to legitimacy, or messages of what should be considered the dominant basis of achievement within a social field of practice. He states further that these 'languages of legitimation' are analysed in terms of their underlying structuring principles or 'legitimation codes' and one such code is 'specialisation', or what makes someone or something different, special and worthy of distinction. Maton (2009) asserts that , discursive practices are analysed according to whether they emphasise as the basis of legitimate insight the possession of explicit principles, skills and procedures (knowledge code), attitudes, aptitudes and dispositions (knower code), both specialist knowledge and knower dispositions equally (elite code), or neither (relativist code). Maton 2007; Moore 2007; Muller 2007 state that these codes help excavate the underlying principles generating forms of knowledge; for example, hierarchical knowledge structures are

underpinned by knowledge codes, and horizontal knowledge structures are typically generated by knower codes.

According to Maton (2009), codes are also being used to explore a range of issues in empirical studies on education. Maton (2000, 2008) states that while the codes shed light on the bases of knowledge-building, they do not directly conceptualise the contextual transfer of knowledge.

Maton and Moore(2010) argue that the Legitimation Code Theory (LCT) represents part of the 'coalition of minds' known as social realism, has five dimensions and the best known at present is LCT(Specialization) which builds primarily on the concepts of epistemic relation, social relation, knowledge-knower structures and four specialization codes. Lamont and Maton (2008) say that this dimension is proving fruitful in a wide range of studies. According to Maton (2009) this dimension provides one way of analysing the underlying principles structuring intellectual and educational fields.

Various scholars have stated that Legitimation codes provide a means of analysing the principles that establish 'what matters' (Lamont & Maton 2008; Maton 2000, 2007; Moore & Maton, 2001). 'What matters' may, for example, include the display of skills and procedures (knowledge code), or of attitudes and dispositions (knower code), or of both, as the basis of legitimate learning. The ways such issues themselves matter is highlighted by how teachers and students negotiate two key challenges to cumulative learning: 'code clashes,' when students' beliefs and practices embody contrasting measures of achievement to those required for success; and 'code shifts,' when the basis of achievement changes between tasks, lessons, or curriculum stages (Maton, 2008).

By looking at Bernstein's model, Maton (2009) concludes that one can describe forms of knowledge in terms of the degree to which meaning is dependent on its context, or what he terms 'semantic gravity'. Maton (2009) avers that semantic gravity may be relatively stronger or weaker. When semantic gravity is stronger, meaning is more closely related to its context of acquisition or use; when it is weaker, meaning is less dependent on its context. Vertical discourse can be described as characterised by weaker semantic gravity than horizontal discourse. Within vertical discourse, hierarchical knowledge structures exhibit weaker semantic gravity than horizontal knowledge structures. Finally, cumulative learning depends on weaker semantic gravity and segmented learning is characterised by stronger semantic gravity constraining the transfer of meaning between contexts. Maton (2009) goes on to state that one condition for building knowledge or understanding over time may be weaker semantic gravity.

Maton (2009) states that in recent years, professional education has been increasingly influenced by 'authentic or 'situated' learning. Proponents claim that, to enable students to transfer their knowledge to contexts beyond education, they require learning tasks that reflect the realities of practices in those everyday contexts and that allow them access to the knowledge of experts with experience of relevant real-world practices .According to Maton (2009), authentic learning is often associated with problem-based, case-based and project-based pedagogies offering students real-life examples of the working practices. Such 'authentic learning environments' are said to create learning experiences that help build on students' prior experience and take their knowledge into the future world of work. They are also claimed to enable cumulative learning.

According to Freebody, Maton & Martin (2008), debates have vacillated between 'traditional' pedagogies ('teacher-centred', 'transmissionist', 'content-focused', etc.) and 'progressive' or 'constructivist' pedagogies ('student-centred', 'process-focused', etc.). Freebody *et al.*, (2008) remark that these discourses are conventionally cast as deeply oppositional, but in fact share both a tendency to offer solutions that are generalised across all subject areas, and a shared neglect of the potential significance of differences in the disciplines on which the core curriculum areas are based. According to these researchers, the development of accounts of teaching and learning that focus on differences among learners, which, as with most contemporary theories of learning, were agnostic on the matter of knowledge was more favoured.

Freebody *et al.*, (2008) also comment that the focus of ongoing debate between educators and the stakeholders, of education is how best to organise knowledge is. Each discipline has developed norms that are applied to the question of how it is that human experience can be converted into knowledge, and how that knowledge can be appropriately disseminated.

According to Freebody *et al.*, (2008), disciplines can be understood as social fields of practice comprising both relatively formal structures of knowledge and practices, and actors who share interests and norms (whether explicit or tacit) of knowledge production and communication.

Freebody *et al* (2008) suggest that disciplines are underpinned by agreements (which, of course, change over time and are always open to contestation) about how to address particular kinds of knowledge problems. They can be seen as more or less coherent answers to questions such as: what counts as a 'right' answer and a 'right' way of getting to one, sufficient that we can know, and act on our knowledge?

Disciplines group clusters of facts and understandings (bricks and buildings, in Poincaré's terms) and people who are attracted to similar answers to these questions Freebody *et al.*, (2008) go on to state that disciplines are seen to be based on differences in their objects of study.

MacDonald, as cited in Freebody *et al.*, (2008) found that the disciplines differ on five major continuums:

- a. in their identification of a central puzzle a key topic;
- b. in the functions they serve in a society's need to base action on knowledge (from explanation to interpretation);
- c. in the main cultural work afforded by the knowledge (from advocacy of position to strictly production of knowledge);
- d. in the way they focus on the current state of knowledge and debate rather than on the phenomenon/problem at hand (from conceptually-driven to textuallydriven);and
- e. in the extent to which the criteria for knowledge production are explicated (from explicit to implicit epistemic self-consciousness).

According to Lemke in Freebody et al (2008) each discipline has its own distinctive set of preferred genres, ways of inter-relating and co-interpreting language and other modalities, register combinations, ways of co-ordinating knowledge in language and image, ways of using abstraction and technicality, and so on . Freebody et al (2008) expound that disciplines are seen to be based on differences in their objects of study. Anderson and Valente, in Freebody (2008) emphasised that a discipline embodies a productive interplay between the constraining force of knowledge development, and the distinctive arena for enhanced intellectual agency that each knowledge domain offers: "the term 'discipline' captures the sense of a dual mandate, carrying a sense of practical regimen into an economy of conceptual enterprise" and enterprise, between epistemological constraint and insightful agency, that is the platform on which genuine conceptual innovation and progress can be made. Freebody *et al.*, (2008) go on to state that without the regimen we cannot tell a new idea from a good new idea from a sustainable good new idea; nor can we effectively transpose an idea from one discipline into another or into an inter-disciplinary setting because we cannot act on how one discipline's regimen-enterprise interplay productively articulates with that of another.

Freebody *et al.*, (2008) ask a question on how the operations of disciplinary-based, cumulative learning are visible in classrooms. They say that addressing this question requires a means of capturing variations in the structuring of knowledge, and then seeing how these are realised through language and communication, including in classroom interactions. Furthermore, it also requires a means of talking about these issues that move beyond the metaphorical, ill-defined language in which disciplinarity and knowledge are often discussed. Sociologists of educational knowledge, especially Bernstein (e.g., 1999), have developed tools for systematically conceptualising the underlying principles that generate forms of knowledge and how they develop over time. Bernstern (1999) explored the characteristics of 'hierarchical knowledge structures' that build and integrate knowledge, and 'horizontal knowledge structures' in which new ideas are aggregated.

According to Bernstern (1999) as mention above, the ways in which understanding of disciplinary knowledge develops over time can be conceptualised in terms of cumulative learning, where knowledge builds over time by integrating and subsuming

previous knowledge, and segmented learning, where new ideas or skills are accumulated alongside past knowledge. In the first place, this contrast analyses the structure of knowledge in terms of its relation to other educational and everyday knowledge, the sequencing of learning, and the hierarchical arrangement of knowledge through a curriculum.

Secondly, for cumulative learning to take place, students need to be able to transfer knowledge between contexts and to build knowledge over time. That is where semantic gravity and temporal portability come in, as mentioned earlier on (Freebody et al, 2008). According to Maton (2009), that semantic gravity refers to the degree of context dependence of knowledge, and shapes the capacity of students to move between concrete examples and abstract principles that go beyond the specific context. Freebody et al (2008) state that temporal portability conceptualises the capacity for bringing knowledge from past educational or everyday contexts into the present, and from the present into future contexts, affording students the ability to revisit, redefine, and extend previously studied concepts in relation to new ideas.

Thirdly, the ways these features of knowledge enable cumulative learning differs depending on the discipline. Students are provided, explicitly or tacitly, with different procedures to follow and these embody principles that underpin each discipline's knowledge. Freebody *et al.*,(2008), as the other authors mentioned above, agree that 'What matters' may, for example, include the display of skills and procedures (knowledge code), or of attitudes and dispositions (knower code), or of both, as the basis of legitimate learning.

Freebody *et al.*, (2008) summarise the three forms of observable disciplinedistinguishing activities as follows:

• Accountability markers, teachers use a variety of accountability markers to indicate the knowledge and processes that students will be held accountable for knowing, the salient and portable learnings potentially relevant to future classroom work or assessment, or to applications outside the classroom. These accountability markers tend to appear prior to, during, and after the elaboration/activity phase/s of lessons and units, and consist of both emphasising moves (e.g., repetitions, pitch variations, multiple illustrations) and explicit connecting moves (e.g., remember last week we ...).

• Formulations made by teachers and students. 'Formulation' refers to talk that steps back from, interprets, explains, summarises, and frames talk occurring before or after (e.g., so what we just did was ...), reiterating, reframing, redirecting or repurposing attention and/or activity. Such formulations, almost always made by teachers, are most likely to be found: i) at the beginning of units and lessons, ii) at the ends, iii) at those points at which there is evident trouble of some sort jeopardising progress, and iv) at those points where there is a major change of activity or work configuration.

• Finally, shuttling which refers to the ways in which teachers and students engage in movements back and forth, for example between levels of abstraction and technicality in vocabulary, concepts and relations, genre choices, interactional formats, and so on (McHoul & Watson, 1984). Shuttling may also be observed in the well-documented Initiation-Response-Evaluation (IRE) cycle in classroom talk, whereby teachers use the E component to modify students' candidate answers, recasting the students' words into more elaborated, abstract, technical, or retro- or pro-spectively relevant words, concepts, and connections, and thereby recasting

students' knowledge from here-and-now, common-sensical to portable, disciplinebased (Hammond & Gibbons, 2005; Lee, 2007).

According to Freebody (2008), learners need to learn the reading, writing, talking, and listening rules of the game for each subject area if they wish to succeed. Hammond's and Gibbons' papers in Freebody et al (2008) state that for a clearer sense of what constitutes intellectual challenge among curriculum developers, teachers, teacher educators and students, a clearer sense of the relationship between intellectual challenge and language and literacy is needed. Freebody et al (2008) go on to state that without such an understanding of what is involved in disciplinary literacy, students will be offered only a series of discrete skills or ideas rather than the basis for building their understandings over time – nice bricks, no plans.

2.6.9 Summary for the above Models

The different models are important in their own ways. There is no single design appropriate to the total array of learning opportunities a school can provide. Any one of these curriculum designs is unlikely to be followed in its entirety either as a top down or as a bottom up system. What is most important is that there is a design and that all the elements of the curriculum system have been thought about. They can be used to help design and deliver one's program to obtain the best and most coherent educational experience for students as well as educators. They can be chosen in such a way that they compensate each other. O'Neill (2010) states that no one model is ideal and no one model may suit a full programme. However, identifying and being consistent in these models will support cohesion and clarity of approaches in one's programme.

Although Taba and Tyler's models received criticism, they were very influential models which directed many curriculum developers and teachers in their planning for years. According to Posner (1998), Haung and Yaung (2004), the designers of these traditional models listed similar steps in curriculum construction and these step are (1) define the goals, purposes or objectives (2) define experiences or activities related to the goals (3) organize the experiences and activities and (4) evaluate the goals. It is worth noting that most of the curriculum design models developed from Tyler's and Taba's models. For, almost all the objective models serve the same purpose, that is, they have the same objective. By eliminating the problem of execution from these two models, they provide a good guiding principle for directing curriculum design. Since they are both objective models, they have a disadvantage in execution.

This study of the different curriculum design models paves the way for the critical discussion on the South African Curriculum post 1994 when the democratic dispensation ushered in.

2.7 SOUTH AFRICAN CURRICULUM

Cross, Mungadi, and Rouhani (2002) state that the introduction of the National Curriculum Statement which is outcome- based (OBE) curriculum in South Africa is noteworthy. Its value remains unquestionable. What requires problematisation is the range of expectations around an outcome based curriculum in South Africa which is related to the wide question of what to expect from schools or schooling today. Graven (2002) states that the OBE curriculum is a vehicle for restructuring South

African society along democratic principles. Graven (2002) identifies four new roles for Mathematics teachers;

- To support learners and critically analyse the way Mathematics is used socially, politically and economically to prepare them for democratic citizenship.
- To bring Mathematics from outside into the classroom.
- To apprentice learners into ways of investigating mathematics, being a person who has an interest in pursuing Mathematics for its own sake.
- To convey the practices of the boarder community of Mathematics teachers.

Cross et al (2002) expound that OBE curriculum tried to (i) align school work with work place, social and political goals; (ii) emphasize experiential and cooperative learning; (iii) pursue the value of diversity in the areas of race, gender and culture (iv) develop citizens who are imaginative critical problem solvers. However, a critique of the outcome based curriculum has been waged with reference to the following main dimensions (i) its origins and conceptual basis, (ii) its policy nature, (iii) its knowledge and pedagogical features; (iv) process issues such as the management of its formulation, adoption and implementation; (v) design issues and (vi) its position in the contexts of schooling (Cross et at (2002).

The DOE (2000), states that former model C schools appear to have been able to implement curriculum 2005 with greater ease than the majority of schools, largely because of being better resourced. Jansen (1998) also agrees with the above. He states that implementation of OBE favours well resourced schools with well qualified teachers.

Potenza and Monyokolo (1999) point out that the charge here was the lack of alignment between curriculum development, teacher development, selection and supply of learning material. Christie (1999) suggests that the curriculum was poorly planned and hastily introduced in schools with teachers being insufficiently prepared, without adequate resources. Also there is a proliferation of new terminology in the implementation of OBE. For instance, the procedures for developing a learning programme are deemed complex and hence the need for better prepared teachers, many of whom, especially in the previously disadvantaged groups, are inadequately prepared for basic teaching let alone comprehending the new curriculum, (Cross et al, 2002).

2.8 MATHEMATICS CURRICULUM

Anderson (2009), states that a national curriculum must focus on what is best for all learners. Teachers need resources and support, with the acknowledgement that they always try to do their best for their learners.

According to Witzel and Riccomini (2007), the performance levels stipulated in the general education curricula are problematic for students and present many challenges for teachers, who are responsible for providing programmes and services to students. Witzel and Riccomini (2007) also assert that mathematics is one academic area of particular concern for students and teachers and, therefore, there is a need to develop more efficient and effective mathematics instructional procedures, curricula and material for low performing students. Witzel and Riccomini (2007) state that many mathematics curriculum programs require a number of modifications before low performing learners can benefit from them.

Chard , Baker; Clarke, Jungjohamn, Davis, Smolkowski, (2008) assert that one potential approach to improving mathematics achievement is the delivery of effective instructional materials to all students in the early primary grades to lay a sound foundation for mathematical understanding and prevent early difficulties in mathematics. Chard *et al.*, (2008) also state that instructional programs provide teachers with daily activities that build on students' knowledge of their environment, but they are often not linked to a strong, logical sequence of instruction. Also, many of the programs emphasize authentic childhood activities that may or may not result in students' mastery of key concepts and skills. Chard *et al.*, (2008) state that often those who teach mathematics to young children as well as those who develop the curricula for teaching numbers and basic arithmetic concepts to kindergartens fail to fully take into account that children develop or fail to develop number sense.

Chard *et al.*, (2008) assert that simultaneously integrating number sense activities with early measurement concepts, simple plane geometry and related Mathematics vocabulary, rather than teaching these skills sequentially as is typically done, will reduce subsequent difficulties in Mathematics.

According to Burny, Valcke, Desoete, Hans Van Luit, (2012), the curriculum appears to have a strong impact on what children learn and when they learn it. Burny *et al.,* (2012) go on to state that teachers should always be alert to the fact that:

The curriculum might not always provide the most efficient way of teaching a topic. Teachers should therefore be encouraged to evaluate curriculum materials on the basis of their own experiences. Resources and a platform could be created for teachers to share their classroom experiences with curriculum and textbook developers. Thus, next to researchers, teachers should also be involved in curriculum development. For example, curriculum developers and textbook editors could call in teachers to systematically

evaluate existing curriculum materials in order to gain insight into strengths and weaknesses in the current curriculum.

The reviewed literature criticizes some aspects of the Mathematics programme which might be some of the factors which contribute to underachievement in mathematics. This study seeks to explore the bearing that the Mathematics curriculum design has on achievement at Grade 12, link and progress from primary to high school.

Below curriculum design aspects are discussed.

2.9 CURRICULUM DESIGN ASPECTS

2.9.1 Sequencing

According to the Department of Education and Training, sequence is the order in which the content is presented to learners overtime. The sequence of learning brings order to the delivery of content, supporting the maximizing of student learning and offering sustained opportunities for learning. Without a sequence there is a risk of ad hoc content delivery and the missing of significant learning. Witzel (2007) states that teachers must examine the curriculum sequence for completeness and appropriateness for their students. He says that the above should be done because there maybe gaps in sequencing of lessons within current mathematics textbooks. Therefore, it is a teacher's responsibility to help learners master each skill. Witzel and Riccomini (2007) state that many Mathematics curricular materials do not meet the needs of all students. They also assert that organizing mathematics curricula is necessary but not sufficient to positive students' outcome, as a result, teachers must prepare an effective and efficient sequence of lessons, model and guide students through the use of effective materials and monitor learning to modify and

accommodate learners who are in need of either remediation of enrichment during instruction.

An Umalusi report (2008), states that the order in which topics are listed in a syllabus for a particular grade does not necessarily have particular significance. The Umalusi report (2008) states that very few teachers follow the curriculum for the Grade in the order in which it is set out. For example, completing all the Algebra before starting with Geometry.

According to the Umalusi report (2010), work schedules, which are drawn up at provincial, district and school levels can provide educators with guidance as the sequence in which they should teach topics and the length of time in which they should spend on them. However, these documents are not prescriptive; they only provide one suggested ordering of topics, which is at times different to the ordering given in the NCS.

According to Umalusi (2008), very few teachers follow the curriculum for the grade in the order in which it is set out. According to Witzel and Riccomini (2007) many mathematics curricular materials do not meet the needs of all students in addition to teaching adequately and effectively all the relevant Mathematics standards. Therefore, sequencing might be one of the aspects of curriculum design that contributes to Mathematics underachievement.

Sequencing as one of the aspects of curriculum design has been discussed and its importance has been observed. This study seeks to find out whether curriculum design aspects have any bearing on underachievement. In particular, it seeks to discover the sequencing of Mathematics topics in the N.C.S, that is, the order in which the topics are presented in the mathematics N.C.S.

Some of the aspects of curriculum design i.e., progression, integration, learning pacing, Outcomes and Assessment Standards will also be discussed below.

2.9.2 Progression and integration

According to Muller, Taylor, Vinjevold (2003), mathematics progression within Grades, across grades and across phases is strong, explicit and content led, but there is no strong skill progression stipulated, Skills and content are coupled. Maphalala (2003) states that learners are encouraged to develop gradually more complex, deeper, broader knowledge, skills and understanding in each grade. According to the DOE (2002), assessment standards in each learning area statement provide the conceptual progression in each learning area from one grade to another. Skills on resolution of problems should also go on increasing from grade to grade as the learners go on learning new concepts from grade to grade.

Integration is also a very important aspect of curriculum design to consider. Integration requires learners to use their knowledge and skills from different parts of the same learning area as they carry out tasks and activities or use their knowledge and skills from one learning area to another. Maphalala (2006) asserts that in this way learners experience the curriculum as being linked and related. Also this gives coherence and expands their opportunity to attain skills, acquire knowledge and develop the attitudes and values that are encompassed across the curriculum.

According to Jansen (2009), in an integrated type of curriculum subjects stand in an 'open relation' to one another. Contents of different subjects are blurred in relation to each other. Jansen (2009) goes on to say that there is less focus on detailed understanding of specific subjects, and much more emphasis on 'horizontal' or 'lateral' links across a greater range of subjects. Jansen (2009) asserts that since

there is more room in integrated curricula for a greater degree of learner participation, learners would also probably be encouraged to express their own understandings and experiences, and bring various relevant articles into the classroom. Teaching and learning are less likely to be teacher-driven and more likely to allow some space for learners to decide on what they learn, in what order and at what level of depth. Jansen (2009) goes on to state that an integrated curriculum is associated with the competence model.

Jansen (2009) further asserts that in South Africa, the review of Curriculum 2005 found that there was too much integration in the curriculum and too little specification of content to be learnt. What was at jeopardy in the curriculum was the learning of concepts at progressively higher levels within subjects. There was also too little specificity around what learners should know at specific points. Jansen (2009) goes on to state that for example, exactly what Mathematics a grade one learner should learn was not clearly stated in the curriculum. Jansen (2009) affirms that the National Curriculum Statement retained the outcomes-based form of education. It also retained some integration at the GET level, but it specified what outcomes, in terms of both skills and knowledge, needed to be achieved in each grade, rather than in each phase – except in the Natural Sciences where outcomes were grade specific but knowledge was still specified for each phase rather than each grade.

Jansen (2009) goes on to state that the NCS also did away with phase organizersthe themes which guided learning across subjects but at the FET level it reintroduced subjects and that lists of contents were also introduced to specify precisely what should be learnt in different subjects at different grades. Jansen (2009) continues by saying that the level of specificity varies across subjects. Some

attempt was made to focus on 'vertical demarcation' – the development of concepts and knowledge within a subject over time.

Jansen (2009) states that teaching was expected to remain learner-centred as a matter of policy and assessment to include continuous assessment and be varied. The points mentioned above about the NCS are concluded as follows by Jansen (2009):

- It can be integrated (as in Social Studies) or presented in separate subjects (History and Geography)
- It can be clearly specified (exactly what is to be learnt and when) or left more open.
- It can focus on what the teacher must teach (teacher-centred) or on the knowledge that the learners bring into the classroom (learner centred)
- It can be organized in a sequence, so that one piece of knowledge is ordered to follow another, in increasing complexity (vertical demarcation).
- It can consist of unrelated topics.

In Mathematics the work schedules the integration aspect are clearly stated. For example when looking at learning outcome 3 which is Trigonometry, under integration there is Physical Science, DOE (2010). This means that by the time learners learn this topic in Mathematics, it is assumed that they can link it to physical science

This study wants to find out from educators how easy it is to integrate Mathematics with other Learning Areas.

2.9.3 The learning Outcomes and Assessment Standards.

According to the DOE (2002), learning outcomes are derived from the critical and developmental outcomes and are descriptions of the knowledge, skills and values learners should know, demonstrate and value by the end of the course. They deal with what a learner must know and be able to do. In the Mathematics curriculum these are clearly stated, DOE (2010).

The DOE (2002) states that Assessment standards (AS) describe the extent to which learners must be able to demonstrate their achievement of the learning outcome. This defines the scope (depth and breadth) of what a learner is expected to achieve in a given period of time. According to the Umalusi report (2010), the breadth of the curriculum measures the total number of topics covered per course of study. Assessment standards consist of the knowledge, skills and values that are required to achieve the learning outcome. According to the DOE (2002), assessment standards are grade specific and show how conceptual progression will occur in the learning area and there are different assessment standards for each grade in each of the different learning areas. The difference between the LOs and the ASs is that the LOs remain the same from grade to grade whereas ASs change from grade to grade.

According to the Umalusi report (2010), the Mathematics curriculum is organized into four learning outcomes which are content-oriented and the assessment standards which provide details of what candidates need to be able to do, are listed under these learning outcomes. The Umalusi report (2010), states that in most subjects, the NCS curricula show the greatest attention to sequencing, progression and pacing, then the NCS curriculum specifies the content by year of study and builds

progressively on concepts across the grades, facilitating vertical progression and increasing cognitive complexity.

According to Witzel and Riccomini (2007), an emphasis on following state Mathematics standards has helped teachers scrutinize more closely the completeness and appropriateness of their Mathematics curricula, although, there are additional details for teachers to address to transition more effectively to the next skill or concept. Witzel and Riccomini (2007), go on to state that there is not always a natural connection or transition among and between Mathematics standards. The disconnection between standards is obvious to Mathematics teachers who on a daily bases observe students mastering one skill and struggling on a subsequent skill, which may or not link directly with the previous skill because of a missing or forgotten precursor skill. For example, in South Africa In grade 4 ,Learning Outcome 1, number operations and Relationships , A.S estimate and calculate by selecting using division of at least whole 3-digits by 1-digit number is done from grade 4 to grade 7. (National Curriculum Statement grade R-9). The learners will use long division to divide.

Example: 1 Divide 652 by 5.

Solution

5)652

According to the National Curriculum Statement when learners get to grade 12, they do L.O 2. Functions and Algebra whereby the A.S is: Factorise third degree polynomials including examples which require the factor theorem.

Example 2

$$\begin{array}{c} x^{2} + x - 6 \\ x - 2 \end{array} \right) \overline{x^{3}} - x^{2} - 8x + 12 \\ \end{array}$$

In this case learners might have forgotten the long division which they would have last done in grade 7. It is the educators' duty to remind learners how long division is done. The educator should not just assume that since it is done from grade 4-7 all learners know how to do it. Some learners might have forgotten it, and others might not have done it before because of many factors such as lack of knowledge of the subject content on the part of the of the educators or some learners might have transferred from one school to another and by the time they got there, that content may already have been covered in that school.

The teacher who recognizes the curriculum sequence gap would be able to revisit some concepts which might be used in the lesson being taught. However, the teacher who is either unaware that students have not learned some of the necessary concepts or assumes that students will recall important concepts from previous grades may experience difficulty teaching particular school measurement standards. Witzel and Riccomini (2007), state that because many Mathematics curricular materials do not meet the needs of low performing students, teachers are left with the daunting labor-intensive task of modifying the curricular to meet the needs of all

the students in addition to adequately and effectively teaching all relevant Mathematics standards.

If teachers are always aware of the gaps in content that take place from grade to grade, it will help reduce underachievement in Mathematics.

2.9.4 Pacing

In Mathematics work schedules, pacing is stated for each topic and the depth and breadth are stated underneath each topic, (DOE 2010). According to Witzel and Riccomini (2007), school district educators and administrators have emphasized pacing guides with the intent to help teachers maximize their effectiveness in teaching Mathematics. Pacing guides assist Mathematics teachers with planning effective lesson sequences and appropriate timelines for students to learn certain skills and concepts. These guides help teachers eliminate unnecessary concepts or skills not aligned with state standards or not included on end of year state assessments. Witzel and Riccomini (2007) state that although teachers may claim success after completion of a certain lesson, many students, especially those with low performance or with disabilities, still may not have fully developed or mastered the specific skills or concepts of the lesson objective.

Boltge and Hasselbring (1993) state that students who do not reach mastery of primary skills within a curriculum or curricula are likely to experience augmented failure frustration later in the year and even possible in subsequent Mathematics courses. Therefore, teachers must exercise caution when using pacing guides to direct their daily Mathematics instructional decisions. Many low performing students and students with disabilities require additional time, sometimes a longer time frame than that of the average student; to acquire a skill or concept. Sometimes a pacing

guide may influence or direct teachers to skip or de emphasize important precursor skills necessary for learning future critical concepts. As a result, this might lead to underachievement in Mathematics.

This study seeks to discover whether the time allocated for every topic in Mathematics N.C.S is enough, and whether, according to the Mathematics NCS, the skills that the learners are required to develop are easy to develop and how educators make it possible. Meanwhile the above curriculum design aspects help the educator in planning lessons. But, care should be taken not to disadvantage the learners. With very good learners all the aspects can be taken as they are but where there are disadvantaged learners some alterations can be made. For the curriculum design to fill the underachievement gap there should be a good type of curriculum design, which makes learners able to follow the lesson.

2.9.5 Organising philosophy.

According to Tuge (2008), much of the failure in school Mathematics is due to traditional of the curriculum design and in appropriate teaching to the way students learn. Tuge (2008) states that the philosophy of Mathematics influences the designing of the Mathematics curriculum. According to Tuge (2008) the philosophy of mathematics defines what constitutes a valid source of information from which come accepted theories, principles and ideas relevant to the Mathematics curriculum. Tuge (2008) states that the philosophy of Mathematics helps especially a curriculum designer of Mathematics to answer questions such as: What schools are for? What contents of Mathematics are of value? What materials and methods are to be used? And how do the students learn Mathematics? Tuge (2008) goes on to state that the philosophy of Mathematics also helps to determine the goals of Mathematics education. According to the Mathematics Research in Tuge (2008), research into

learning shows that students actually construct their own understanding based on new experiences that enlarge the intellectual framework in which ideas can be created. Mathematics becomes useful to a student only when it has been developed through a personal intellectual engagement that creates new understanding.

Tuge (2008) indicates that there are two major organizing principles for the Mathematics curriculum, namely: i) habits of mind which students are expected to develop, and ii) the organising principle is the content which the learners are expected to cover over a certain grade level. Tuge (2008) also states that a curriculum designed around habits of the mind comprises both the content and the process. According to Cuoco and Goldberge in Tuge (2008), a curriculum organised around habits of the mind is informed by the fallibilist philosophy and seeks to do the following:

- Close the gap between what the users and makers of mathematics do and what they say.
- Let students into the process of creating, inventing, conjecturing, and experimenting
- Help students develop the habit of reducing things to Lemmas for which they have no proofs.
- Help students look for logical and heuristic connections between new ideas and old ones
- Give students a genuine research experience.

According to Lacatos in Tugo (2008), there are two schools of Mathematics, namely: absolutist and fallibilists. These schools shape the design of Mathematics curriculum. Tugo states that these make influence on the content, organisation, methods and general structure of Mathematics

curriculum. Below, is the discussion of the characteristics of the two philosophies informing the organisation of Mathematics curriculum.

2.9.5.1 Absolutist Philosophy (Content)

The absolutist organising philosophy for Mathematics is premised on the following:

- It is organized around the content (content-centred)
- The teacher is an "explainer" to help students to understand, relate ideas and concepts. The teacher is an authority and his knowledge is unquestionable.
- There is a fixed Curriculum model, in that, changing the curriculum means changing one subject for another. For instance instead of taking plane Geometry, students are made to take statistics etc. Since for the absolutists mathematical objects are discovered and are static, therefore the corresponding curriculum is fixed.
- Learning is through abstraction, relating Mathematical ideas and concepts with no real counterpart.
- Mathematics is seen as an isolated and discreet discipline and in the corresponding Curriculum the subjects are treated separately with no subject integration.

2.9.5.2 Fallibilist Philosophy (Habits of the mind)

The fallibilist philosophy rests on the following assumptions about the teaching and learning of Mathematics:

- Children are liberated from traditional emphasis on rote learning, lesson recitation, and textbook authority.
- Learning is possible as the person actively engages in problem solving which is transferable to a variety of situations and subjects.
- The role of the teacher is helping students to identify their problems and seeking solutions to the problem
- Teaching and learning is child-centred unlike the traditional philosophies.
- Learning is an integral part of life and not a preparation for a future life.
- The Curriculum is problem-centred, which helps students develop how to think.

According to Tuge (2008), for the absolutists, Mathematical knowledge or Mathematical objects have an independent realm in the world, whereas for the fallibilists philosophy of Mathematics the focus of teaching is not the content. It is the process aspect that is more important, which means that the content has to be combined with the method. According to the National Council of Teachers of Mathematics in Tuge (2008), content refers to the numbers, Algebra, Geometry, Measurement, Data analysis and probability. The process refers to problem solving, communication, reasoning, interconnection and representation.

There are ways in which the Mathematics curriculum should be organised. According to Tuge (2008), the benchmark for deciding whether or not to include an activity in a curriculum should be the extent to which it provides an arena in which students can develop specific Mathematical ways of thinking such as :

- Algorithmic thinking: Constructing and using mechanical processes to model situations.
- Reasoning by continuity: Thinking about continuously varying systems.
- Combinatorial reasoning: Developing ways to "count without counting."
- Thought experiment: Learning to imagine complex interactions.
- Proportional reasoning: Thinking about scaling, area, measure, and probability.
- Reasoning about calculations: Developing algebraic thinking about the properties of operations in various symbol systems.
- Topological thinking: Generalizing notions of closeness and approximation to non-metric situations.

The section below discusses the most common types of curriculum designs, namely: linear, sequential and spiral.

2.10.1 Linear and sequential Curriculum designs

According to Davis (2007), a curriculum where the learning of concepts and skills are predicated on the mastery of previous concepts and skills is linear. A linear curriculum is characterized by a sequential presentation of concepts. It takes the body of the knowledge that is to be taught to students and builds upon each concept, block by block, each concept interlocking with the next. Mastery of a concept is essential before proceeding to the next concept.

According to Gupta, Joseph, Alcantar, Toomey and Sunol (2008), the sequential arrangement separates the co curriculum into smaller units, exposing students to each unit in succession and requiring mastery of each unit before stepping on to the next unit. Gupta et al (2008) go on to state that a sequential arrangement has both advantages and disadvantages as follows:

i) Advantages

- It is easy to teach.
- It provides structure to the course offered and defines boundaries to the content.
- One ensures that students have mastered each increment of a subject in a hierarchical sequence before going on to the next topic.

ii) Disadvantages

 A final examination is the primary mechanism to test the competency of the students in the topic that has been studied and satisfactory performance allows a student to advance to the next stage of the study.

- Little consideration is given to the way the knowledge and the skills in one grade will be used in the subsequent grades or its contribution to the whole curriculum.
- Integration is not emphasised in a sequential curriculum. Even though there are many unifying and common concepts between grades, there is no systematic emphasis on these linkages unless an individual educator focuses on this unification at his or her own discretion.

2.10.2 Spiral Curriculum design

According to Harden and Stamper (1999), a spiral curriculum is one in which there is an iterative revisiting of topics, subjects or themes throughout the course. They go on to say that a spiral curriculum has the following features:

- i) Topics are revisited.
- ii) There are increasing levels of difficulty; that is, every visit can bring new knowledge or skills relating to the theme or topic, more advanced applications of areas previously covered, increased proficiency or expertise through further practical experience.
- iii) New learning is related to previous learning, that is, new information or skills introduced are related back and linked directly to learning in previous phases of the spiral.
- iv) The competence of students increases. The learner's competence increases with each visit, until the final overall objectives are achieved.

In South Africa, the spiral curriculum design is used in National Curriculum Statements for Mathematics (2007). For example, Learning Outcome (LO) 1, Number and Number relations: when looking at Further Education Training (FET) band or phase, this L.O is repeated from Grade 10 to Grade 12.; the difference being that more complicated content is introduced in each grade, which means new Assessment Standards (A.Ss) are introduced for each Grade. This can be seen in the below table.

Table 2.2: Examples of different Assessment Standards from the sameLearning outcome from grade 10 to grade 12.

Learning Outcome1:	Learning Outcome1:	Learning Outcome1: Number
Number and Number	Number and Number	and Number Relations.
Relations.	Relations.	
Grade 10 A S	Grade 11 A S	Grade 12 A S
Investigate number	Investigate number	a)Identify and solve problems
patterns (including but not	patterns (including but not	involving number patterns,
limited to those where	limited to those where	including but not limited to
there is a constant	there is a constant second	arithmetic and geometric
difference between	difference between	sequences and series.
consecutive terms in a	consecutive terms in a	b) Correctly interpret sigma
number pattern and the	number pattern, and the	notation
general term is therefore	general term is therefore	
linear) hence : make	quadratic, and hence;	c) Correctly select the formula
conjectures and	make conjectures and	and calculate the sum of the
generalizations.	generalizations.	series' including :
		$\sum_{i=1}^{n} a + (i-1)d = \frac{n}{2}(2a + (n-1)d)$

	$\sum_{i=1}^{n} ar^{i-1} = \frac{a(r^{n}-1)}{r-1}; r \neq 1$
	$\sum_{i=1}^{\infty} ar^{i-1} = \frac{a}{1-r}; for - 1\langle r \langle 1$

Source: National Curriculum Statement Grade 10-12 (general).

By looking at Table 2:2, the A.Ss from Grade 10 to Grade 12 are repeated and at the same time new A.Ss are introduced from Grade to Grade. In Grade 10 number patterns are done where the common difference mainly is linear. In Grade 11 number patterns are also done including the ones where the second difference is common. Finally in Grade 12 the sigma notation is introduced.

The examples below show the content which can be treated from grade 10 to Grade 12 consecutively.

Example 1: For the below sequence; 2,4,6,8...

Find (a) the next two terms of the sequence.

(b) the general term for the sequence.

Solution: a) 10, 12

b)
$$T_n = a + (n-1)d$$

 $a=2, d=2$
 $T_n = 2 + (n-1)2$
 $T_n = 2n$

Example 2: A sequence has a common difference of 4 between terms. The first two terms are 3 and 12.

- a) Write down the third and the four terms.
- b) Determine the nth term.

Solution

- a) The third and forth terms are 25 and 42.
- b) 3; 12; 25 ;42

9 13 17

- 4 4
- a+b+c=3 (i)
- 3a+b=9 (ii)
- 2a=4 (iii)

a=2

3(2) +b=9

b=3

3+2+c=3

:. c=-2

$$Tn=2n^2+3n-2$$

Example 3: Given: $\sum_{k=3}^{12} 3(-2)^{k-2}$

- a) How many terms are in the sequence?
- b) Find the sum of the series.

Solution

- a) !2-3 +1=10 terms
- b) Series: -6+12+ (-24) +...

a=-6 r=-2

$$S_{10} = \frac{a(1-r^{n})}{1-r}$$
$$= -\frac{6[1-(-2)^{10}]}{1+2} = 2046$$

Advantages of the spiral curriculum are that learners go on to build new knowledge on prior knowledge. Learners achieve a better understanding by exploring the same topics at deepening levels. Since in the spiral curriculum attention is paid to both the scope and sequence of topics, this can help to bring some order to the increasing complex nature of mathematics and its applications.

Disadvantages of the spiral curriculum appear when teachers are not confident of the content they are teaching. Instead of using prior knowledge to increase the difficulty of the topic some teachers cannot go into depth and just repeat what learners have done before, Which bores the learners. Educators should be very careful when approaching a topic that the learners have met before to avoid boredom. This study seeks to find out how the curriculum arrangement adopted by the DoE in the NCS Mathematics curriculum affects learners' achievement in Mathematics.

2.11 CHAPTER SUMMARY

In the above chapter, underachievement has been discussed as well as the factors that contribute to it. The curriculum and its design have also been interrogated. The literature has revealed that there are a number of models of curriculum design. It has also revealed that curriculum design theories are meant to guide the teaching process so as to limit underachievement, especially in mathematics. The literature reviewed on curriculum design theories revealed that there is not even one curriculum theory that is complete on its own. The curriculum design theories compensate each other for the learning process to be smooth.

In the next chapter, the research design and methodology of the study are detailed.

CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

3.1 INTRODUCTION

The literature reviewed in the previous chapter revealed that curriculum design theories are meant to guide the teaching process so as to limit underachievement, especially in Mathematics. The literature also revealed that there is not even one curriculum theory that is complete on its own. Curriculum design theories should compensate each other for the learning process to be smooth. In this chapter the research design and methodology used in the investigation of educators and subject advisors' perceptions on the bearing that Mathematics curriculum design has on underachievement is discussed.

3.2 THE RESEARCH PARADIGM

The term paradigm is defined as a "loose collection of logically related assumptions, concepts or propositions that orient thinking and research" (Bogdan and Biklen 1998: 2) or philosophical intent or motivation for undertaking a study (Cohen and Manion 1994:38).

Williams (1998) states that paradigms provide a conceptual framework for seeing and making sense of the social world. According to Burrell and Morgan (1979: 24) to be located in a particular paradigm is to view the world in a particular way. Kuhn (1970: 175) states that a paradigm stands for the entire constellation of beliefs, values and techniques and so on, shared by the members of a community.
According to Williams (1998), the significance of paradigms is that they shape how we perceive the world and are reinforced by those around us, the community of practitioners. Williams (1998) goes on to say that within the research process, the beliefs a researcher holds will be reflected in the way the research is designed how data are both collected and analysed and how research results are presented. Patton (1982) referred to paradigms as frame works for thinking about the research design, measurement, analysis and personal involvement. Schwandt (1989) referred to paradigms as world views and beliefs about the nature of reality, knowledge and values. Lincoln (1990) described paradigms as alternative world views with such pervasive effects that adopting a paradigm permeates every aspect of a research enquiry. Morgan (2007) summarized the essential elements of Kuhn's concept of paradigms as a set of shared beliefs among the members of a speciality area about which questions are most important and which methods are most appropriate for answering those questions.

It is important for one to have a research paradigm when conducting a research because a paradigm is the basis of everything done in the research. According to Mackenzie and Knipe (2006), without nominating a paradigm as a first step in research, there is no basis for subsequent choices regarding methodology, methods, literature or research design. Ching (2008) states that each paradigm can be thought of as a set of binoculars through which the practitioner views and works within the field. Ching (2008) goes on to state that each paradigm is grounded in a particular set of generally accepted approaches regarding ontology (what is knowledge), epistemology (how we know it), methodology (the processes for studying it) and human nature.

Mackenzie and Knipe (2006) state that there are a number of paradigms which include positivist (post positivists), constructivists, interpretivist, transformative, and pragmatism. These are discussed below.

3.2.1 Positivism

According to Mackenzie and Knipe (2006), positivism is referred to as the "scientific method" or "science research". Positivists aim to "test a theory or describe an experience through observation and measurement in order to predict and control forces that surround us" (Leary 2004:5). A positivist researcher relies on quantitative data collection and analysis methods. According to Thorne (2000), quantitative researchers accept that the goal of science is to discover the truths that exist in the world and to use the scientific method as a way to build a more complete understanding of reality.

According to William (1998), a positivist studies the parts to understand the whole, they look for regularities and causal relationships to understand and predict the social world. William (1998) goes on to say that the positivists approach to research design seeks to deduce cause and effect relationships and to predict patterns of behaviour. The researcher then develops a theory and uses this to explore the world. Williams (1998) states that research sample size in a quantitative approach would be a reasonable, large and random sample with the same characteristics as those of the population. Data analysis is of low complexity through accepted statistical analysis methods. William (1998) also states that the researcher's involvement in the stage of the research process is low with the researcher acting as an independent observer. According to Mack (2010), the purpose of the research in this paradigm is to prove or disprove a hypothesis and that the characteristics of a positivist research

include an emphasis on scientific method, statistical analysis, and generalisable findings.

3.2.2 Interpretive paradigm

According to Cohen and Manion (1994:36), interpretivist/constructivist approaches to research have the intention of understanding the world of human experience. Creswell (2003:8) states that the interpretivist researcher tends to rely upon the participants views in the situations being studied and recognize the impact on the research of their background and experiences. Creswell (2003) goes on to say that interpretivist do not generally begin with a theory as positivists do, rather, they generate or inductively develop a theory or pattern of meanings. According to Mackenzie and Knipe (2006) an interpretivist researcher relies on qualitative data collection and analysis methods. Thorn (2000) states that although some qualitative researchers operate from a similar philosophical position as that of positivists, most recognize that the relevant reality as far as human experience is concerned is that which takes place in the subjective experience, in social context, and in historical time. Thus, qualitative researchers are often more concerned about uncovering knowledge about how people think and feel, about the circumstances in which they find themselves, than they are in making judgments about whether those thoughts and feelings are valid.

William (1998) states that to the interpretivist, the social world can only be understood by occupying the frame of reference of the participant in action,; therefore, interpretivist research is primarily exploratory and descriptive in purpose, designed to discover what can be learned about the area of interest. According to Williams (1998) interpretivist research design evolves over time as features emerge

from the research and that the qualitative approach to research is characterised by low sample members.

3.2.3 Transformative paradigm

Creswell (2003:9) states that transformative researchers feel that the interpretivist approach to research does not adequately address issues of social justice and marginalized people. Creswell (2003:9) also says that transformative researchers believe that an inquiry needs to be intertwined with politics and the political agenda, and contain an action agenda for reform that may change the lives of participants, the institutions in which individuals work or live, and the researcher's life. According to Mack (2010), the critical educational researcher aims not only to understand or give an account of behaviours in societies but to change behaviours. Cohen, Manion and Morrison (2007) suggest that critical paradigm stems from critical theory and the belief that research is conducted for the emancipation of individuals and groups in an egalitarian society. According to Mackenzie and Knipe (2006), these researchers may utilize both qualitative and quantitative data collection and analysis methods.

3.2.4 Pragmatic paradigm

Mackenzie and Knipe (2006), and Khumwong (2004) state that pragmatism is not committed to any one system of philosophy or reality. According to Creswell (2003:11), pragmatic researchers focus on' what' and 'how' of the research problem. Creswell (2003:11) says further that the pragmatic paradigm places the research problem as central, and applies all approaches to understanding the problem. According to Morgan (2007), from a pragmatic approach, an important question is the extent to which we can take the thing that we learn with one type of method in

one specific setting and make the most appropriate use of that knowledge in other circumstances.

Mackenzie and Knipe (2006) assert that with the research question being 'central', data collection and analysis methods are chosen as those most likely to provide insight into the question with no philosophical loyalty to any alternative paradigm. As a result, according to Khumwong (2004), this opens the door for mixed method researchers.

Although the researcher is aware of the disadvantages that the interpretivist paradigm has, the study adopted the interpretive paradigm. According to Mays and Pope (1995), qualitative research is often criticised for lacking scientific rigour. Mays and Pope (1995) go on to mention the most commonly heard criticisms which are:

- That qualitative research is merely an assembly of anecdote and personal impressions, strongly subject to researcher bias;
- It is argued that qualitative research lacks reproducibility because the research is so personal to the researcher that, there is no guarantee that a different researcher would not come to radically different conclusions;
- Qualitative research is criticised for lacking generalisability. It is said that qualitative methods tend to generate large amounts of detailed information about a small number of settings.
- Many qualitative researchers have neglected to give adequate descriptions in their research reports of their assumptions and the methods, particularly with regard to data analysis.

Since the study adopted an interpretivist paradigm, all procedures of a qualitative research were followed. A qualitative approach was chosen in this research due to the difficulty of quantifying human behaviour. All procedures with respect to the type of data collection methods of a qualitative research were followed.

A case study was used to gain information from subject specialists and educators, that is, the Mathematics educators and Mathematics subject specialists were interviewed so that they could state their perceptions about the link and progression in Mathematics curriculum design, and whether this has a bearing on achievement at Grade 12. According to Creswell (2003) qualitative researchers seek to understand the context or setting of the participants through visiting and gathering information personally. Therefore, the researcher went to schools to interview teachers and to offices to interview subject specialists. This enabled the researcher to develop a level of detail about the teachers and the subject specialists.

For this study the interpretivist paradigm was chosen particularly for its characteristics regarding the research problem for this study. According to Creswell (2003), certain types of social research problems call for specific approaches. Creswell (2003) goes on to say that the interpretivist approach may be needed because the topic is new; the topic has never been addressed with a certain sample or group of people. According to the literature reviewed the research topic for this study has never been addressed in the King Williams Town District. Therefore, the interpretive approach was best for this research. This type of research relies on the participants' views of the situation studied. This can only be fulfilled through interaction with people, finding out from them the behaviour one wants to understand. The interpretivist paradigm was found to be relevant to this research because the study sought to discover the perceptions of the educators on the

bearing that the Mathematics curriculum design has on Mathematics underachievement.

3.3 RESEARCH DESIGN

According to Flick, Kardorff and Steinke (2004), a research design is a plan for collecting and analyzing evidence that will make it possible for the investigator to answer whatever questions he or she has posed. Flick, *et al* (2004) go on to state that the design of an investigation touches almost all aspects of the research, from the minute details of data collection to the selection of the techniques of data analysis. According to Rose and Sullivan (2006), the function of a research design is to ensure that the evidence obtained enables the researcher to answer the initial question as unambiguously as possible. Rose and Sullivan (2006) go on to state that a good research design prevents the manipulative use of data by taking into account possible alternative explanations and enabling comparisons and judgements between them.

According to Zikmund (1991:42), a research design is a master plan specifying the methods and procedures and Hussey (1997:114) opines that a research design is a detailed plan which you will use to guide and focus your research. Williams (1998) states that a research design determines how to conduct the research and the methods to use. In this way researchers are concerned with what they collect, where and how they will collect it, and how they will analyse the data in order to answer the research question.

The study adopted an interpretivist paradigm and followed a qualitative case study research design.

3.3.1 Case study

Hammersley (1998: 93) defines a case study as a collection of detailed, relatively unstructured information from a range of sources about a particular individual, group or institution, usually including the accounts of subjects themselves. Khumwong (2004) states that case studies are those in which the researcher explores in depth a programme, an event, an activity, a process, or one or more individuals. According to Neale, Thapa, and Boyce (2006) a case study is a story about something unique, special, or interesting stories can be about individuals, organizations, processes, programmes, neighbourhoods, institutions, and even events.

According to Bergen and White (2000), critics have argued that a case study's research is a poor basis for generalization, and this criticism is based on the traditional sampling theory, itself based on the representativeness of sample selection, and the consequent ability to make inferences about the population. Yin (1994) suggested that the sources of evidence suitable for a case study research are almost unlimited and discussed the following: documentation archival records, direct observation, participant observation, interviews and physical artefacts. Yin (1994) detailed their relative strengths and weaknesses, but concluded that no single source has an advantage over the rest. Hutchinson (1990) agreed with Yin (1994) and added that it is the depth and breadth of evidence supporting the case study, rather than a definitive method which is important.

Neale, Thapa, and Boyce (2006) gave the advantages and disadvantages of a case study which are articulated below:

Advantages

- It provides much more detailed information than what is available through other methods, such as surveys.
- Case studies also allow one to present data collected from multiple methods (i.e., surveys, interviews, document review, and observation) to provide the complete story.

Disadvantages

Can be lengthy: Because they provide detailed information about the case in narrative form, it may be difficult to hold a reader's interest if it is too lengthy. In writing the case study, care should be taken to provide the rich information in a digestible manner.

Concern that case studies lack rigor. Case studies have been viewed in the evaluation and research fields as less rigorous than surveys or other methods. The reasons for this include the fact that qualitative research in general is still considered unscientific by some and in many cases, case study researchers have not been systematic in their data collection or have allowed bias in their findings. In conducting and writing case studies, all involved should use care to be systematic in their data collection and reliability in the study (source).

Not generalisable: A common complaint about case studies is that it is difficult to generalize from one case to another. But case studies have also been prone to overgeneralization, which comes from selecting a few examples and assuming without evidence that they are typical or representative of the population. The cases in the study were the selected schools in the King Williams Town District. Within the

selected schools, teachers formed part of the case. Subject advisors also formed part of the case. According to Neale et .al (2006), the case study gives the story behind the result by capturing what happened to bring it about, and can be a good opportunity to highlight a project's success, or to bring attention to a particular challenge or difficulty in a project. Neale, *et al* (2006) go on to state that cases might be selected because they are highly effective, not effective, representative, typical, or of special interest.

In this study Mathematics teachers and subject advisors were chosen because they were of special interest to the study. This was appropriate for the study which wanted to discover from the cases whether the Mathematics curriculum design has any bearing on underachievement.

3.4 SAMPLING AND SAMPLE

Kumar (1996) defines sampling as the process of selecting a few (a sample) from a bigger group (the sampling population) to become the basis for estimating or predicting a fact, situation or outcome regarding the bigger group. According to Sekaran (1992: 226), sampling is the process of selecting a sufficient number of elements from a population to represent the properties or characteristics of that population. Mays and Pope (1995) also say that the purpose is not to establish a random or representative sample drawn from a population but rather to identify specific groups of people who either possess characteristics, or live in circumstances relevant to the social phenomenon being studied. Informants are identified because they will enable exploration of a particular aspect of behaviour relevant to the research. Mays and Pope (1995) further state that this approach to sampling allows

the researcher deliberately to include a wide range of types of informants and also to select key informants with access to important sources of knowledge.

Curtis, Gesler, Smith, and Washburn (2000) summarise the criteria for sample selection as follows:

- The sampling strategy should be relevant to the conceptual framework and the research questions addressed by the research. This may imply consideration of whether sampling is intended to provide cases in categories which are pertinent to a pre-existing conceptual framework for the research, or how far the choice of cases might affect the scope for developing theory inductively from the data.
- The sample should be likely to generate rich information on the type of phenomena which need to be studied.
- The sample should enhance the `generalizability' of the findings.
- The sample should produce believable descriptions/explanations (in the sense of being true to real life). It should provide a really convincing account and explanation of what is observed.
- Is the sample strategy ethical? The researcher may consider whether the method of selection permits informed consent where this is required; whether there are benefits or risks associated with selection for and participation in the study, and the ethical nature of the relationship between the researcher and informants.
- Is the sampling plan feasible? The researcher should consider the feasibility in terms of the resource costs of money and time, the practical issues of accessibility and whether the sampling strategy is compatible with the

researcher's work style. Competencies of the researcher may also be important for feasibility. For example, in terms of linguistic and communication skills, ability to relate to informants and their experiences, or the researcher's (or informant's) capacity to cope with the circumstances under which data collection may take place.

The characteristics of the sample are clearly defined under purposive sampling and the number of the participants that comprised the sample is stated in chapter 4.

3.5 PURPOSIVE SAMPLING

In the case study, the sample was selected purposively from Mathematics teachers. Purposive sampling techniques involve selecting certain units or cases "based on a specific purpose rather than randomly" (Tashakkori & Teddlie, 2003: 713). The sequential sampling strategy was used for this particular research. According to Teddlie and Yu (2007), the above stated sampling strategy uses the gradual selection principle of sampling when (a) the goal of the research project is the generation of theory (or broadly defined themes) or (b) the sample evolves on its own accord as data are being collected. Gradual selection may be defined as the sequential selection of units or cases based on their relevance to the research questions, not their representativeness (Flick, 1998). According to the literature reviewed, not much is known, particularly in King Williams Town (KWT) about the bearing that the Mathematics curriculum design has on underachievement. Therefore, using purposive sampling to choose the participants was useful as Kumar (1996:152) states that purposive sampling is extremely useful when you want to describe a phenomenon or develop something about which only a little is known. Mathematics teachers were from the selected schools in the King Williams Town

District. The FET Mathematics Subject Advisor from KWT District also participated in the interviews. 5 schools were selected from schools in King Williams Town and its outskirts. The schools were selected purposively according to their performance. Underperforming schools in mathematics were selected and Mathematics teachers teaching Mathematics at FET participated. Underperforming schools were taken to be those producing less that 50% pass rate in Mathematics. Respondents were chosen based on the fact that they were likely to give the best picture of the phenomenon the researcher wished to inquire about. That is, to give their perceptions on the bearing that the Mathematics curriculum design has on underachievement. According to Patton (1990), the power of purposive sampling lies in selecting information rich-cases for in-depth analysis related to the central issues being studied. In this case, educators from the underperforming schools in Mathematics were chosen.

For the purpose of confidentiality, schools which were the cases were referred to as P, Q, R, S, and T. Schools P, Q and R were from townships and schools S and T were from the rural areas around King Williams Town, where most learners were from disadvantaged back grounds. From the above selection, an attempt was made to provide variation with regards to educators' perceptions on the link between Mathematics curriculum design and Mathematics achievement. Therefore, under the purposive sampling, a maximum criterion case was considered, that is, that they should be underperforming in Mathematics. Patton (1990) considers this as picking cases that meet some criterion for quality assurance. Only Mathematics educators from the underperforming schools and Mathematics subject specialists were chosen. The information about the schools underperforming in Mathematics was obtained

from 2012 report on the 2011 National Senior Certificate Examination Schools Performance Analysis Report.

3.6 INSTRUMENTATION

Semi-structured interviews were used for teachers and subject advisors as they participated in the case study. A semi- structured interview consists of a list of prepared questions, (Phuthego, 2007). According to Britten (1995), semi structured interviews are conducted on the basis of a loose structure consisting of open ended questions that define the area to be explored, at least initially, and from which the interviewer or interviewee may diverge in order to pursue an idea in more detail. According to Hofstee (2006:132), the purpose of an interview is to gather reliable information relating to the problem being investigated. Semi-structured interviews have advantages and disadvantage. Kumar (1996:115-116) identifies the following advantages and disadvantages:

Advantages

- More appropriate for complex and sensitive situations. (Interviewer can prepare and explain to respondent).
- Useful for collecting in-depth information (probing possibility by researcher)
- Questions can be explained (where respondent does not understand terms used or intent of the question).
- Respondents need not be literate
- There is a high response rate.

Disadvantages

- Time consuming and expensive (especially where respondents are scattered over a large geographical area).
- The quantity of the data depends on the quality of the interaction (interaction in each interview is unique so responses may vary significantly).
- The quantity of data may vary when many interviewers are used.

Semi-structured interviews were selected as a major feature of this research.

These were selected for their unique contribution to the research question so as to assist in obtaining the most desired results. Documentation was also scrutinized i.e. the NCS documents.

Although the researcher was aware that writing notes at the time of interviews can interfere with the process of interviewing, the interviewer wrote the notes during the process for fear that writing afterwards, she was likely to miss out some details. The interviewer also audio taped the interviews.

The use of a tape recorder ensured that more data was captured. It also allowed for the analysis of the tone of the respondent's responses to questions asked by the interviewer, and relating the gestures used when the interviewees responded. The disadvantage of a tape recorder is that it may have made the respondents keep information to themselves that would have proved important to the research. This is because of the fear that the respondents might have felt about being asked to talk about issues that could get them into trouble.

The interviews helped the researcher get a deeper understanding from the teachers, and subject advisors about their perceptions in relation to the link and progression between primary school and high school Mathematics curriculum design and their bearing on achievement in mathematics amongst the Grade 12 learners in the King Williams Town District.

The interview protocols are divided into 2 parts (appendix 2) as follows:

(1) academic experience and (2) opinion.

In Part 1, items were meant to ascertain the nature of educators' experiences in teaching Mathematics, and to ascertain whether their varying experiences helped their understanding of aspects of the Mathematics curriculum design, and how this affects Mathematics achievement.

Finally, in Part 2, the information was used to find out about teachers and the subject advisors' opinions on the bearing that various curriculum design aspects, such as sequencing, integration, progression, articulation, and arrangement have on Mathematics achievement in Grade 12.

3.7 DATA ANALYSIS

According to Leedy and Ormrod (2001:94), data are those pieces of information that any particular situation gives to an observer. According to Thorn (2000), data analysis occurs as an explicit step in conceptually interpreting the data set as a whole, using specific analytic strategies to transform the raw data into a new and coherent depiction of the thing being studied. Flick, Kardorff and Steinke (2004) state that analysing materials is to reveal a maximum of meaning from a minimum of data and to avoid detaching oneself from the text too quickly and developing

theoretical considerations that are not grounded in the data. Leedy and Ormrod (2001:94-97) state the following about data:

- Research is viable approach to a problem only when there are data to support it.
- Data are not absolute reality, but manifestations of that reality.
- Primary data (e.g. data collected through interviews) are often the most valid, the most illuminating, and the most truth-manifesting.
- Secondary data are derived from primary data and are therefore distorted by channels of communication through which they pass.
- Researchers need to be cautious in interpreting and reporting research findings because of the uncertainty over data (e.g. by using words such as maybe, possibly, perhaps, it seems, one might conclude and it would appear to be).

For this study, since it is in the interpretivist paradigm, the qualitative method was used. Thorne (2000) states that what makes a study qualitative is that it usually relies on inductive reasoning processes to interpret and structure the meanings that can be derived from the data. Distinguishing inductive from deductive inquiry processes is an important step in identifying what counts qualitative research. Generally, inductive reasoning uses the data to generate ideas (hypothesis generating), whereas deductive reasoning begins with the idea and uses the data to confirm or negate the idea (hypothesis testing). Thorn (2000) goes on to explain that the distinction between explaining how something operates (explanation) and why it operates in the manner that it does (interpretation) may be a more effective way to distinguish quantitative from qualitative analytic processes involved in any particular study.

Thorn (2000) asserts that the theoretical lens from which the researcher approaches the phenomenon, the strategies that the researcher uses to collect or construct data, and the understandings that the researcher has about what might count as relevant or important data in answering the research question are all analytic processes that influence the data.

In this study, content analysis was used to analyse the data obtained through the writing of notes during the interviews and tape recording. Since it was mentioned ealier on that the use of a tape recorder ensured that more data was captured, data from the tape recorder was transcribed verbatim question by question and compared with the data which was obtained through the writing of notes. This allowed the researcher to get more information which was left out of the data which was collected through writing of notes.

Hancock (2002) states that content analysis is a procedure for the categorisation of verbal or behavioural data, for purposes of classification, summarisation and tabulation. According to Thorn (2000), this strategy involves taking one piece of data (one interview, one statement, one theme) and comparing it with all others that may be similar or different in order to develop conceptualizations of the possible relations between various pieces of data. According to Hancock (2002), the qualitative researcher has no system for pre-coding and so needs a method of identifying and labelling (coding) items of data which appear in the text of a transcript so that all the items of data in one interview can be compared with data collected from other interviewees. Coding is a procedure that disaggregates the data, breaks them down into manageable segments and identifies or names those segments, says Schwandt cited in (Phuthego, 2007). This requires a process called content analysis and the basic procedure described below by Hancock (2002:17) was followed:

- A copy of the transcript was read through. When something that contained apparently interesting or relevant information was seen, it was written under the code column.
- After having a list of items excerpted from the text, a list of data items were read though and each item was categorised in a way that described what it was about some of the categories were used several times because several items of data referred to the same topic.
- Looking at the list of categories identified from the transcript some of the categories were linked in some way. Those were listed as major categories/themes.
- The list of categories of data were compared and contrasted. As "the big picture" started to develop, some items of data were perceived differently and seen as "fitting" better into an alternative category.
- The processes from stages 1-4 were repeated on the next transcript. As work
 was done through the second and subsequent transcripts new categories of
 information were identified but some items of data seemed to belong to a
 previously identified category. Eventually new categories ran out and all the items
 of relevant and interesting information were accommodated in the existing
 categories.
- All the extracts from the transcribed interviews that were put into one category because they appeared to bear some relationship to each other were collected together. Each of the extracts was examined in turn, to check whether they

belonged together or there were any extracts that at that time looked as though they did not fit, and really belonged in a different category.

- When all the relevant transcript data were sorted into categories, data contained in each category were examined again. As data was reviewed within the system of categorisation developed some items of data were moved from one category to another. Some of the information was in the right categories, the "right place", in that, it fitted together, but the terms used to name or describe the categories were inaccurate.
- Once all categories were sorted out and all the items of data appeared to be in the right category, ranges of categories were examined to see whether two or more categories seemed to fit together. If so, major themes were formed in our research.
- Original copies of the transcripts were revisited. The text that was not hlighted initially because it did not appear relevant at the time was re-examined. At this time themes, major categories and minor categories were clearly sorted. Some of the previously excluded data was found to be relevant and was included in the results.

In this study transcripts were compiled according to question numbers.

According to Flick *et. al.*, (2004) the researcher's own theoretical prior knowledge and the research questions guide his/her attention in the reading of the transcripts. They further mention that the aim is to note, for every single interview transcript, the topics that occur and individual aspects of these, which can be related – in a very broad sense – to the context of the research question(s). Taking the above into

consideration, in this study the categories emerged from the data. Powell and Renner (2003) state that emergent categories are formed from reading through the text and finding the themes or issues that recur in the data. Themes may be ideas or concepts that one had not thought about. Flick et.al (2004) state that to take account of the openness of the interviews, it is important not simply to take over the formulations from the questions that were asked, but to consider whether the interviewees actually take up these terms, what the terms mean to them, which aspects they supplement, which they omit and what new topics, which were not foreseen in the guide, actually turn up in the collected data.

In this study, the analysis of data adopted an "emic" approach. Hancock (2002) states that in an emic approach the researcher attempts to interpret data from the perspective of the population under study. According to Williams (1998), for the interpretivist, what is meaningful emerges from the data. In presenting the results it is the narrative of participants that speaks. The researcher does not impose his/her language and interpretation but, makes use of the language and the terminology of the research participants.

According to Knafi and Howard (1984), authors may use identical data gathering techniques but have different ends in mind. The above authors go on to state that a clearly stated purpose will help the reader formulate a realistic set of expectations. The purpose of this study is to sensitize the reader to the view point of a particular group, that is, to find out from Mathematics subject advisors and educators whether the underachievement in Mathematics by grade 12 learners is due to aspects of the curriculum design. Therefore, for data interpretation all the procedures for sensitization by Knafi and Howard (1984) were followed.

- i) In the introduction, the there was emphasis on the lack of research and the need for an in-depth understanding of the subject.
- ii) Sample: the representiveness of the sample was mentioned and the characteristics of the sample were described.
- iii) Procedure: For the procedure the following were reported,
- Preparation for data collection, including gaining access to study sites.
- Length of time spent collecting data, how data were recorded and amount of data collected.
- Steps taken to organize, categorise, or summarise the data prior to final analysis.
- Management of threats to the validity and reliability of data.
- Process by which conclusions were derived from the data.

iv) Discussion: a summary of major themes and identification or practice and research implications. Specific implications were identified and discussed with reference to the frame work.

3.8 TRUSTWORTHINESS, VALIDITY AND RELIABILITY

Carlson (2010) asserts that reliability and validity are conceptualized as trustworthiness, rigor and quality in the qualitative paradigm. For validity, member checking /participant review was used. Creswell and Miller (2000) state that member checking is a validity procedure which consists of taking data and interpretations

back to the participants in the study so that they can confirm the credibility of the information and narrative account. Researchers may have participants view raw data and comment on their accuracy; in turn researchers incorporate participants' comments in the final narrative. In this way, participants add credibility to the qualitative study by having a chance to react to both the data and the final narrative. Like in Creswell and Miller (2000), after each interview the researcher had the participants view the raw data and comment on their accuracy.

Audit trails were also created. According to Carlson (2010), creating an audit trail refers to keeping careful documentation of all components of the study, e.g. keeping field notes, interview notes, calendars, et cetera. The researcher had a journal for recording thoughts and uncertainties. Carlson (2010) states that one way to engage in reflexivity is for researchers to keep a journal that is specifically for recording thoughts, feelings, uncertainties, values, beliefs and assumptions that surface throughout the research process. Therefore, that helped the researcher in the final report to state what went well and what did not and what should be avoided in future.

The researcher used member-checking to determine the accuracy of the findings through taking specific descriptions back to participants and determining whether those participants felt that they were accurate. The researcher also used a rich, thick description to convey the findings. This was done to transport readers to the setting and give the discussion an element of shared experiences. According to Carlson (2010), one of the main functions of a thick and rich description is to provide an understanding of the relevance to other settings. The detailed descriptions of the setting, participants, data collection and analysis procedures are provided as a way of making the researcher's account more credible.

3.9 ETHICAL CONSIDERATIONS

Permission was sought from the University of Fort Hare to carry out research in the selected schools in the King Williams Town District. On approval, letters were written to the Department of Education, the district office, and school principals of the selected schools seeking permission to use the selected schools for carrying out research and explaining the importance of the research and also, asking for the maximum cooperation from the Mathematics educators and subject specialists. The researcher asked for written permission from the DoE to gain entry into the schools .Burn (2000) considers that informed consent is the most fundamental ethical principle that is involved. Burn (2000) states that the importance of the consent forms is that it makes the situation clear and provides a degree of proof that the person was informed and consented to take part. Therefore, a consent form was given to the participants to sign. Only those who agreed to sign participated in the study.

Since the researcher went to participants 'sites, it introduced the ethical consideration of gaining entry to the research site. Connections between the researcher and the participants on the research sites were mentioned to create reader confidence in the accuracy of the findings.

Data collected by researchers should be anonymous, that is, not related to names or other forms of identification (Sarantokos, 1998). It is not possible for the participants in interviews to remain anonymous, but researchers can maintain confidentiality about who has been interviewed and what was disclosed (Reid, 2001). Considering the statement above, participants were assured of anonymity as well as the confidentiality of information obtained from them. They were also not asked to

furnish their ID's, personal numbers or full names. Codes for both participants and their respective schools are used in this particular research.

3.10 SUMMARY

In this chapter, the research paradigm, research design, the methods and procedures for selecting subjects for sampling, collection and analyses of data using the qualitative method, trustworthiness and ethical considerations have been discussed.

In the next chapter the qualitative research data are reflected on, and an analysis and Interpretation of the data gained by means of the qualitative research are presented.

CHAPTER 4

DATA ANALYSIS AND INTERPRETATION

4.1 INTRODUCTION

In the previous chapter, the research paradigm, research design, the methods and procedures for selecting participants for sampling, the collection and analyses of data using the qualitative method, trustworthiness and ethical considerations have been discussed. In this chapter the document analysis, qualitative research data is reflected on, and an analysis and Interpretation of the data gained by means of the qualitative research is presented.

4.2 DOCUMENT ANALYSIS

In this part, the documents analysed are the Mathematics National Curriculum Statement (NCS), Mathematics pace setters and Mathematics Learning Programmes. Since the study sought to find out whether aspects of the curriculum design have any bearing on Mathematics underachievement, the Mathematics NCS, Mathematics Learning Programme Guidelines and Mathematics pace setters had to be analysed since they guide the learning and the teaching of Mathematics. In these documents the curriculum design aspects are clearly stated so as to guide the educators in the teaching of Mathematics. For this reason it is necessary, analyse them to see what they are like, and be able to compare the Subject Advisors and educators perceptions of them and finally come to conclusions about whether they are responsible for the underachievement in Mathematics.

The curriculum design aspects are, among others: integration (horizontal and vertical), link/progression from Grade to Grade, time allocation for each every topic, sequencing of topics, scope to be covered per Grade, Articulation, Assessment Standards, Learning Outcomes and skills to be acquired by learners. These are analysed below and examples given of how they are found in the documents.

According to Mathematics NCS (2008), the Mathematics curriculum supports the application of NCS principles as follows:

(a) Integration

"Integration involves the grouping of Assessment Standards (A.Ss) according to the natural and authentic links" NCS (2008). According to NCS (2008), an integrated understanding of mathematical concepts is provided for in a holistic view of the Learning Outcomes (LOs), as well as in the requirement that the learners use existing knowledge and understanding to solve problems as a basis for further development. All Grade 10-12 educators should consider the integration of ASs within and across the grades. In Mathematics work schedules, the integration aspect is clearly stated. For example when looking at learning outcome 3 which is Trigonometry, under integration, there is physical science (DOE, 2010). This means that appears in the work schedule as shown in table 4.1, below.

Table 4.1 Mathematics	integration wit	h Physical science
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Week	Topic(Los+Ass)	INTERGRATION	ASSESSMENT	DATE
				COMPLETED
11-12	Trigonometry:	Physical Science	Class-work;	
	special angles		homework,	
	and identities,		discussions	
	reduction		short informal	
	formulae		test.	
	LO3 AS			
	11.3.5,a,b,c,d,e			

Source: Work schedules, DOE Curriculum section, KWT(2008)

This means that, by the time learners learn this topic in mathematics, it is assumed that they can link it to physical science. Below are examples of Mathematics and Physical science problems consecutively where integration can be seen.

Mathematics

a) Question

A, B and L are points in the same horizontal plane, HL is a vertical pole of length 3 metres, AL = 5,2m, the angle $ALB = 113^{\circ}$ and the angle of elevation of H from B is 40° .





Calculate the length of AB.

Answer:

$$Tan40^{\circ} = \frac{3}{LB}$$
$$LB = \frac{3}{LB}$$

 $LB = \frac{1}{\tan 40^{\circ}}$

LB = 3,8m

Physical Science

 a) Learners investigate the change in the broadness of the central bright band formed when monochromatic light of different wavelengths passes through a single slit.

They set up the apparatus, as shown in the diagram below, and measure the breadth of the central bright band in the pattern observed on the screen. The width of the slit is $5.6 \times 10^{-7} m$.





In one of their experiments, the distance from the midpoint of the central bright band to the first dark band is measured as 0,033 m.

Calculate the wavelength of the light used in this experiment.

Solution

$$\sin \theta = \frac{m\lambda}{a}$$

To calculate the wavelength we use the diffraction equation \square

To determine θ , we use the formula

$$\tan \theta = \frac{opposite}{adjacent} \Rightarrow \tan \theta = \frac{0.033}{0.45} \Rightarrow \therefore \theta = 4.19^{\circ}$$
$$\sin \theta = \frac{m\lambda}{a} \Rightarrow \sin 4.19^{\circ} = \frac{(1)(\lambda)}{5.6 \times 10^{-7}}$$
$$\therefore \lambda = 4.1 \times 10^{-8} m$$

Educators can use such examples to integrate Mathematics and Physical Science. Trigonometric ratios are applied in both examples. Educators do not normally integrate Mathematics with other learning areas. If teachers would make learners aware that they could apply aspects they learn in Mathematics to some other subjects when possible, then learners would realize that subjects could be linked and this would make things easy for them especially when they get to content such as the one illustrated in the above example. They would know that there is no difference between Trigonometry found in Mathematics and that found in Physical science.

Subject curriculum designs also agree with the NCS. They merge several disciplines into an interdisciplinary subject area to allow for more correlation, integration and holism (O'Neill, 2010). The spiral curriculum also agrees with the NCS in that organisation and integration are implemented in the spiral approach as the complex relationship between different Mathematics topics can be correlated. The NCS (2008) states that integration within the subject should be considered in broad terms during discussions. The NCS goes on to state that all Grade 10 -12 teachers should consider integration of ASs within and across the grades. This is summarised in the NCS (2008: 15) as follows:

Table 4.2: Integration of assessment objectives within and across the Grades

STAGE 1	Integration within the subject should be considered in broad
Subject Framework	terms during discussions at this stage. All Grade 10-12 teachers should consider integration of ASs within and across the grades.
STAGE 2	The integration and sequencing of the ASs is undertaken in the
Work Schedule	Work Schedule to ensure that all ASs for a particular grade are
	covered in the 40-week contact period.
STAGE 3	The same groupings of LOs and ASs as arrived at in the Work
Lesson Plan	Schedule should be used to develop a coherent series of
	learning, teaching and assessment activities for each Lesson
	Plan.

Source: Mathematics National Curriculum Statement 10-12(2008).

(b) Assessment Standards

The ASs indicate the minimum requirement to be attained while the system for grading performance allows for extension to higher levels of knowledge and skills. In developing the ASs, care has been taken to provide for conceptual and skill progression from grade to grade. Below is the table showing conceptual progression from grade to grade.

Table 4.3: Conceptual progression from Grade to Grade.

STAGE 1	The Subject Framework should indicate the
Subject Fremowerk	increasing depth of difficulty across Grades 10-12.
	Progression across the three grades is shown in the
	ASs per Learning Outcome.

STAGE 2	Progression in a grade is evident in the increasing
Work Schodulo	depth of difficulty in that particular grade. Grade-
Work Schedule	specific progression is achieved by appropriately
	sequencing the groupings of integrated LOs and AS in
	the Work Schedule.
STAGE 3	In the individual Mathematics classroom increasing
Losson Plan	depth of difficulty is shown in the activities and Lesson
	Plans. Progression is achieved by appropriately
	sequencing the activities contained within each
	Losson Plan and in the series of Losson Plans
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Source Mathematics NCS (2008)

According to the work schedule, ASs to be covered are clearly stated. Looking at the ASs and LOs to be covered in term one, they seem to be too many, considering that some topics are long and for learners to grasp some of the key concepts they need a lot of time. More time should be given for term one. However, according to the work schedule (2008), ten weeks are given for term one including time for class tests as well as control tests. The Mathematics NCS (2008) states that 4 hours per week are allocated to Mathematics. This means that 40 hours are allocated for Mathematics per term since the given topics are to be covered within ten weeks as stated in the work schedule. The Mathematics NCS further states that the teachers of the subject should plan how this time will be used for the teaching of Mathematics in the three Grades that is, the FET phase. It is summarised as follows:

Table 4.4: Time Allocation and Weighting.

STAGE 1	4 hours per week is allocated to Mathematics in the NCS. This is
Subject	approximately 160 hours per year. The teachers of the subject
Framework	should plan how this time will be used for the teaching of

	Mathematics in the three grades.
STAGE 2	The groupings of ASs as arrived at in the integration process
Work Schedule	should be paced across the 40 weeks of the school year to ensure coverage of the curriculum.
STAGE 3	The amount of time to be spent on activities should be indicated
Lesson Plan	in the Lesson Plans.

Source: National Curriculum Statement Grades 10-12 (General) (2008).

Limited time and many topics to be covered have a negative bearing on the teaching and learning of Mathematics. In the end, educators do not giving standard work or activities because they are rushing to cover all the LOs and ASs by the end of the term.

(c) Skills

The object of education is to prepare individuals for their future careers. Therefore, specific activities and curriculum plans should help develop skills and knowledge that will enable students to successfully enter the job market. According to NCS (2008), concepts and 'big ideas' in Mathematics are progressively developed and ensure the Mathematical future of the learner. The NCS (2008) states that the process skills developed in Mathematics are those that enable learners to become mathematicians as opposed to stunting their growth through an emphasis on rote approaches to the subject. The NCS goes on to state that the Assessment Standards indicate the minimum requirements to be attained while the system for grading performance allows for the extension to higher levels of knowledge and skills. The NCS (2008) also states that all learning, teaching and assessment opportunities must be designed down from what learners should know, do and produce by the end of

Grade 12. The Learning Outcomes and Assessment Standards that learners should master by the end of Grade 12 are specified in the Mathematics Subject Statement.

(d) Articulation

There is a relationship between the General Education and Training (GET) and the Further Education Training band (FET) phases since the mathematics NCS curriculum is spiral. All the procedures of a Spiral Curriculum design as described by Harden and Stamper (1999) are followed in the NCS. This is illustrated in the NCS (2008: 10) as follows:

LEARNING OUTCOME	NCS Grades R-9	NCS Grades 10-12
1	Number and Number Relationships	Number and Number Relationships
2	Patterns, Functions and Algebra	Functions and Algebra
3	Shape and Space	Shape, Space and Measurement
4	Data Handling and Probability	Data Handling and Probability
5	Measurement	

 Table 4.5: Example of a spiral curriculum design

Source: National Curriculum Statement Grade 10-12 (General) (2008)

As can be seen above, the topics are repeated from Grade to Grade except for measurement which is only done up to grade 9. Any learner offering Mathematics in Grade 10-12 will be working towards the same LOs nationally.

(e) Link/progression

According to Gupta et al, (2008), the spiral curriculum puts into practice the philosophy that learning is an organised process with the acquisition of new knowledge requiring prior core knowledge. Gupta et al, (2008) go on to state that in a spiral approach, links between different traverses of the spiral are emphasised, which allows students to reinforce the prior concepts and begin grasping the application to the new knowledge. The above agrees with the Mathematics NCS curriculum. For example, when students learn how to solve quadratic equations, the link to first factorise a quadratic expression is emphasised. The Mathematics NCS states that Learning Outcomes in the NCS Grades R-9 and the NCS Grades 10-12 are similar. In planning the elements of a Mathematics Learning Programme it is important to take into account what was covered in Grades R-9. The learning achieved in Mathematics in Grades R-9 provides an essential base from which to proceed to the demands of Mathematics in Grades 10-12. By comparing Grades R-9 NCS and 10-12 NCS for Mathematics, it is clear that there is link in the topics done from primary to high school. Below, one learning outcome, that is, data handling, has been taken as an example to show how it is treated from Grade 1-12.

Table 4.6. Data handling from Grade 1 to Grade 12	

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Grade	LOs	ASs	Content
1	5 (Data handling)	1.5.1	Collect everyday objects in the classroom and school environment
		1.5.2	Sort physical objects according to one attribute chosen for a reason (e.g. sort crayons in colours)
2	5 (Data	1.5.1	Same as in grade one
----	------------------	--------	--
	handling)	1.5.2	Same as in grade one.
3	5 (Data	1.5.1	Same as in grade one and two.
	handling)		Sort objects by one or more attributes for
			a particular reason
		1.5.2	
	L. (Data	4.5.4	
4	5 (Data	1.5.1	Pose simple questions about own school
	nandling)		and family environment, and identifies
			appropriate data sources in order to
			address numan rights, social, political,
			cultural environmental and economic
			issues in that environment.
5	5 (Data	2.5.1	Same as in grade 4
	handling)		
0	L. (Data	0.5.4	
6	5 (Data	2.5.1	Same as in grade 4 and 5.
	nandling)		
7	5 (Data	7.5.1	Draw a variety of graphs by hand/
	handling)		technology to display and interpret data.
0	L. (Data	0.5.4	Come on in such 7 she the contrar slate
8	5 (Data	8.5.1	Same as in grade 7 plus the scatter plots.
	nandling)		
9	5 (Data	9.5.1	Same as in grade 8.
	handling)		
10		40.4.4	
10		10.4.1	Using probability models for comparing
	and Probability)		the relative frequency of an outcome with
			the probability of an outcome.
			- Use Venn diagrams as an aid to solve
			probability problems, appreciating and

			correctly identifying :
			 a) The sample space of a random experiment. b) An event of a random experiment as a subset of a sample space. c) The union of two or more subsets of the space.
			sample space
Grade	LOs	ASs	Content
11	4 (Data handling and Probability)	11.4.1	 -Correctly identify dependent and independent events and therefore appreciate when it is appropriate to calculate probability of two independent events occurring by applying the product rule for independent events (A and B)=P(A).P(B) - Use tree Venn diagrams to solve probability problems
12	4 (Data handling and Probability)	12.4.1	Generalize the fundamental counting principle and solve problems using the fundamental counting principle.

Source: R-9 NCS and 10-12 NCS for mathematics

By looking at the Foundation phase (Grade 1-3) one realizes that the content covered is related. For example, if we look at sorting physical objects according to one attribute chosen for a reason (e.g. sort crayons in colours), the same procedure is done in Grade Two as well as in Grade Three, but this time in Grade Three sorting objects by one or more attributes for a particular reason.

When looking at the learning outcome that has an intermediate phase (Grade 4-6) in the table above, though the content within the phase seems to be interrelated, it looks like there is a big gap when one compares the Foundation and Intermediate phase content. For example, in Grade Four, learners are introduced to probability which needs a lot of reasoning as compared to descriptive statistics. More complicated concepts such as possible outcome, certain events, uncertain, and likelihood of events are introduced. It looks as if these concepts are too complex for this phase and as a result learners have difficulty mastering them and remembering them at a later date. The University of Zimbabwe (1995) states that child psychology - theories of learning and child development have to be considered when designing the content of a curriculum; that is, activities and experiences should be introduced at the right time. Taking the above into consideration, the Mathematics NCS curriculum design did not take the state above into serious consideration when one looks at the gap between Grade 3 and Grade 4 Mathematics. Some of the concepts introduced in Grade 4 seem to be far too complex and intellectually demanding for their brains.

Once learners master the intermediate phase content, the chances of having problems with senior phase (Grade 7-9) content will be minimal since the Mathematics curriculum for the intermediate phase and senior phase are related. There is a big gap between the senior phase and the Further Education and Training Band (FET) (Grade 10-12) curriculum. When one looks at the learning outcome chosen in the table above, more complicated probability is introduced from Grade 10. For example, the use of Venn diagrams as an aid to solving probability problems is introduced, which had not happened before. Solving probability problems using Venn diagraphs is complicated because two concepts are being introduced, which

are Venn diagrams and probability. This is a problem for the learners. Learners normally have problems in grasping every concept that they are taught, but it is much worse if two concepts are to be introduced at the same time and problems be solved combining the two difficult concepts.

(f) Learning Outcomes

Central to the attainment of the learning outcomes is the development of mathematical progress skills e.g. investigating, conjecturing, organising, analysing, problem solving, and modelling. Through the use of the skills, knowledge and understanding of important concepts in Mathematics is built up progressing from Grade to Grade. LOs are clearly indicated in the Mathematics work schedules for Grade 12s.

(g) Time allocation

The documents show that 4 hours per week are allocated to Mathematics (NCS 2008). This is approximately 160 hours per year. The teachers of the subject should plan how the time will be used for the teaching of Mathematics. By looking at the work schedule, it seems that time allocated for the LOs and ASs is not enough because there is a lot which has to be covered within a short space of time. Again, considering that the majority of learners are weak, they need more time for each topic. Taking for example topics to be covered in term one, there are four very long topics which are Number patterns, Functions, Inverse and Logarithms, Coordinate Geometry and Financial Mathematics. All these topics are to be covered within ten weeks. The time allocated in the work schedule in term one where there is a lot to be covered does not take into account the time used for the control tests. During the time for tests learners do not learn, as a result some of the topics to be covered in

that term are not done. The topics not covered in term one are moved to term two and so on. As a result it becomes a problem to cover all the topics by the end of the year, and at the same time revise Grade 11 content which forms part of the Matric Paper One examinations.

Term 2 has two long topics which are to be covered within 5weeks. Two weeks are meant for revision of grades eleven and twelve work. Two weeks are set aside for the mid-year examinations. This means that there should be 7 weeks of learning in term two. Since the backlog of term one's work has to be also covered in term two, and term two has only seven weeks of learning, it becomes impossible to cover the work from term one, term two and do the revision. Normally, learners write June examinations without having done any revision because educators are usually trying to rush and complete the syllabus before end of the year.

Term 3 has three topics to be covered in 8 weeks. Two weeks are set aside for revision and trial exams. Term 4 has 5 weeks meant for revision of Grades 11 and 12 work. Normally not only revision is done in term 4. In some schools educators are still trying to finish the syllabus since a lot of Mathematics learners are slow; as a result educators spend a lot of time on one topic.

(h) Sequencing

According to Burny, Valcke, Desoete and Van Luit (2011) the sequence of learning opportunities provided by the textbooks determines when children acquire specific knowledge. For some topics, sequencing is not properly done in the NCS. For example, according to the Grade 12 Mathematics work schedule, transformation has to be done before Trigonometry. Within Transformation, compound angle identities are applied to generalise the effect on the coordinates of point (x; y) after a rotation

about the objective function and the linear constraint about the origin through an angle, yet compound angle identities are only done in Trigonometry. Therefore, in this case, the order should have been Trigonometry before Transformation. This anomaly confuses educators during the teaching, learning and assessment of Mathematics because some educators follow the topics as per the work schedule and others do their own arrangement. This becomes a problem when common examinations are written before the end of the year because different contents will have been taught in different schools.

(i) Scope

The NCS (2008), states that planning for the teaching of Mathematics in Grades 10 to 12 should begin with a detailed examination of the scope of the subject as set out in the Subject Statement. The NCS suggests that the five steps below be used as a checklist.

i) Clarify the Learning Outcomes and Assessment Standards.

The essential question for Mathematics is: What Learning Outcomes do learners have to master by the end of Grade 12 and what Assessment Standards should they achieve to show that they are on their way to mastering these outcomes?

All learning, teaching and assessment opportunities must be designed down from what learners should know, do and produce by the end of Grade 12. The Learning Outcomes and Assessment Standards that learners should master by the end of Grade 12 are specified in the Mathematics Subject Statement.

ii) Study the conceptual progression across the three grades.

Study the Assessment Standards for Mathematics across the three grades. Progression should be clearly evident across the grades.

iii) Identify the content to be taught.

Analyse the Assessment Standards to identify the skills, knowledge and values to be addressed in each grade. Also consider the content and context in which they will be taught.

iv) Identify three-year plan of assessment.

Use the Subject Assessment Guidelines to guide the three-year assessment plan. Consider what forms of assessment will be best suited to each of the Learning Outcomes and Assessment Standards. This ensures that assessment remains an integral part of the learning and teaching process in Mathematics and that learners participate in a range of assessment activities.

v) Identify possible LTSM (resources)

Consider which LTSM will be best suited to the learning, teaching and assessment of each Learning Outcome in the three grades using the Assessment Standards as guidance.

According to the NCS (2008), if learners manage to master the Mathematics NCS scope for the FET phase, then they can use mathematical process skills to identify, pose and solve problems creatively and critically. They can engage responsibly with quantitative augments relating to local, national and global issues. The topics of

Financial Mathematics can help the learners to critically investigate and monitor the financial aspects of personal and community life decisions.

According to Lunenburg (2011) among curriculum designers' alternatives is a subject design utilizing specific studies in the specified curriculum area and a scope and sequence plan built around a selection of persisted topics or themes. This agrees with the Mathematics NCS curriculum design though the sequencing is not that good/correct/logical in the NCS as seen in the examples where some topics were covered when they were not supposed to be covered.

4.3 MATHEMATICS ORGANIZING PRINCIPLE IN SOUTH AFRICA

According to the Learning Programme Guidelines Mathematics (2008), Mathematics is a concept and process driven subject. Central to the attainment of the LOs is the development of mathematical process skills (e.g. investigating, conjecturing, organizing, analyzing probing problem solving, modelling). Through the use of these skills, knowledge and understanding of important concepts in Mathematics are built up progressively from Grade to Grade.

According to the Learning Programme Guideline Mathematics (2008), Mathematics curricula include content and involve process skills that make up a comprehensive set of instructional activities whereby an appropriate balance of conceptual knowledge and procedural competence (manipulative skills) is achieved. According to this programme, content means the combination of knowledge, skills and values. All learners offering mathematics are empowered by emphasis on the development of the process skills as opposed to the rote learning of procedures and manipulation skills. The learning programme also states that the process skills developed in

Mathematics are those that enable learners to become Mathematicians as opposed to stunting their growth through an emphasis on the rote approaches to the subject.

The emphasis on mathematical modeling in dealing with real life concepts empowers the learner to apply the mathematics learned. According to the Learning Programme Guidelines, mathematical modeling involves identifying and selecting relevant features of real-world situations, presenting those features in mathematical representations, quantitatively and qualitatively analyzing the model and the characteristics of the situation, and considering the accuracy and limitations of the mathematical model. The emphasis on contexts of integration within Mathematics and across the curriculum is maintained while mathematical modeling becomes more prominent. Care has been taken to provide for conceptual and skill progression from Grade to Grade. Learners bring their existing knowledge to bear in problem solving and communicating about Mathematics.

The South African Mathematics curriculum has some content as organizing principle, because according to the pacesetter there are a number of topics that have to be covered by the end of year. By looking at the characteristics of the organizing principles of Mathematics curriculum of South Africa discussed above, it is clear that the dominant organizing principle is the habit of mind. The National Curriculum Statement (2008) also states that Mathematics in South Africa is a "concept and process driven subject". It also states that the Mathematics curriculum includes "content and involves process skills". Although the habit of mind is the dominant principle, there is also evidence of content as an organising principle and one can conclude that the NCS document attempts to balance the two philosophical approaches and organizing principles.

Jansen (2009) states that, if Bernstein's concepts are used to describe the South Africa curriculum, curriculum 2005 was, largely, an integrated and competencebased curriculum, while the old South African curriculum tended to be a collection type, performance-based curriculum. The National Curriculum Statement is a hybrid or mixed model. It is more strongly classified and less integrated than Curriculum 2005, but it keeps many aspects of a competence model of curriculum, such as a learner-centred pedagogy. Jansen (2009) states that at the GET level classification between subjects is weaker (and we get Natural Sciences instead of Physical Sciences and Life Sciences), but at the FET level, traditional subjects have been reintroduced and classification between subjects is strong. The specification of outcomes and content also make the National Curriculum Statement more performance – like, in relation to knowledge acquisition. For example, given the mixed model of the National Curriculum Statement, there is likely to be some confusion and contradiction in how it is implemented (Jansen, 2009).

4.4 FINDINGS FROM INTERVIEWS WITH THE MATHEMATICS EDUCATORS AND SUBJECT ADVISORS

Background information was used to determine the nature of educators' experiences in teaching mathematics, and to ascertain whether their varying experiences related to their understanding of the Mathematics curriculum design, and how this affects Mathematics achievement. It seemed that the educators background information did not affect achievement in Mathematics because there was no difference between the answers of the more experienced and those of the less experienced in terms of their explanations of the curriculum design aspects. The sample size was representative. Out of five purposively chosen schools, every school had one educator for Mathematics FET phase except for one school which had two educators at that phase. Therefore, six Mathematics educators volunteered to participate in the interviews and one Mathematics subject advisor.

The duration of the interviews was a month because some of the educators kept postponing the appointments dates. Some of these were busy with afternoon lessons and others had some other commitments in the afternoons. The interviews were done after school so as to avoid disturbing the lessons in the morning.

4.4.1 Background information

The study revealed that most of the participants obtained their qualification more than 11 years ago and had been teaching Mathematics for more than 12 years except for one who had been teaching Mathematics for 5 years. All the interviewees taught mathematics at the FET phase. The educators stated that they found teaching Mathematics interesting and challenging but that the problem was with the learners who lacked the basics in Mathematics and motivation from previous grades. For example one educator said he found teaching Mathematics *"Interesting, have learners from GET phase who are coming to another dimension of Mathematics in FET and also challenging."* Another one said *"…It is not difficult to teach Mathematics but learners lack basics, they are not motivated from the previous grades."* Some of the educators stated that they liked teaching Mathematics but the problem was the quality of learners.

4.4.2 Opinion Information

 i) Educators and Subject Advisor's opinions on the bearing that the NCS design aspects for Mathematics has on teaching and learning of Mathematics.

Two educators stated that the NCS curriculum was easy for educators to understand and teach, as well as well organized. Others stated that it was not easy for educators or for learners. They stated that it did not cater for slow learners but it was meant for the gifted learners. The subject advisor stated that the NCS built a nation which is democratic which also heals the divisions so that the quality of life is improved in Mathematics. The subject advisor went on to state that the NCS ensured the use of proper skills and problem solving.

Three of the respondents found the NCS design for Mathematics good for both learners and educators and four of the respondents found the NCS design for Mathematics difficult to understand.

ii) Educators and subject Advisor's perceptions of the Mathematics NCS design aspects which have a bearing on the teaching and learning of Mathematics.

One educator said that there were too many topics to be covered. Another one stated that time allocation was not enough, as there was a shortage of teachers and they had to teach different subjects for different grades leaving them little time to prepare better be more prepared. Out of the 7 respondents only 2 gave the relevant answers to this issue, which is, the response on shortage of time and too many topics to be covered within a term.

iii) Educators and Subject Advisor's opinions on the bearing that the Mathematics NCS design has on the learners' achievement in Mathematics.

The study sought to determine whether the Mathematics NCS design has a bearing on the learners' achievement in Mathematics. Four of the respondents stated that

the NCS design had a negative bearing on achievement because the content was difficult for the learners. Two educators thought that learners did not understand the questions because of language barriers. One educator stated that learners were not capable of applying concepts well and teachers were struggling to teach them. Another educator stated that the curriculum was always changing; there was OBE and then NCS and now CAPS so it confused the learners.

The Mathematics subject advisor felt that the Mathematics NCS design had a bearing on the learners' achievement in that it gave learners proper connections with real world, i.e. mathematical modeling.

According to the responses from all the respondents, except for the subject advisor, the NCS design has a negative bearing on the learners' achievement in Mathematics.

iv) Educators and Subject Advisor's opinions on the integration of Mathematics with other Learning Areas.

The majority of the educators said they found integrating Mathematics with other subjects easy. One respondent stated that "*integration is not easy, but one can integrate other topics in Mathematics like transformation/translation with arts and culture, history of numbers in Mathematics and history in Social sciences*". The subject advisor stated that "*in the NCS it is easy to integrate all the subjects.*"

In general the respondents found it easy to integrate Mathematics with other learning areas.

v) Educators' and subject Advisor's perceptions on the bearing that the integration of Mathematics with some other subjects has on Mathematics achievement.

Five of the interviewed educators stated that integration of Mathematics with other subjects had a bearing on achievement even though learners do not see the integration. They stated that integration made it easy for learners to understand different subjects. One educator stated that "*if learners can integrate Mathematics with other subjects they can achieve better*". Another one stated that "*integration helps learners even in other subjects example graphs in physical science and Mathematics, learners won't struggle, also in topics like financial Mathematics since they find that topic in many subjects"*. Two educators felt that integration was not necessary; it depended on how subjects were being taught since learners did not see the integration between the subjects.

The subject advisor stated that it was good to see that mathematics was not isolated. The subject advisor went on to state that the integration of subjects helped to save on contact time and repetition of work and resulted in better understanding. In general, the respondents found integration of mathematics with other learning areas had a positive bearing on achievement.

vi) Educators views on integrating Mathematics and other learning areas (horizontal integration) and the subjects as well as the topics on which they find it easy.

All the respondents except for one stated that they normally integrated Mathematics with other learning areas. They integrated transformation in Mathematics and Arts and Culture, Mathematics and Accounting in Financial Mathematics, Mathematics with Physical Sciences in Calculus, Mathematics and natural science in scientific notation, economic graphs, geography graphs and gradients, physical science graphs and Mathematics in measurement. The respondent who stated that there was no need for integration did not give any reason for that response.

Therefore, when teaching Mathematics, educators normally integrated it with other learning areas (horizontal integration).

vii) Educators and subject Advisor's opinions about the Mathematics Assessment Standards in the NCS.

All the educators stated that the Mathematics Assessment Standards in the NCS were good. The educators stated that Assessment Standards helped learners achieve the goal and the educator in planning. They also stated that standards catered for different learners and educators needed to know what they want to achieve. Educators also stated that Assessment Standards gave direction on assessment of learners and in the NCS they were very user friendly.

There were contradictions between the subject advisor and the educators' responses concerning the Assessment standard. The subject advisor believed that the Assessment Standards definitely needed to be replaced; hence, the Curriculum Assessment Policy Statement (CAPS) .The subject advisor stated that not all areas covered would be useful in tertiary education hence the need for replacement.

viii) Educators and Subject Advisor's views on the sequencing of Mathematics topics in the NCS.

The majority of the educators stated that the sequencing of Mathematics topics in the NCS was good. One reason given as an example for this view was that one could do logarithms before financial Mathematics so that log laws could be applied in financial Mathematics when one wanted to find the value of "n" especially in compound interest. One educator stated that the sequencing was good but there were some parts that were not good; for example the pace setter from the department for Grade 12 term 3, transformation Geometry and Trigonometry. In this case the educator stated that he/she usually started with Trigonometry and then transformation so that learners would understand the concepts better as they build up from each other. The response given by the subject advisor was that sequencing was not properly done in the Eastern Cape; hence the need for a plan for better sequencing in South Africa (CAPS).

ix) Educators' and subject Advisor's opinion on the bearing that the sequencing of Mathematics topics in the NCS has on Mathematics achievement.

The majority of the educators believed that the sequencing of Mathematics topics in the NCS was good. One educator stated that the problem was with the learners, since they had problems with the language of instruction, lacked prior knowledge and they tended to forget easily. Some educators believed that the sequencing of topics had a negative bearing on achievement. They stated that the way the topics were arranged in the NCS was not good for learners. They also stated that learners needed foundation principles first. NCS is structured in such a way that learners can

achieve as seen by progression of topics from grade11 to12. The subject advisor stated that this sequencing was not good, and that similar topics should follow one another for better results.

On average, the interviewed stated that the sequencing of Mathematics topics in the N.C.S had no effect on Mathematics achievement.

x) Educators views on Instances where they had to change/deviate from the prescribed/conscripted sequencing of topics, which topics, and the reasons for the deviation.

The majority of the educators stated that they never deviated from the prescribed sequencing of topics. One of the educators mentioned that there was no need for deviation because there were guidelines on when to do certain topics. One of the educators stated that, at times, there was need for deviation from the prescribed content, giving the example that according to the pace setter from the department for Grade 12 term 3, it was transformation Geometry first and then Trigonometry when it should have been Trigonometry first and then transformation so that learners would understand the concepts better as they build up from each other. Another educator said that deviation should depend on what learners would have covered in the previous grade, giving the example that for one to do grade12 inverse of functions, one needed to do functions first, which were covered in grade11 and effects of parameters.

Educators did not change/deviate from the prescribed/conscripted sequencing of topics as they followed the pacesetters.

xi) Perception of the Subject Advisors and the educators on the Mathematics content progress/link from grade to grade according to the NCS.

All the educators agreed that content was repeated from Grade to Grade. They gave as example Algebra and many topics such as data handling, space, shape and measurement, triangular prisms. One of the educators gave the example that some of the Grade 10 topics were repeated in Grade 11 but in more depth. The subject advisor also stated that content was repeated from grade to grade and easy to difficult. The subject advisor stated that even though progression was fine, not all details were covered.

According to the respondents, the Mathematics content progress/linked well from Grade to Grade.

xii) Opinions of the Subject Advisor and the educators on the articulation of the GET Mathematics content and that of the FET phases..

All the educators agreed that the GET band Mathematics content articulated well into the FET phase Mathematics. The example was given of factorisation, which was done at an easier level in Grade 9 than in Grade 10, factorization of cubic functions would have been introduced. Prisms done in Grade 9 are also done in Grade 10, Financial Mathematics and Statistics from Grade 9 continue up to Grade 12, number patterns from Grade 9 to Grade 12, et cetera. Some of the educators stated that the GET Mathematics content covered all the basics of all concepts covered in the FET phase. The subject advisor stated that topics done in GET fit well in FET, giving examples of Geometry, Algebra, graphs. Therefore, the GET band Mathematics contents articulate well into the FET phase Mathematics.

xiii) Educators and subject Advisor's view about content coverage within a term.

Three of the educators interviewed stated that in most of the case the scope is not fully covered, giving the reason as, *"it is difficult to cover all the topics as the scope is too wide, because of unforeseen circumstances for example teachers strike or learners strike which can last up to 2-3 weeks and educators will not be able to teach during that period".* One of the educators stated that time is not enough and also it depends on the quality of learners. This educator went on to state that sometimes there has to be extra lesson so as to cover the content. The one who stated that they are able to cover all the topics did not explain how they do that and when they cover all the topics.

The subject advisor stated that all the topics should be covered, depending on the level of understanding of the learners. From the responses, the topics to be covered within a term are not always all covered.

xiv) Educators and subject advisor's opinions on the skills that the Mathematics NCS encourage to develop in learners and how that is make that possible.

Educators state the following as the skills developed in learners, manipulation, interpretation, facilitation presentation, business skills and building skills. Educators stated that they make that possible by giving learners homework every day, giving them exercises, practice book for learners to take home for use when not in school, mark homework and give feedback, make learners Investigate through research in

projects. Make learners work in small groups so that every learner can participate and do presentation to the whole class. The subject advisor stated that the Mathematics NCS encourage to develop problem solving skills, financial, workplace, engineering environment, by giving real life content. From the respondents, Mathematics NCS encourages to develop a number of skills from learners.

xv) Educators and subject advisor's opinions about the time allocated for every topic in Mathematics in the NCS for each term.

Four of the respondents educators stated that time allocated for every topic in Mathematics in the NCS is not enough for every term because it all depends on the quality of the learners. Sometimes one has to go back and refer to Grade 8-9 work and even re-teach those concepts. One of the educators stated that average and slow learners need more time, after school and Saturday lessons. Another educator stated that a topic which is allocated 2 weeks in the NCS needs 4 weeks to be completed in that particular school because learners that are there are slow, while another educator felt that the scope is too wide so it needs more time. Two educators stated that time allocated for every term is enough because they manage to finish the tasks on time. The subject advisor stated that completing the topics depended on learners abilities.

According to the given responses, time allocated for every term was not enough taking into account the quality of learners the schools have.

xvi) Educators and subject advisor's opinion on whether according to the scope given for every term by the end of each term the learners would have

fully developed or mastered the specific skills or concepts for that particular term.

More than half the educators stated that by the end of each term, the learners would not have fully developed or mastered the skills or concepts for that particular term because at times some educators rush to cover all work so that they can give learners prescribed tasks. One educator stated that it is difficult to say they have mastered all but some master. Maybe 1 or 2 out of 10 will have mastered all concepts. Other educators had a feeling that if learners practice every day it will not be a problem if they want to achieve. One educator expressed concern that learners do not give themselves time to practice. The subject advisor stated that not all aspects covered make learners fully develop. The subject advisor said not all the scope is covered in the NCS but is covered in CAPS.

Therefore, from the responses, one can conclude that by end of each term learners would not have fully developed or mastered the specific skills or concepts for that particular term.

xvii) Perceptions of educators and subject Advisor's on bearing that the Mathematics type of curriculum arrangement for re-visiting the same topics every year has on Mathematics achievement.

The majority of the educators believed that the Mathematics type of curriculum arrangement for re-visiting the same topic every year has a bearing on Mathematics achievement. They stated that revisiting of topics helped learners perform better. They also stated that learners had a better understanding of topics especially if it was the same teacher from Grade10-12 with same group of learners. Educators also felt that revisiting of topics made things simpler because it seemed like revision. The

subject advisor felt that revisiting topics could bring better results but the repetition in itself did not amount to understanding.

Therefore, from these results, the Mathematics type of curriculum arrangement for re-visiting the same topics every year could have a positive bearing on Mathematics achievement.

xviii) Opinions of educators and subject Advisor's on whether the balance between superficiality and depth is achieved in a Mathematics curricula arrangement that is characterized by re-visiting the same topics (spiral arrangement) every year.

Five of the educators believed that the balance between superficiality and depth is achieved in a Mathematics curriculum arrangement characterised by re-visiting of the same topics because there are some topics where the basics are done and others where there is need for depth in content. For example, addition and other topics where one needs to give explanations like space, measurement and shapes. One of the educators stated that the *"FET content is structured such that in Grade 10, learners do distance gradients and midpoint and in Grade 11 they apply the concepts by doing equation of lines and in Grade12 its application from accrued knowledge from Grade 10-11".*

One educator believed that balance was not achieved, giving the example that sequences and series, and rotation around points negatively affected achievement as some learners had problems of memorising the formulae. Educators always needed to work with them and drill them. This educator went on to state that superficiality affected achievement. If a learner could not understand the basics,

he/she would not achieve good grades, and therefore at times the educator had to refer to basics done in Grade 9 with the Grade 12s.

According to the educators interviewed, the balance between superficiality and depth is achieved in a Mathematics curricula arrangement characterized by re-visiting the same topics (spiral arrangement) every year.

xix) Educators' opinion on whether the NCS Mathematics document allows space for logical and linear ordering of contents, and whether, sufficient or insufficient consideration of logical and linear ordering/arrangement has a bearing on NCS Mathematics achievement.

Two of the interviewed educators stated that the NCS Mathematics document allowed space for logical and linear ordering of contents. One educator stated that work schedules gave have room for maneuvering. Another educator stated that one could not do calculus without doing average rate of change (analytical geometry) and then go on to the analysis of a curve. Four the educators stated that the NCS Mathematics document did not allow space for logical and linear ordering because the department always gave the pace setters which were to be followed as they were.

Therefore, according to the respondents, the NCS Mathematics document does not allow space for logical and linear ordering of contents, and this insufficient consideration of logical and linear ordering/arrangement has a negative bearing on Mathematics achievement.

4.5 SUMMARY

Chapter four detailed the document analysis. The NCS documents were analysed with regard to curriculum design aspects. Perceptions of educators and subject advisors about the curriculum design aspects were analysed and interpreted qualitatively.

The next chapter (Chapter five) details the discussion of the results.

CHAPTER FIVE

DISCUSSION OF THE RESULTS

5.1 INTRODUCTION

In chapter four, details of the analysis and interpretation of data were given. In this chapter, the findings emanating from the data analysed in chapter four are discussed. That is, a summary of findings with regard to educators and subject advisors' perceptions on curriculum design aspects such as scope, pacing, link/ progression from grade to grade, spiral curriculum design, articulation, et cetera, are given.

5.2 SUMMARY OF THE FINDINGS

From the 22 questions on opinions, questions 18, 20, 21, 23, 24 were found to affect achievement in Mathematics negatively. Those questions were on curriculum design aspects and how they affected Mathematics achievement negatively. They are as follows:

- i) Scope: not all topics are covered within a term.
- ii) Pacing: time allocated for every topic in Mathematics in the NCS is not enough for each term.
- iii) Skills: too many topics are given every term. By the end of each term, not all topics are covered. As a result, learners are not fully developed or have not mastered the specific skills or concepts for that particular term.

iv) Ordering (spiral): although the revisiting of the same topic every year has a positive bearing on Mathematics achievement, the balance between superficiality and depth is not achieved by revisiting the same topic every year. Therefore, this superficiality has a negative bearing on Mathematics achievement.

v) Logical and linear ordering: there is no linear ordering of the content.

The means that the above mentioned curriculum design aspects contribute to Mathematics underachievement at Grade 12.

5.3 FINDINGS WITH REGARD TO HOW TEACHERS PERCIEVE THE IMPACT OF MATHEMATICS CURRICULUM DESIGN ON STUDENTS' UNDERACHIEVEMENT AT GRADE 12.

Though a few educators stated that the NCS was easy for educators to understand according to the findings, in general, it was not easy for educators as well as for learners. It depended on the quality of learners. It did not cater for slow learners but it was meant for gifted learners. A number of curriculum design aspects were found to affect the learners' performance. These are as follows:

i) Pacing:

Less than half of the interviewed educators denied having any problem with passing because they completed the given tasks in time. More than half of the educators stated that the time allocated for every topic in Mathematics in the NCS was not enough for every term because it all depended on the quality of the learners. Sometimes one has to go back and refer to grades 8-9 work and even re-teach those concepts. Educators stated that average and slow learners needed more time

perhaps after school or Saturday lessons. Learners always needed double the time compared to what was planned for them. This agrees with Witzel and Riccomini (2007),when they state that, because many Mathematics curricular materials do not meet the needs of low performing students, teachers are left with the daunting labor –intensive task of modifying the curricular to meet the needs of all the students in addition to adequately and effectively teaching all relevant Mathematics standards. This takes up all the time planned for the topics to be covered within a term.

The findings of the study support what literature says about pacing. For example, Boltge and Hasselbring (1993) state that many low performing students and students with disabilities require additional time, sometimes a longer time frame than that of the average student, to acquire a skill or concept. Sometimes a pacing guide may influence or direct teachers to skip or deemphasize important precursor skills necessary to learn future critical concepts. As a result, this might lead to underachievement in Mathematics.

ii) Scope

Several educators stated that, in most cases, the scope was not fully covered, for the reason that the scope was too wide. The educators also stated that because of unforeseen circumstances. For example, teachers' strike or learners' strike which can last up to 2-3 weeks, educators were unable to teach. For not covering the scope, the educators gave the same reasons as the ones for pacing, that there was not enough time and also that it depended on the quality of learners. The educators stated that, for the scope to be fully covered by end of the year, they gave extra lessons.

Since these extra lessons were held after school or during the weekends, they were not fruitful to all learners. The reason for this was that, not all learners stayed after school for afternoon lessons and not all learners attended the weekend lessons. The reason learners gave for not attending weekend lessons were that they had other commitments such as doing laundry, going to church, et cetera. The reason they usually gave for not attending afternoon lessons was that they were tired. Some of them said that they had contract transportation which carried them after school, and once they were left behind they would be unable to get home. This was a serious problem for an educator who was willing to help.

The majority of the educators stated that the NCS design had a negative bearing on achievement because the content was difficult for the learners. Some educators thought that learners did not understand the questions because of a language barrier. Educators stated that learners were not capable of applying concepts well and teachers struggled to teach them. Some educators stated that the curriculum was always changing. There was OBE, and then NCS, and now CAPS. So it confused the learners.

If educators are said to be struggling with the NCS Mathematics, it might have a serious impact on Mathematics achievement. Learners might not be able to apply concepts because educators fail to deliver the content effectively. The DOE should make sure that it trains the educators in the NCS so that they are confident of the content and deliver it to the learners without any problems.

As a Mathematics educator the researcher has also realised that language is a barrier to Mathematics achievement. Some learners are not confident in expressing themselves in discussions during Mathematics lessons because of language issues.

Sometimes it is obvious when one asks a question or explains a point that the learners do not even understand what he/she is saying. The language barrier has become a serious problem especially in public schools. The researcher strongly feels that public school learners are disadvantaged because of the English barrier. Every subject that they do except for their mother language is taught and examined in English which is a burden to them.

The language in Education Policy (1997) states that:

- All learners shall offer at least one approved language as a subject in Grade 1 and Grade 2.
- From Grade 3 onwards, all learners shall offer their language of teaching and at least one additional approved language as a subject.

As a result, in public schools learners at foundation phase are taught in their mother tongues and English is introduced at later stage. It would be good to see the Department of Education introduce English in public schools as early as Grade R. The earlier this is done, the better because it is much easier to learn a language at a young age. Knowing and understanding English is an advantage for better results from Primary school up to the Tertiary level.

The findings support what the literature says about the scope. For example, according to Witzel and Riccomini (2007), the performance levels stipulated in the general education curricula are problematic for students and present many challenges to teachers who are responsible for providing programmes and services to students. Witzel and Riccomini (2007) also assert that Mathematics is one academic area of particular concern for students and teachers and therefore, there is

a need to develop more efficient and effective Mathematics instructional procedures, curricula and material for low performing students. Witzel and Riccomini (2007) state that many Mathematics curriculum programs require a certain number of modifications before low performing learners can benefit from the curriculum.

The findings for this study also support the earlier findings. For example, studies by Howie (2003), Adler (1998), Monyana (1996), Setati & Adler (2000), state that factors that contribute to underachievement in Mathematics at Matric level in South Africa include:

- Inadequate subject knowledge of the teacher. Educators have little or no knowledge of Mathematics but are requested to teach that subject, for the reason that there is a shortage of educators trained to teach the subject.
- Inadequate communication ability of pupils. Learners have a serious language barrier, as a result they fail because they cannot read and understand what some of the questions need.
- Inadequate communication ability of teachers in the language of instruction.
 Some educators have language problems as a result they cannot explain topics well to the learners in English and that contributes to underachievement in Mathematics.

iii) Integration

The majority of the educators said they found integrating Mathematics with other subjects easy. More than half of the educators stated that integration of Mathematics with some other subjects had a positive bearing on achievement even though learners did not see the integration. They stated that integration made it easy for

learners to understand different subjects and they could even achieve better results. This agrees with Maphalala (2006) when he states that integration gives coherence and expands the learners' opportunities to attain skills, acquire knowledge and develop the attitudes and values that are encompassed across curriculum. They stated that they normally integrate Mathematics with Arts and Culture, Accounting in Financial Mathematics, Physical Sciences in Calculus, Natural Science in scientific notation, Economics graphs, Geography graphs and gradients, Physical science graphs.

The findings for this study support what literature says about integration. For example, Maphalala (2006) states that integration requires learners to use their knowledge and skills from different parts of the same learning area as they carry out tasks and activities or use their knowledge and skills from one learning area to another. The findings for this study also agree with Jansen (2009) who states that teaching can be integrated (as in Social Studies) or presented in separate subjects (Mathematics and Accounting).

From the researcher's teaching experience, some Mathematics topics are done in Physical Science. For example, Trigonometry is done in Mathematics finding distances and same applies in Physical Science. For the learners who are good at integrating subjects when they get to those topics in Physical science after having done them in mathematics, the topics become easy for them.

iv) Assessment Standards

All the educators stated that the Mathematics Assessment Standards in the NCS were good. The educators stated that Assessment Standards helped learners achieve goals and the educator in planning. They also stated that standards catered

for different learners and educators should know what they want to achieve. Educators also stated that Assessment Standards gave direction on the assessment of learners and in the NCS they were very user friendly.

The findings of this study support the literature reviewed. For example, according to the Umalusi report (2010), the breadth of the curriculum measures the total number of topics covered per course of study and assessment standards consist of the knowledge, skills and values that are required to achieve the learning outcome. The findings differ in that according to Witzel and Riccomini (2007), there is not always a natural connection or transition among and between Mathematics standards. According to Witzel and Riccomini (2007) the disconnection between standards is obvious to Mathematics teachers who on a daily bases observe students mastering one skill and struggling on the subsequent skill, which may or may not directly link with the previous skill because of a missing or forgotten precursor skill.

v) Sequencing

The majority of the educators stated that the sequencing of Mathematics topics in the NCS was good. One reason given for this view was that one could do logs before financial Mathematics so that log laws could be applied in financial Mathematics when one wanted to find the value of "n" especially in compound interest. The educators stated that the NCS was structured in such a way that learners could achieve the goals as seen by progression of topics from Grade11 to12.

The majority of the educators also stated that they did not deviate from the prescribed sequencing of topics. One of the educators mentioned that there was no need for deviation because there were guidelines on when to do certain topics. Another educator said that deviation should depend on what learners would have

covered in the previous grade, using as an example, the fact that for one to do Grade12 inverse of functions one needs to do functions first, which are covered in Grade11 and effects of parameters. One educator stated that the problem was with the learners, since they had problems with language, lacked prior knowledge and tended to forget easily.

Another educator stated that the sequencing was acceptable but that there were some parts that were not appropriate; for example, the pace setter from department for grade 12 term 3, Transformation, Geometry and Trigonometry. In this case the educator stated that he/she usually started with Trigonometry and then transformation so that learners could understand the concepts as they built up on each other. Some educators believed that sequencing of topics had a negative bearing on achievement. They stated that the way the topics were arranged in the NCS was not good for learners.

On average the interviewed stated that the sequencing of Mathematics topics in the N.C.S had no effect on Mathematics achievement. This contradicted the subject advisor's view that the sequencing was poorly done. This might be because the educators did not have much knowledge about the order in which topics were supposed to follow each other for better achievement in Mathematics.

The findings of the study from the point of view of the educators agrees with the Umalusi report (2008) which states that the order in which topics are listed in a syllabus for a particular grade does not necessarily have particular significance. Very few teachers follow the curriculum for the Grade in the order in which it is set out, for example, completing all the Algebra before starting with Geometry.

The findings also agree with the Umalusi report (2010), which states that work schedules, which are drawn up at provincial, district and school levels, can provide educators with guidance as the sequence in which they should teach topics and the length of time which they should spend on them. However, these documents are not prescriptive; they only provide one suggested ordering of topics, which is at times different from the ordering given in the NCS and very few teachers follow the curriculum for the grade in the order in which it is set out.

vi) Skills

About half the educators stated that, at the end of each term, the learners would not have fully developed or mastered the skills or concepts for that particular term because at times some educators rushed to cover all work so that they could give learners prescribed tasks. One educator stated that it was difficult to say that they had all mastered the tasks but some master them. Maybe 1 or 2 out of 10 would have mastered all concepts. Other educators had a feeling that if learners practiced every day it would not be a problem. One educator expressed concern that learners did not give themselves time to practice.

The problem in this case was that the scope would not be fully covered as there was limited time to cover all the aspects within a term. Another reason was that, since learners were slow in understanding concepts, a lot of time was spent on one topic, as a result, not all the topics are covered within a term and as a result skills are not fully developed or mastered within a term.

Educators stated the following as the skills developed in learners: manipulation, interpretation, facilitation presentation, business skills and building skills. Educators stated that they made this possible by giving learners homework every day, giving them exercises and practice books for learners to take home for use when they were not in school, marking homework and giving feedback, making learners participate in investigations through research in projects. They also made learners work in small groups so that every learner could participate and give presentations to the whole class.

From the researcher's point of view, if all educators' teaching philosophies could be learner centred, it would help learners develop a number of skills through independence. They would get used to research and solve even real life problems on their own, and not wait to be given everything as they normally do .This agrees with Graham and Harris (1996) when they state that excellent teaching often begins with explanation and modeling, and continues with teacher scaffolding of students' more independent efforts.

The study supports Witzel and Riccomini (2007) who state that although teachers may claim success after completion of a certain lesson, many students, especially those with low performance or with disabilities, still may not have fully developed or mastered the specific skills or concepts of the lesson objective.

5.4 FINDINGS WITH REGARD TO SUBJECT ADVISORS' PERCEPTIONS ON THE BEARING THAT THE MATHEMATICS CURRICULUM DESIGN HAS ON GRADE 12 UNDERACHIEVEMENT IN MATHEMATICS.

The subject advisor felt that the NCS built a nation that is democratic that also heals the divisions, so that the quality of life is improved in Mathematics. The subject advisor also felt that the NCS ensure the use of proper skills and problem solving. On pacing, the subject advisor felt that completing the topics depended on learners' abilities. Similarly, the subject advisor believed that the coverage of the scope depended on the level of understanding of the learners. The subject advisor stated that in the NCS it was easy to integrate all the subjects. He stated that it was good to see mathematics not being isolated from other learning areas. The subject advisor went on to state that the integration of subject helped to save on contact time and repetition of work resulted in better understanding.

On the aspect of Assessment standard, the subject advisor believed that the Assessment Standards definitely needed to be replaced; hence, the Curriculum Assessment Policy Statement (CAPS). The subject advisor stated that not all areas covered would be useful in tertiary education, or rather be differentiated further Therefore, there is a need for replacement. This was a contradicted by the educators who believed that the Assessment Standards were good. There might have been a contradiction between the educators and the subject advisors because the educators did not study the ASs very well to see how useful they were at the tertiary level.

The subject advisor stated that sequencing was not properly done in the Eastern Cape. Therefore, there was a need for improvement in sequencing in South Africa (This is attempted in CAPS). He stated that the sequencing was inappropriate and,
that similar topics should follow one another for better results. What the subject advisor said agrees with Witzel (2007) when he states that teachers must examine the curriculum sequence for completeness and appropriateness for their students.

Concerning skills, the subject advisor stated that not all aspects covered developed learners fully. The reason was the same one given stated by the educators, which was their inability to cover all the assigned tasks within a term. The subject advisor stated that the Mathematics NCS encouraged learners to develop problem solving skills, financial, workplace, engineering environment, by providing real life content. The respondents disclosed that the Mathematics NCS encouraged them to develop a number of skills from learners although it does not always happen because of the many factors as mentioned above.

Like the educators, the subject advisor agreed with Witzel and Riccomini (2007) who state that although teachers may claim success after completion of a certain lesson, many students, especially those with low performance or with disabilities, still may not have fully developed or mastered the specific skills or concepts of the lesson objective.

5.5 FINDINGS WITH REGARD TO HOW THE MATHEMATICS CURRICULUM DESIGN LINKS AND PROGRESSES FROM PRIMARY TO HIGH SCHOOL.

All the educators agreed that content was repeated from Grade to Grade. They gave examples of algebra and many other topics such as data handling, space shape and measurement, triangular prisms. One of the educators referred to some of the Grade 10 topics that were repeated in Grade 11 but in more depth. The subject advisor also stated that content was repeated from Grade to Grade, from easy to difficult but not all the aspects were covered.

All the educators agreed that the GET band Mathematics content articulated well into the FET phase Mathematics, giving the example factorization of which is done at an easier level in Grade 9 but in Grade 10 is more difficult because factorization of cubic functions is introduced. Prisms done in grade 9 are also done in grade 10, financial Mathematics and statistics from Grade 9 continue up to Grade 12, number patterns from Grade 9 to Grade 12, et cetera. Some of the educators stated that the GET Mathematics content covered all the basics of all concepts covered in the FET phase. The subject advisor stated that topics done in GET fit well in the FET, giving examples of geometry, algebra, and graphs.

The findings for this study agree with Muller, Taylor, Vinjevold (2003) when they said that Mathematics progression within grades, across grades and across phases is strong, explicit and content led, but there is no strong skill progression stipulated and skills and content are coupled.

If all educators could realise this articulation and be able to cover all the aspect for every grade, then learners could master mathematical concepts without any problems.

The majority of the educators believed that the Mathematics type of curriculum arrangement of re-visiting the same topic every year has a bearing on Mathematics achievement. They stated that revisiting of topics made learners perform better. They also stated that learners had a better understanding especially if it was the same teacher from Grade10-12 with same group of learners. Educators also felt that revisiting of topics makes simplified things because it was like revision. The subject advisor felt that revisiting topics could bring better results but that the repetition in itself did not guarantee understanding.

If only all educators could genuinely revisit the topics every year even going into depth, then it would help learners a lot. The problem was that some educators just repeated the same content covered in the previous grades, instead of using the previous Grades' content as a base for introducing new content for the new grade. If educators just repeat the same content, then it does not contribute to any achievement in mathematics. According to Harden and Stamper (1999) in a curriculum where there is revisiting of topics, new learning is related to previous learning. That is, new information or skills introduced are related back and linked directly to learning in previous phases of the spiral. If done that way, then re- visiting the same topics every year will have a positive bearing on Mathematics achievement.

More than half the educators believed that the balance between superficiality and depth was achieved in the mathematics curricula arrangement characterised by revisiting of the same topics because there are some topics where the basics are done and others where there is need for depth. For example, addition and other topics where one needs to give explanations like space, measurement and shapes. One of the educators stated that the *"FET content is structured such that in grade 10, learners do distance gradients and midpoint and in Grade 11 they apply the concepts by doing equation of lines and in Grade 12 it is application of accrued knowledge from Grade 10-11, hence they will pass if they master the concepts".*

Other educators believe that balance is not achieved giving examples that sequences and series, rotation around points negatively affect achievement as some learners have problems with memorising the formulae. Educators always need to work with them and drill them. One educator stated that "superficiality affects achievement, if a learner cannot understand basics, he/she will not achieve good

grades, and therefore, at times the educator refers to basics done in Grade 9 with the Grade 12s".

If educators can revisit the content every year, not superficially that can help learners achieve in Mathematics at Grade 12.

Less than half the educators stated that the NCS Mathematics document allowed space for logical and linear ordering of contents. One educator stated that work schedules had room for maneuvering. Another educator stated that one could not do calculus without doing the average rate of change (analytical geometry) and then go on to analysis of a curve. More than half the educators stated that the NCS Mathematics document does not allow for logical and linear ordering because the department always gives pace setters which have to be followed as they are. Therefore, according to the respondents, the NCS Mathematics document does not allow space for logical and linear ordering of content, and this insufficient consideration of logical and linear ordering/arrangement has a negative bearing on Mathematics achievement.

5.6 FINDINGS WITH REGARD TO HOW APPROPRIATE IS THE NCS MATHEMATICS CURRICULUM FOR THE LEVEL OF GRADE 12 STUDENTS.

In general it has been learnt that teaching Mathematics is interesting but challenging. Understanding the Mathematics curriculum depends on the quality of learners. Some learners are slow and have problems with English, which also contributes to underachievement in Mathematics. Integrating Mathematics with some other learning areas was found to be easy. The NCS Assessment Standards were found to be good but not all the skills were developed in the learners according to the scope given for every term because of the time factor. The sequencing of topics was

found to be good by the majority of the educators. The link/ progression and articulation of the content from grade to grade were also found to be good. The NCS spiral curriculum was found to help with achievement in Mathematics though some educators felt that the revisiting of topics did not balance between superficiality and depth.

5.7 CONNCLUSIONS

The results of the study led to the following conclusions:

- i) Educators perceive the impact of the Mathematics curriculum design on students' underachievement at Grade 12 the following way: the scope is too wide that the skills which are supposed to be developed in learners are not fully developed. Time is limited every term. As a result, learners are unable to cover the scope for the term. Revisiting of topics every year is good but the balance between superficiality and depth is not achieved.
- ii) Subject Advisors perceive the impact of the Mathematics curriculum design on students' underachievement at Grade 12 the following way: Learners' skills are only partly developed because the content for every term is not fully covered. The Assessment standards definitely need to be replaced hence CAPs because not all areas covered are useful in tertiary education. The sequencing of topics is not helpful and needs revision. Revisiting of topics every year is good but at times is done with learners still not understanding the topic.

- iii) The Mathematics curriculum design, link and progress from primary to high school is good, that is, it progresses from easy to difficult, but not all the details are covered. This aspect is explained by the spiral NCS Mathematics curriculum. This means that topics are repeated from Grade to Grade with more complex content being introduced in every Grade. However, the repetition of topics from Grade to Grade does not guarantee that the scope for every grade is covered in depth.
- iv) The NCS Mathematics curriculum for the level of Grade 12 students is not 100% appropriate because some of the curriculum design aspects, such as pacing, scope, sequencing, link of topics from grade to grade, re-visitation of topics every year need to be reassessed.. It be can be concluded that some of the curriculum design aspects contributed to underachievement in Mathematics.

5.8 RECOMMENDATIONS

From this case study, it appears that teachers still need more empowerment in the NCS. Educators still need training on the NCS so they can be confident with the Mathematics NCS content. In most schools the scope is not covered and skills that are supposed to be developed in learners every term are not developed because of slow learners and the time factor. Therefore, the Department of education needs to give the scope taking into consideration the slow learners and make sure that the time they give every term also takes into consideration the time used for tests.

It also appears that the learners are slow because of the language barrier. Educators spend a lot of time saying the same things to the learners so that they can understand. Since the learners do almost all the subjects in English and write their examination in English if they are from an English medium school. It would be a good idea for the DOE to introduce English to the learners as early as Grade R, as in the model C schools. If that is done, it might remove the language barrier and hence reduce underachievement in Mathematics. It appears that the educators revisit topics every year but do not balance superficiality and depth. Educators should be encouraged to take every topic seriously every year and not just repeat what they covered in the previous grade. They should use it as a base for the new content. If that is done, it might help the achievement in Mathematics.

5.9 LIMITATIONS OF THE STUDY AND AVENUES FOR FURTHER RESEARCH.

The following limitations of this study are outlined for directing future studies as it is clear that more research is needed:

- (i) The sample of this study was drawn from educators of 5 schools from the Eastern Cape Province only. Therefore, it is not representative of the entire population of educators in the district. Further studies need to be conducted in other districts and provinces.
- Only public schools were targeted as the population in this study. Further research focusing on private schools is needed.
- (iii) The sample of the study consisted of 6 educators only and one subject advisor. More research, with a bigger sample is essential so that the results can be generalised nationally with confidence.

(iv) Only semi-structured interviews were used as a research instrument in this study. Further research, using a combination of questionnaires and interviews is needed.

5.10 REFLECTION

In spite of the limitations mentioned above, this study has achieved its objective of determining the aspects of the NCS Mathematics curriculum design which have a bearing on underachievement in Mathematics at Grade 12. According to the subject advisors and the educators perceptions it become clear that some of the curriculum design aspects contributed to underachievement in Mathematics. Therefore, the research questions were answered and research objectives achieved.

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APPENDIX 1: Faculty of education

University of Fort Hare

The Director: Research Strategy Development Zwelitsha Department of Education and Culture K.W.T

Dear Sir/Madam

RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH WITH MATHEMATICS EDUCATORS AND SUBJECT ADVISORS.

I am registered for Ph.D. degree in the Faculty of Education at Fort Hare University and a Mathematics educator at St Christopher's Private School. I am writing this letter to request for permission to conduct research with teachers in purposively selected schools in King Williams Town District as well as Mathematics Subject Advisors. My investigation is entitled: The perception of educators and subject specialists on the bearing that the South African Mathematics Curriculum Design has on underachievement in schools in the King Williams Town Education District of the Eastern Cape.

A copy of a consent form and semi-structured interviews for Mathematics teachers and for Subject Advisors are attached. I hope it meets your approval. The names of schools, educators and subjected advisors in the study will be treated as confidential, but the results of the research can be forwarded to your office should you wish me to do so. Your permission to allow me conduct research in King Williams Town will be highly appreciated. I can be reached at <u>boni2002other@yahoo.co.uk</u> or 0835348365.

Thank you in advance

Yours faithfully

Bonani Sibanda (student)

APPENDIX 2: Consent form for the participant

Consent form for the participant

I, hereby give my consent to become a participant in this study. I fully understand and agree to the terms and consenting to be a participant in this study.

Participating official
Contact details:
Address:
Felephone numbers (home)
(Work)
Signed this day of at

Witness.....

Appendix 3: Declarations by researcher and supervisor

5. ETHICAL DOCUMENTS:

This information [the next four pages] with original signatures must be faxed to 086 5410 389, scanned and e-mailed or hand delivered.

5.1. DECLARATION BY THE RESEARCHER

I declare that all statements made by myself in this application are true and accurate.

I have read and fully understand all the conditions associated with the granting of approval to conduct research within the ECDBE, as outlined in the ECDBE Research Briefing Document, and undertake to abide by them.

Should I fail to adhere to any of the approval conditions set out by the ECDBE, I would be in breach of the agreement reached with the organisation, and all privileges associated with the granting of approval to conduct research, would fall away.

Signature:	Bsbanda
Date:	25/07/2012

5.2.DECLARATION BY SUPERVISOR / PROMOTER / LECTURER /FUNDER /PROJECT LEADER/MANAGER		
I declare that: - Dr VJJ NKO	NIG	
The applicant is enrolled at the institution / empl attached.	oyed by the organisation to which the undersigned is	
The overall research meets the criteria of: Educational Accountability Proper Research Design Sensitivity towards Participants Correct Content and Terminology Acceptable Grammar Absence of Non-essential / Superfluous items Anonymity of Research Participants		
Surname:	NKONKI	
First Name/s:	Vuyisine	
Institution / Organisation:	UNIVERSITY OF FORT HARE	
Faculty:	EDUCATION	
Department:	EDUCATION	
Telephone:	040 602 2704	
Fax:	08/ 569 2140	
Cell:	0724437755	
E-mail:	Vakonki@ufh.ac.za	
Signature:	Augh	
Date:	25/07/2012	
APPENDIX 4: Request for Permission to Conduct Research

University of Fort Hare

Faculty of Education

Dear Sir/Madam(Principal)

RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH WITH MATHEMATICS EDUCATORS IN YOUR SCHOOL.

I am registered for Ph.D. degree in the Faculty of Education at Fort Hare University and a Mathematics educator at St Christopher's Private School. I am writing this letter to request for permission to conduct research with FET phase educators in your school.

My investigation is entitled: The perception of educators and subject specialists on the bearing that the South African Mathematics Curriculum Design has on underachievement in schools in the King Williams Town Education District of the Eastern Cape.

The names of schools, educators and subjected advisors in the study will be treated as confidential. Your permission to allow me conduct research in your school will be highly appreciated. I can be reached at <u>boni2002other@yahoo.co.uk</u> or 0835348365. Thank you in advance

Yours faithfully Bonani Sibanda (student)

Appendix 5

Doctor of Philosophy in Education

Fort Hare University

Semi Structured Interviews Concerning:

The perceptions of educators and subject specialists on the bearing that the South African Mathematics curriculum design has on underachievement in schools in the King Williams Town Education Districts of the Eastern Cape.

Dear educator,

There is a high failure rate amongst mathematics learners at grade 12.

The goal of this research is to identify your perception about the bearing that South African Mathematic curriculum design has on underachievement in schools in the K.W.T District.

I would like to ask you to participate in this research by taking part in the interviews. I wish to appeal to you to be as open as possible.

Issues of confidentiality and anonymity will be upheld. I would like to emphasize that participation in this study is voluntary and that you may withdraw your participation in the study at any time.

Yours faithfully Bonani Sibanda Cell: 0835348365

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INTERVIEWS FOR EDUCATORS

Part 1: Teaching Experience

- 1. When did you obtain your qualifications?
- 2. How long have you been teaching?
- 3. For how long have you been teaching Mathematics?
- 4. In which Grades are you teaching Mathematics?

Part 2: Opinion

- 5. How do you find teaching Mathematics at FET phase?
- 6. What bearing does the NCS design for Mathematics has on teaching and learning of Mathematics?
- 7. Which Mathematics NCS design aspects have a bearing on the teaching and learning of Mathematics?
- 8. Do you think the Mathematics NCS design has a bearing on the learners' achievement in Mathematics? If yes, how so?

Integration

- 9. Is it easy to integrate Mathematics with other Learning Areas?
- 10. Does this integration of mathematics with some other subjects have any bearing on achievement?
- 11. When teaching mathematics do you normally integrate it with some other learning areas (horizontal integration)? If yes, with which subjects and on which topics do you find it easy?

12. What is your opinion about the mathematics Assessment Standards in the

N.C.S?

Sequencing

- 13. What can you say about the sequencing of Mathematics topics in the N.C.S?
- 14. Do you think the sequencing of mathematics topics in the N.C.S has any bearing on mathematics achievement?
- 15. Are there instances where you had to change/deviate from the prescribed/conscripted sequencing of topics? On which topics was this case? What were your reasons for the deviation?

Progression and articulation

- 16. According to the N.C.S, how does the mathematics content progress/link from grade to grade?
- 17. Does the GET band Mathematics content articulate well into the FET phase Mathematics? If yes, how so? If no, what articulation issues are there between GET and FET Mathematics?

Pacing

- 18. Do you often cover all the topics to be covered within a term?
- 19. What skills does the Mathematics N.C.S encourage to develop in learners? How do you make this possible?
- 20. Do you think time allocated for every topic in mathematics in the N.C.S is enough for each term? If yes or no, why?
- 21. According to the scope given for every term do you think by the end of each term the learner would have fully developed or mastered the specific skills or concepts for that particular term? Elaborate.

Arrangement/ordering

- 22. Do you think the mathematics type of curriculum arrangement for re- visiting the same topics every year has any bearing on mathematics achievement? If yes, how? If no, why?
- 23. Do you think the balance between superficiality and depth is achieved in a Mathematics curricula arrangement characterized by re-visiting the same topics (spiral arrangement) every year? Could you cite instances in the NCS Mathematics document where topics are dealt with in a superficial way? Does this superficiality has a bearing on Mathematics achievement?
- 24. Does the NCS Mathematics document allow space for logical and linear ordering of contents? Does sufficient or insufficient consideration of logical and linear ordering/arrangement has a bearing on NCS Mathematics achievement?

APPENDIX 6

INTERVIEWS FOR THE SUBJECT ADVISORS

Doctor of Philosophy in Education

Fort Hare University

Semi Structured Interviews Concerning:

The perceptions of educators and subject specialists on the bearing that the South African Mathematics curriculum design has on underachievement in schools in the King Williams Town Education Districts of the Eastern Cape.

Dear Subject Advisor,

There is a high failure rate amongst Mathematics learners at Grade 12.

The goal of this research is to identify your perception about the bearing that South African Mathematic Curriculum Design has on underachievement in schools in the K.W.T District.

I would like to ask you to participate in this research by taking part in the interviews. I wish to appeal to you to be as open as possible.

Issues of confidentiality and anonymity will be upheld. I would like to emphasize that participation in this study is voluntary and that you may withdraw your participation in the study at any time.

Yours faithfully Bonani Sibanda Cell: 0835348365

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INTERVIEWS FOR SUBJECT ADVISORS

Part 1: Academic Experience

- 1. When did you obtain your qualifications?
- 2. How long have you been a Mathematics Subject Advisor?

Part 2: Opinion

- 3. What bearing does the NCS design for Mathematics has on teaching and learning of Mathematics?
- 4. Which Mathematics NCS design aspects have a bearing on the teaching and learning of Mathematics?
- 5. Do you think the Mathematics NCS design has a bearing on the learners' achievement in Mathematics? If yes, how so?

Integration

- 6. Is it easy to integrate Mathematics with other Learning Areas? Elaborate.
- 7. Does this integration of mathematics with some other subjects has any bearing on achievement?
- 8. What is your opinion about the mathematics Assessment Standards in the N.C.S?

Sequencing

- 9. What can you say about the sequencing of Mathematics topics in the N.C.S?
- 10. Do you think the sequencing of mathematics topics in the N.C.S has any bearing on mathematics achievement?

- 11. (a) According to the Mathematics N.C.S are the skills required to be developed in the learners easy to develop?
 - (b) How do you think educators can make that possible?

Progression and articulation

- 12. According to the N.C.S, how does the Mathematics content progress/link from grade to grade?
- 13. Does the GET band Mathematics content articulate well into the FET phase Mathematics? If yes, how so? If no, what articulation issues are there between GET and FET Mathematics?

Pacing

- 14. Do you often cover all the topics to be covered within a term?
- 15. What skills does the Mathematics N.C.S encourage to develop in learners?How do you make this possible?
- 16. Do you think time allocated for every topic in mathematics in the N.C.S is enough for each term? If yes or no, why?
- 17. According to the scope given for every term do you think by the end of each term the learner would have fully developed or mastered the specific skills or concepts for that particular term? Elaborate.

Arrangement/ordering

- 18. Do you think the mathematics type of curriculum arrangement for re- visiting the same topics every year has any bearing on mathematics achievement? If yes, how?
- Do you think the balance between superficiality and depth is achieved in a Mathematics curricula arrangement characterized by re-visiting the same topics

(spiral arrangement) every year? Could you cite instances in the NCS Mathematics document where topics are dealt with in a superficial way? Does this superficiality has a bearing on Mathematics achievement?

20. Does the NCS Mathematics document allow space for logical and linear ordering of contents? Does sufficient or insufficient consideration of logical and linear ordering/arrangement has a bearing on NCS Mathematics achievement?

Appendix 7

STRATEGIC PLANNING POLICY RESEARCH AND SECRETARIAT SERVICES Steve Vukile Tshwete Complex - Zone 6 - Zwelitsha - Eastern Cape Private Bag X0032 - Bhishor - 5605 - REPUBLIC OF SOUTH AFRICA Tel: +27 (0)43 702 7428 + Fax: +27 (0)43 702 7427/38 + Website: www.ecdoe.gov.za Enquiries: Dr Heckroodt Email: bernetia@liafrica.com 04 September 2012 Mrs. Bonani Sibanda 9826 Golf COurse King William's Town 5600 Dear Mrs. Sibanda PERMISSION TO UNDERTAKE A DOCTORAL THESIS: THE PERCEPTIONS OF AND SUBJECT SPECIALISTS ON THE BEARING THAT THE SOT MATHEMATICS CURRICULUM DESIGN HAS AN UNDERACHIEVEMENT IN SKING WILLIAM'S TOWN EDUCATION DISTRICT OF THE EASTERN CAPE 1. Thank you for your application to conduct research. 2. Your application to conduct the above mentioned research in five Secondar the jurisdiction of King William's Town District in the Eastern Cape Depa Education (ECDBE) is hereby approved on condition that: a. there will be no financial implications for the Department; b. institutions and respondents must not be identifiable in any way from the investigation; c. you present a copy of the written approval letter of the Eastern Cape Basic Education (ECDBE) to the District Directors before ar undertaken at any institutions within that particular district; 	F EDUCATOR TH AFRICA CHOOL IN TH
Enquiries: Dr Heckroodt Email: bernetla@lafrica.com 04 September 2012 Mrs. Bonani Sibanda 9826 Golf COurse King William's Town 5600 Dear Mrs. Sibanda PERMISSION TO UNDERTAKE A DOCTORAL THESIS: THE PERCEPTIONS OF AND SUBJECT SPECIALISTS ON THE BEARING THAT THE SOU MATHEMATICS CURRICULUM DESIGN HAS AN UNDERACHIEVEMENT IN SKING WILLIAM'S TOWN EDUCATION DISTRICT OF THE EASTERN CAPE 1. Thank you for your application to conduct research. 2. Your application to conduct the above mentioned research in five Secondar the jurisdiction of King William's Town District in the Eastern Cape Depa Education (ECDBE) is hereby approved on condition that: a. there will be no financial implications for the Department; b. institutions and respondents must not be identifiable in any way from the investigation; c. you present a copy of the written approval letter of the Eastern Cape Basic Education (ECDBE) to the District Directors before an undertaken at any institutions within that particular district;	EDUCATOR TH AFRICA HOOL IN TH
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- the research may not be conducted during official contact time, as <u>educators'</u> programmes should not be interrupted;
- f. should you wish to extend the period of research after approval has been granted, an application to do this must be directed to the Director: Strategic Planning Policy Research and Secretarial Services;
- g. the research may not be conducted during the fourth school term, except in cases where a special well motivated request is received;
- h. your research will be limited to those schools or institutions for which approval has been granted, should changes be effected written permission must be obtained from the Director – Strategic Planning Policy Research and Secretariat Services;
- you present the Department with a copy of your final paper/report/dissertation/thesis free of charge in hard copy and electronic format. This must be accompanied by a separate synopsis (maximum 2 – 3 typed pages) of the most important findings and recommendations if it does not already contain a synopsis. This must also be in an electronic format.
- j. you are requested to provide the above to the Director: The Strategic Planning Policy Research and Secretarial Services upon completion of your research.
- k. you comply to all the requirements as completed in the Terms and Conditions to conduct Research in the ECDBE document duly completed by you.
- I. you comply with your ethical undertaking (commitment form).
- m. You submit on a six monthly basis, from the date of permission of the research, concise reports to the Director: Strategic Planning Policy Research and Secretariat Services.
- The Department reserves a right to withdraw the permission should there not be compliance to the approval letter and contract signed in the Terms and Conditions to conduct Research in the ECDBE.
- 4. The Department will publish the completed Research on its website.
- 5. The Department wishes you well in your undertaking. You can contact the Director, Dr. Annetia Heckroodt on 043 702 7428 or mobile number 083 275 0715 and email: <u>annetia.heckroodt@edu.ecprov.gov.za</u> should you need any assistance.

DR AS HECKROODT DIRECTOR: STRATEGIC PLANNING POLICY RESEARCH AND SECRETARIAT SERVICES $\mathbf{V}_{\mathbf{F}}$